

Report: IET Faraday Challenge Days Impact
Study 2016-17

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Shift Learning

because learning
keeps changing

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Key findings

- 83% of students who took part in IET Faraday Challenge Days reported that they would recommend it to other students, suggesting high levels of enjoyment and satisfaction.
- Likewise, all teachers reported that they would recommend it to other schools - with several confirming they had already done so at the point of interview.
- Nearly a third of students indicated that the opportunity to code and programme was the best part of the day, whilst the same proportion cited working in a team as the most enjoyable aspect.
- 85% of students either agreed or strongly agreed that they learnt new things at their Challenge Day, suggesting participation has had a positive impact on their skill and knowledge development.
- When looking at students' perceived impact of participating in an IET Faraday Challenge Day, 85% either agreed or strongly agreed that participation has helped to increase their understanding of what engineering is.
- Similarly, 84% of students agreed or strongly agreed that their participation has given them a better understanding of the skills needed by engineers, suggesting that students have increased their understanding and awareness of STEM careers.
- 72% of students indicated that they felt more positive about engineering since taking part in their IET Faraday Challenge Day, suggesting that participation has a positive impact on young people's attitudes here.
- Teachers reported a number of perceived positive impacts on student participation, including increased interest in STEM subjects and activities, increased engagement in learning more generally, a stronger awareness of STEM careers, an increase in confidence both academically and personally, development of soft skills such as teamwork and communication, and improvements in technical skills such as coding.
- The ANCOVA analysis revealed that there are no statistically significant differences between IET Faraday Challenge Day participants and non-participants when looking at attitudes to Maths, Science, Engineering and Technology, and personal skills.
- Although there are no statistically significant differences, participants scored higher on most attitude aspects than non-participants, suggesting that participation in IET Faraday Challenge Days may promote a more positive perception of STEM, and of future career options.
- Despite the lack of a measurable impact, a positive change in attitude scores over time was still observed in participants, especially with regard to pursuing STEM careers. This could potentially be attributed to the introduction of students to the real-world application of STEM in Challenge Days.

Background

The Institution of Engineering and Technology (IET) was looking to understand the longer-term impacts of participation in IET Faraday Challenge Days on young peoples' attitudes toward engineering and STEM.

IET Faraday Challenge Days

The IET Faraday programme offers a collection of free publications, resources and activities that use real engineering case studies to help teach the secondary curriculum for STEM subjects.

[IET Faraday Challenge Days](#) have run since 2008. They are one day long STEM activities designed for 6 teams of 6 students and are delivered free of charge in 129 schools (as of 2015-2016). The Challenge Days are designed to give participants the opportunity to research, design and make prototype solutions to genuinely tough engineering problems. For 2015-16 the Challenge Days are designed for year 7 pupils, aged 11-12 years (they are normally for those in year 8).

Key research questions

In order to better understand the impact of involvement in IET Faraday Challenge Days, we set out to answer the following questions:

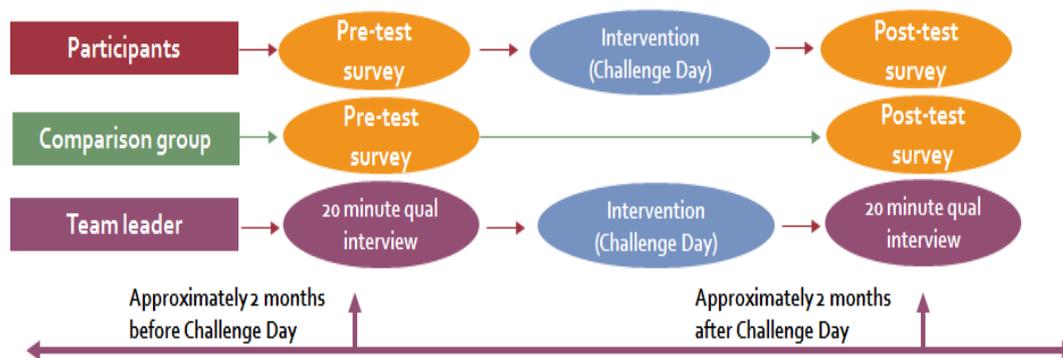
- What impact does taking part in IET Faraday Challenge Days have on participants' attitudes towards STEM and future careers?
- How does this differ from those that do not take part?
- What improvements to the programme could be made to improve perceptions of STEM?

Methodology

This study has a two-group pre-test/post-test experimental design as shown below with fieldwork conducted before and after participation in IET Faraday Challenge Days.

As shown below, the data collection had two elements:

- **Interviews:** We conducted interviews with teachers, pre and post the Challenge Day
- **Surveys:** Students who were participating in the Challenge Day as well as a control group of students with similar characteristics were asked to fill out a survey before and after the activity



Use of ANCOVA

In order to effectively measure the impact participating in a Challenge Day has on perceptions and attitudes towards STEM, we ran a two-group pre-test/post-test experimental design using ANCOVA (Analysis of Covariance).

This involved the selection of two groups: one group who participate in the Challenge Day and another with members from the same school who do not participate (control group). A pre-test is given to both groups. The participants are involved with the programme, while the control group is not. Both groups are then given a post-test and the results are compared. It is assumed that those learners that take part in the Challenge Day are likely to reflect an audience within the school that are already more engaged and interested in STEM or demonstrate a higher aptitude.

ANCOVA is a statistical technique that allows to account for these difference between the participant group and the control group, and it ensures that any post-differences truly results from participation in the Challenge Day and are not related to random pre-test differences between the groups. In other words, ANCOVA allows to control, to some extent, for the fact that participants will be likely to already have a positive attitude toward STEM, while non-participants may not be as interested in the first place.

ANCOVA looks for differences in adjusted means, i.e. adjusted for the covariate that could be confounding the results. It seeks to account for some of the unexplained variance with the covariate(s). Thus, it increases the power of the ANCOVA by explaining more variability in the model. However, the more covariates are entered into the ANCOVA, the fewer degrees of freedom the model has. So, even though the model would explain more variance, including a weak covariate would decrease the statistical power of the analysis instead of increasing it.

Impact on the following potential outcomes was measured via the survey:

- Attitudes to Maths
- Attitudes to Science
- Attitudes to Engineering and Technology
- Attitudes to personal skills

The battery of attitude statements were based on the questionnaires developed by Guzey *et al.* (2014) and Tyler-Wood *et al.* (2010).¹

Please note that throughout the quantitative sections of this report, “impact” refers to the differences in outcomes between IET Faraday Challenge Day participants and non-participants, after controlling for any pre-existing differences that may exist at baseline measures.

In addition, respondents were asked questions around:

- Participation in other STEM activities
- How far they went in the tournament
- Enjoyment overall and satisfaction and with key aspects of the Challenge Day
- Best and worst aspects of it
- Likelihood to recommend IET Faraday Challenge Days
- Likelihood to participate again
- Suggestions for improvement
- Changes to their feelings of positivity around engineering

Sample size

Due to the two phase experimental research design and sample type, risks of drop-out or non-completion were high, therefore Shift Learning sought to over-recruit in order to ensure that our results would be robust. Using the similar US study for the *FIRST*® LEGO® League, we calculated the number of schools and participants that we were likely to require using the maximum projected sample requirements based on estimated difference in means of 0.4 and estimated standard deviation of 0.7. We found that the minimum required sample size for this study would be 54 students, assuming similar differences as observed in the US study. Please note that this minimum sample size is merely a guide and requirements may differ according to actual differences observed in this study.

Estimated difference in means	Estimated SD	# Participants	# Control group	Total
0.4	0.4	27	27	54
	0.5	42	42	84
	0.6	60	60	120
	0.7	81	81	162

¹ Guzey, S.S., Harwell, M., & Moore, T. (2014). Development of an instrument to assess attitudes towards science, technology, engineering and mathematics (STEM). *School Science and Mathematics*, 114(6), 271-279.

Tyler-Wood, T., Knezek, G., & Christensen, R. (2010). Instruments for Assessing Interest in STEM content and careers. *Journal of Technology and Teacher Education*, 18(2), 341-363.

To counter risks, we aimed to recruit a sample of 162 students. However, due to successful recruitment we completed the study with a sample size of 336 students. Following data cleaning (e.g. removal of students who had not sufficiently completed their surveys in both stages), our final sample included 113 Challenge Day participants and 93 non-competing comparison students, a total of 206 students.

An additional 51 Challenge Day participants were included in some parts of the analysis for the second stage, covering experiences and satisfaction with the Challenge Day. However, they were excluded from the main impact analysis due to incomplete data.

Profile of respondents

Schools

16 schools took part in the research, with a total of 32 teams. 2 schools dropped out before administering their second stage surveys therefore their student data was excluded from analysis, however insight from their teacher interviews is still reported on where relevant. In the first stage, a total of 414 students took part in the research, including 212 Challenge Day participants, and 202 comparison group students. In the second stage, a total of 336 students took part, including 179 Challenge Day participants and 157 comparison group members².

A further breakdown of schools involved in the research is shown below:

Variable	Breakdown
School type	A mixture of academies (10), state comprehensives (3), private (3) in the sample.
Region	Schools were located in London (3), South-East England (3), South-West England (1), Northern Ireland (1), Wales (1), East Midlands (1), West Midlands (1), North-East England (2) and North-West England (2).
Ofsted rating	OFSTED ratings (excluding private and schools outside England), ranged between Outstanding (5), Good (6) and Requires Improvement (2).

² Our final sample included 113 Challenge Day participants and 93 non-competing comparison students, a total of 206 students, following data cleaning.

% Pupil premium	Of those applicable, 1 school was below the national average. 1 school was at national average and 6 schools were above the national average % of pupil premium students.
Entrant type	There was a roughly equal split of schools who were taking part in Challenge Days for the first time (7) and those who had taken part in previous years (9).

Teachers

16 teachers were interviewed before and after their Challenge Day as part of the study (an additional 2 first stage interviews were conducted with teachers in schools that later dropped out of the study). These interviews were 20 minutes long, discussing their preparation for, expectations of, and subsequent experiences and perceived impact of the Challenge Day.

A further breakdown of the profile of teachers is shown below:

Variable	Breakdown
Job role	Teachers held the following roles: Science teacher (5), Physics teacher (1), Chemistry teacher (1), STEM coordinator (4), Computer Science teacher (2), Computing teacher (1), Maths teacher (1) and High achievers coordinator (1).
Gender	Female (12) and Male (4)
Number of times led a team in a Challenge Day previously	Teachers had previously led a team: zero times (9 teachers), 1 time (5 teachers), 2 times (1 teacher), 3 times (1 teacher)
Background in STEM	Although many respondents were holding STEM coordinator roles in their schools, most teachers reported not having a formal background in STEM. Most had degrees in science fields with 1 respondent reporting a background in languages before becoming STEM coordinator for the school.

Students

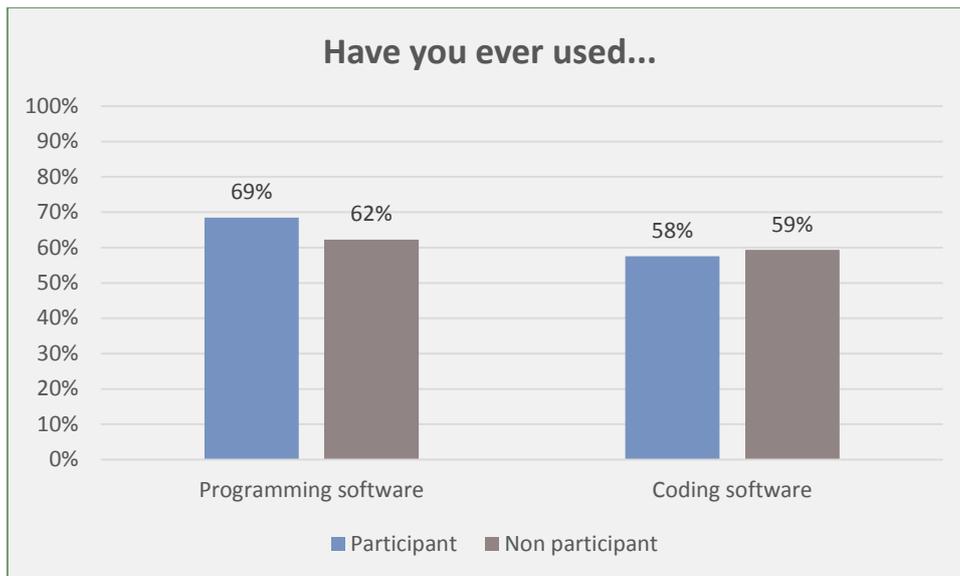
After data cleaning, 206 students from 16 schools were included in the analysis. Only those respondents who had completed both the first and second stage and therefore could be tracked were included, resulting in 113 Challenge Day team members (participants) and 93 non-participants (control group).

Variable	Breakdown
Student gender	Most of the students who participated in the Challenge Day were female (54% vs. 46% male). A similar proportion of students were female in the control group (53% vs. 47% male).
Age range of teams	The majority of participants were 12 years old (64%), followed by 13 year olds (35%) and 11 year olds (2%).
Parents job role	Of those who participated in the Challenge Day, the small majority of students mentioned that none of their parents or primary carers held a STEM related job role (51%), similar to non-participants (57% reporting non-STEM related jobs). 36% of participants reported one parent or carer holding a STEM related job (compared to 35% of non-participants), while only 7% of participants and 4% of non-participants reported both parents/carers holding STEM-related jobs.
Participation in other STEM activities	Most participants and non-participants were not involved in any STEM club (90% and 98%, respectively) or coding club (97% and 100%, respectively) prior to the Challenge Day.

Students' experience with programming and coding

Within interviews, the majority of teachers cited that students in their Challenge Day teams had some prior experience of programming or coding equipment. This usually came in the form of use of Scratch and/or Micro:bit within ICT lessons. 1 respondent also reported students having used Raspberry Pi, while another cited use of Python. Students' competency levels with these programmes was said to vary, with some highly skilled and others at beginner level, however student's confidence with using these programmes was consistently cited as strong. 5 teachers, however, reported that their students had little to no experience using any programming or coding software.

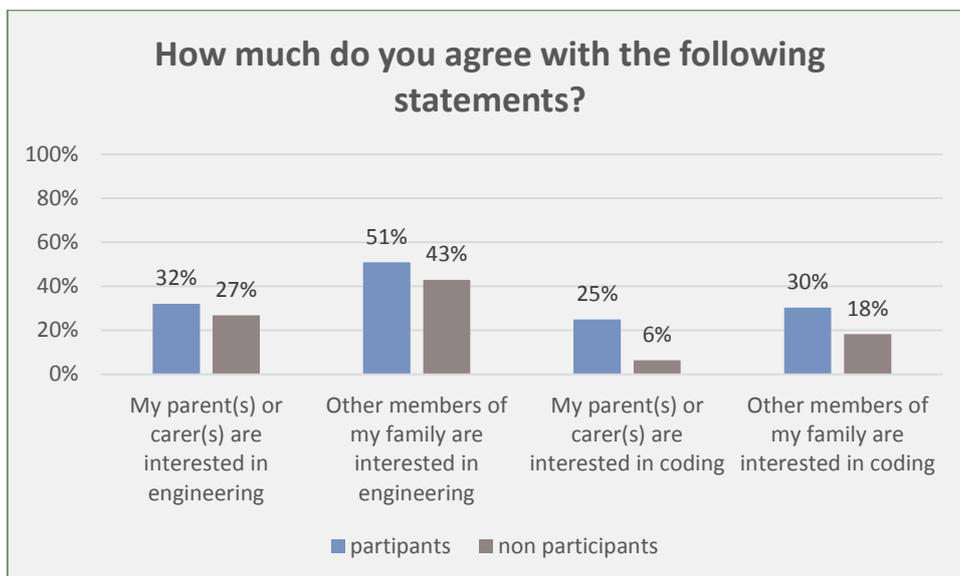
Student participants reported very similar cases of having used programming and/or coding software previously compared to non-participants.



Stage 1 survey, Base n = from 197 to 198

Familial interest in engineering and coding

Far fewer non-participants reported that their parent(s)/carer(s) were interested in coding than participants (6% compared to 25%). In general, however, there was relatively low familial interest in coding of both participants and non-participants reported.



Stage 1 survey, % strongly agree and agree, Base n = 205

Extra-curricular STEM activity

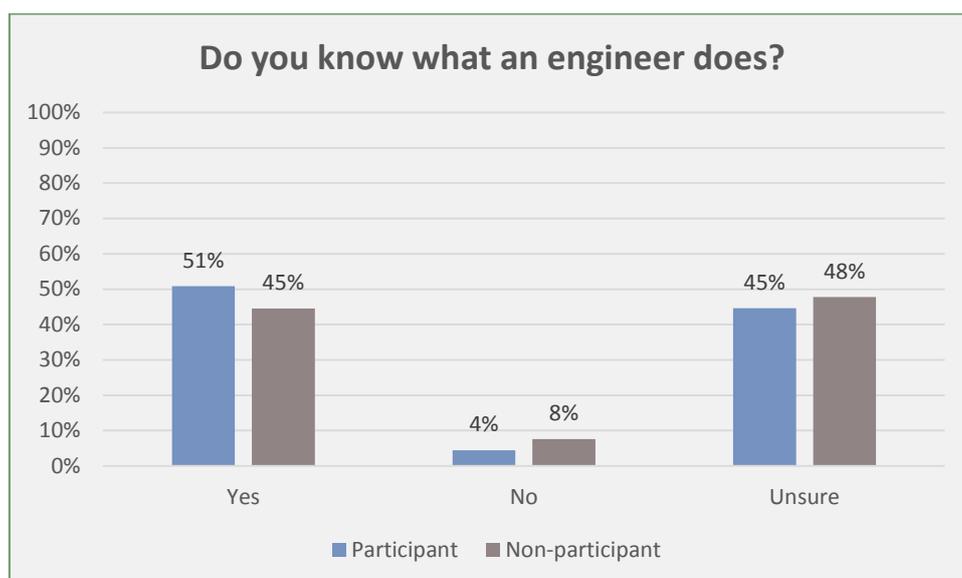
Challenge Day participants were somewhat more likely than non-participants to watch TV shows or listen to radio shows with a STEM focus. Top shows included 'Absolute Genius' (watched by 32% of participants and only 8% of non-participants) and 'Dengineers' (watched by 35% of participants and 12% of non-participants). Non-participants were more likely to report not watching or listening to any STEM related programmes than participants (26% compared to 12%).

Participants were also somewhat more likely to play STEM related games or apps than non-participants, with 'Minecraft' the most frequently played (70% of participants compared to 44% of non-participants).

Challenge Day participants were much more likely than non-participants to have visited science museums or other STEM exhibitions at the weekends or during holidays (51% compared to 31%), with 55% of non-participants citing that they had not visited such an exhibition in the last year. This ties in with the idea that those taking part in Challenge Days are more widely engaged with science/STEM.

Understanding of engineering

51% of Challenge Day participants reported that they knew what an engineer does, compared to 45% of non-participants. Those who provided a definition were likely to cite "building, fixing and designing" in relation to cars, machinery, infrastructure and products. Use of coding, programming and science were highlighted by some students. A number of specific job roles were also mentioned, such as biological, mechanical and civil engineers. These definitions suggest a somewhat narrow understanding of engineering roles and the variety of careers available. Just under half of both participants and non-participants were also unsure of what an engineer does at all.



Stage 1 survey, Base n = 204

Findings

Season preparation

Student drivers to participate

Teachers suggested that team members' initial thoughts on the Challenge Day were of a general sense of excitement. Students were said to be very enthusiastic, excited to do something different from their day-to-day timetable and to apply classroom knowledge in a real-world environment. Most teachers felt it was likely to be high achievers and those most interested in science who were most enthusiastic and keen to take part in the Challenge Day. Amongst the wider school, it was reported that whilst there was a degree of excitement, those less keen on science/STEM were less likely to be engaged with the Challenge Days.

Some teachers felt that the competitive nature of the day was a draw for students and helped to engage them, while others felt their students sometimes felt apprehensive because of this, particularly at the prospect of different schools attending. Many of those taking part for the first time this year reported that students were unsure of what to expect from the day, which led to this apprehension to take part – with a sense that they may not be 'good enough' to take part.

There will be a mix about how they perceive it, where some are excited and others are more apprehensive, in the fact that they might be nervous...They might be nervous about not working with friends and working with new people.

High achievers coordinator

They're quite competitive and they're worried about looking like they don't know something or they won't know what to do. In the wider student body, they think it's for clever people and some are jealous as they would have liked to have taken part.

Science teacher

Producing videos or other materials detailing past student participants' experiences, or encouraging repeat entry schools to get previous contestants to share tips with new teams may help to ease apprehension and foster excitement.

One teacher, whose school had taken part in a Challenge Day previously, mentioned that past contestants had really enjoyed the freedom within the Challenge Day to think creatively; new students were excited for this opportunity.

Team selection

Students were selected to take part in the Challenge Day in a variety of ways. Largely this was through:

- Department recommendations
- Student application process
- Specific invite from teachers

Almost all teachers expressed that they would seek recommendations as to which students were deemed most suitable to take part in a Challenge Day from subject teachers or department heads. 'Suitable' criteria included students who were demonstrably engaged with STEM. These recommendations were primarily sought from Maths, Technology and Science departments. Teachers would then personally invite these students to take part, along with other personally identified individuals that they saw as appropriate to take part.

Approximately half of the teachers expressed that they would explicitly seek recommendations from teachers of higher ability groups, as opposed to lower sets.

I approached the heads of department, to give me names of people who were academically strong in their subject and who they thought would be suited to take part in a team challenge.

STEM coordinator

The remaining teachers stated that they did not prioritise higher ability students in their selection process, with the most important characteristics being enthusiasm and creativity. Many of these teachers expressed that they would actively look to invite those that are perhaps academically able but not currently achieving or engaging in class in order to offer a new and varied learning environment for them.

I didn't choose high academic performers exclusively, I chose people who I thought were quite charismatic and creative, and I did choose some of the more quiet members as well to bring them out of their shell. I have a real cross section... People who are a bit creative, have a good personality...people who are innovative, or have initiative.

Physics teacher

2 students were nominated by their department as they were seen to be really enjoying the subject or being really able, but not engaging in the subject.

High achievers coordinator

One teacher reported selecting students from the STEM club, rather than opening participation to the wider student population. This was primarily due to these students already having a keen interest in STEM and therefore being highly likely to engage and enjoy the day.

A handful of teachers offered an open invitation to students to apply to take part if interested in the Challenge Day. This was often delivered via an assembly to the year group, or through lessons (typically in Technology, Sciences or Maths lessons only). Students would then fill in an application form, with a few teachers also asking students to write a piece stating why they would like to take part and what value they could bring to the team.

I asked them to tell me in 50 words, if they could invent anything, what would they invent and I chose the best ones. It was a choice whether they would like to apply and everyone who applied got it.

Science teacher

Once all applications and/or nominations had been received, depending on the level of interest, either all children would get a place on the team, or the teacher would narrow down the selection based on who they felt would make the most of the day. A few mentioned that they would aim to do this randomly, while most others suggested that they would look to curate their team, looking for a mix of student types to be included.

Those selecting individuals themselves looked to include a range of high and low achievers, those that are more outgoing and those that tend to be more reserved in class, a mixture of boys and girls, as well as those they felt would work well in a small team situation. Teachers would often prioritise those with higher enthusiasm and/or those who have demonstrated greater commitment through wider school behaviour in this team selection.

A reserve list was also in place for almost all schools, where interest was high enough, in case of dropouts or illness on the day.

Schools and teachers' drivers to participate

As previously explored within the profile of respondents, a number of teachers held a background in STEM and were the STEM coordinator for their school. As such, they held a key interest in

promoting STEM activities within their school, which sparked their initial interest in the Challenge Day.

Key drivers for schools taking part included:

- Reports from other teachers who had taken part in previous years and seen a positive impact on student engagement.
- A drive to promote STEM activity within their school, with a Challenge Day seen as a great way of facilitating this.
- The activity was seen to offer an engaging, practical experience for students, which was different to day-to-day learning/curriculum.
- It was considered to expose students to careers in engineering, something often felt to be lacking in the current curriculum.

It gets people to think about careers in Engineering, which is not looked at much by my students.

It helps to increase a love of Engineering in the school.

Maths teacher

I look for any opportunities to promote science and give kids a chance to take part in these sorts of challenges. Kids are not often strong at working together. It's a great opportunity to do something that they get to do at school, cooperate and use their brain cells a bit more.

Science teacher

Teachers had first heard about Challenge Days through:

- Colleagues / word of mouth
- Email, the majority of which stated these had come direct from the IET
- General internet searches
- Previous Challenge Days that the school had taken part in
- From speaking with the IET at a science fair

Teachers often expressed that they were keen to promote STEM in their school wherever possible. The fact that Challenge Days are free to run and attend made them a particularly appealing option for teachers and schools.

I wanted more promotion of STEM stuff as the school doesn't do anything at the moment. I also want people to be excited about maths and I thought this would help with that. The school were completely supportive and as it was free, and I was going to run it.

Maths teacher

Expectations of participation

Teachers very much saw IET Faraday Challenge Days as a student-led experience, and expected their role to be supervisory rather than being hands-on on the day. Teachers expected to be managing any behaviour issues, encouraging students and prompting/questioning to help them develop their own ideas, rather than providing answers.

Some teachers who were new to IET Faraday Challenge Days were unsure as to how involved they were allowed to be, but had assumed they would take this more supervisory role. There was a general sense that in order for students to get the most out of the day, it should be very much student-led.

If you have a problem, try to figure it out yourself. If you can't figure it out yourself and your friends around you can't figure it out then you come to me for help. I'll be more of a facilitator than holding a child's hand and going through it together, they don't learn that way.

Computing teacher

Confidence of students prior to the Challenge Day varied, primarily due to certain student characteristics and whether the school had taken part previously. Teachers felt that higher achieving students were more likely to feel confident going into the Challenge Day than lower achievers, as they were more secure in their abilities.

Whether the school has taken part in a Challenge Day before also appeared to have a larger impact on the confidence of students. Schools that had taken part previously reported higher levels of team member confidence and excitement for the activity as they had heard about previous entrants' enjoyment. Those from schools who had not participated before, however, reported lower confidence/more hesitation over the Challenge Day, as students weren't sure what to expect.

Some teachers liked the fact that there was not much information on what the event would entail and purposefully wouldn't tell their students much detail, beyond it being an engineering based activity day that involved solving real-world problems. They often felt that this helped to maintain student excitement over the event. Others felt the lack of detailed information made their students more anxious as they weren't sure what to expect.

They are a little apprehensive as they don't know what they will be doing. They are pleased to be selected, but they have no expectations apart from the fact that it will be an enjoyable day. I got a pack which I haven't read yet, but the less info the better.

Physics teacher

Some felt students would also feel anxious as they would be competing against other schools. This was heightened if they had to attend a host school for the day as they were also in an unfamiliar environment. However, some teachers reported that some team members really enjoyed the competitive element.

Some are quite anxious as they're competing against other schools and want to do well and are also quite anxious as they don't know much about the challenge. They've got no idea whatsoever.

Science teacher

There were a number of expected benefits that teachers saw in taking part in IET Faraday Challenge Days. These were often those that first sparked their interest in participating, including:

- Instilling an enthusiasm and love for STEM subjects
- Helping students to see the relevance of classroom learning in real-life situations
- Exposing them to career paths in STEM subjects and allowing students to consider other career paths that they may not have considered previously
- Potentially influencing their later GCSE choices
- Developing soft skills in communication, team working, negotiation, problem solving, listening, planning and presentation skills
- Developing self-confidence in their skills/ability

For them personally, obviously it's a chance to improve their communication skills and their problem solving, become more aware of the practical side of STEM. We do bang on a lot about STEM and the subjects but that's a bit dry for a pupil, so to actually get them to do and solve a problem, I would like to think they'll get a lot out of doing that and learn a lot. And then I'd like them to come back and talk about their experiences to the rest of the class.

STEM coordinator

Preparation

As initially anticipated in stage 1 of the research, the majority of teachers did not undertake any formal preparation for the Challenge Day. As the event is set up as a challenge, they expected to be largely in the dark about the content in the lead up to the day and many recalled being told by IET reps that they should not tell students much information in order to maintain the challenge element.

Some teachers mentioned that they looked online for past examples of Challenge Days for clues of what the day might involve, browsing the IET website in particular. Some also centred classroom teaching in the run-up to the Challenge Day on problem solving and introducing their own challenges into lessons to bring in these relevant skills. A handful of respondents who had taken part previously also mentioned running sessions with students to get them acquainted with the Micro:bit. However, most teachers felt that the less preparation was given to students, the better, in order for them to think more creatively on the day.

The students had a go using the Micro:bit in two of their lunchtimes. That was about it because I didn't know what to expect. That was about a week before. This was our first time doing it, but I was aware that the Micro:bit was going to be used.

Science teacher

It's better to go in with a blank open mind. Last year they were prepared on the BBC Micro:bit and the previous leader may have prepped them. I feel that the less that they prepare, the more ideas they have on the day.

Physics teacher

The bulk of teacher preparation instead focussed on logistics – seeking guidance on how the room should be set up and how to invite other schools, if hosting. Respondents were very happy with the guidance given from IET in this respect.

Anticipated problems

Anticipated challenges included:

- Student engagement
- Level of difficulty of the Challenge Day
- Logistics of hosting
- General uncertainty over what the day entailed

Teachers spoke of issues around student engagement with their Challenge Day. This primarily stemmed from first time entrants who reported that not knowing a great deal about what the day entailed meant they couldn't give much information to help get students excited about participating. Some teachers mentioned that, although they were happy not to know the details of the challenge, they would like to receive some communications from IET with examples of past challenges to help pique student interest. Videos and photos of students taking part in a Challenge Day were thought to be a great way of engaging students.

I think it would have been nice to have a video beforehand, maybe of yachts sailing, just a taster to get their enthusiasm going. Not telling them what the challenge was, but a bit about 'what is engineering' and what the challenge day is about. They did do that at the beginning of the day, but it would have been nice for me to do that beforehand to make them think 'wow we really want to do this, this is something really special'.

Science teacher

A few teachers from schools that had not taken part previously also worried about the level of difficulty of the Challenge Day. They worried that lower ability students may struggle and would have liked more information to help them in their team selection and to gauge what classroom preparation may be needed – particularly around the level of coding knowledge necessary. This uncertainty was also a concern for students, with the lack of knowledge on the required level causing some to feel less confident going into the Challenge Day.

Only to say that if we were using the Micro:bit, what sort of programming knowledge that they needed to have. I think they were a little bit out of their depth. They could have done with some skills before they did the challenge so they could have been more creative when knowing what the devices were capable of and so on.

Computer Science teacher

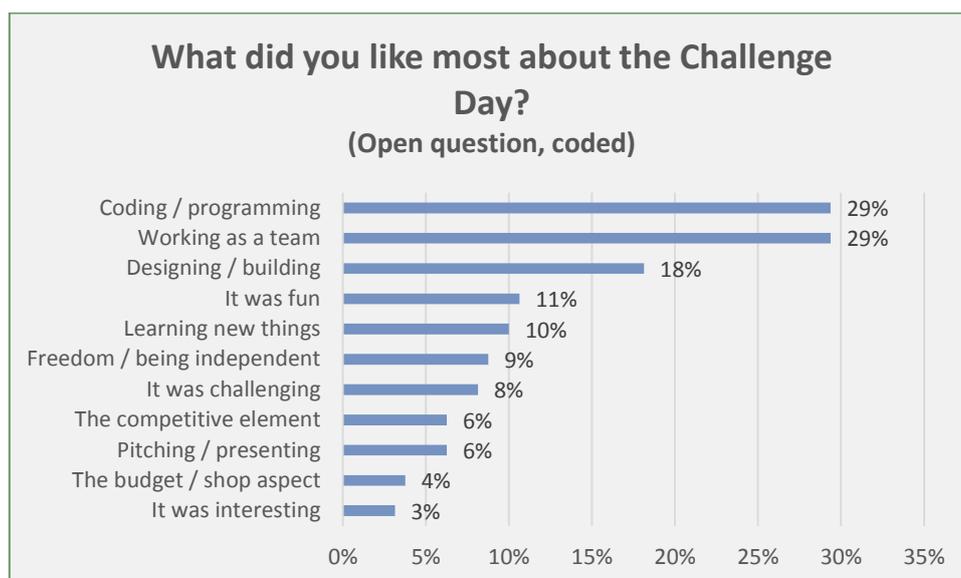
Logistical issues often centred on internal school problems of room bookings and technology provision. Although a hassle for teachers, this was not a great concern, and they didn't expect any additional support from IET in this regard. For schools that were hosting a Challenge Day, logistical issues were anticipated and experienced, such as confirming schools to take part and managing drop-outs. It was felt that IET could perhaps provide more support to host schools here, for example with school recruitment.

For schools that had taken part in IET Faraday Challenge Days in previous years, there were very few challenges that teachers anticipated, as they were familiar with what the day demands. These schools' problems centred more on internal logistics (e.g. room bookings) and these schools were happy with the level of support and information offered by IET.

Student experiences of IET Faraday Challenge Days

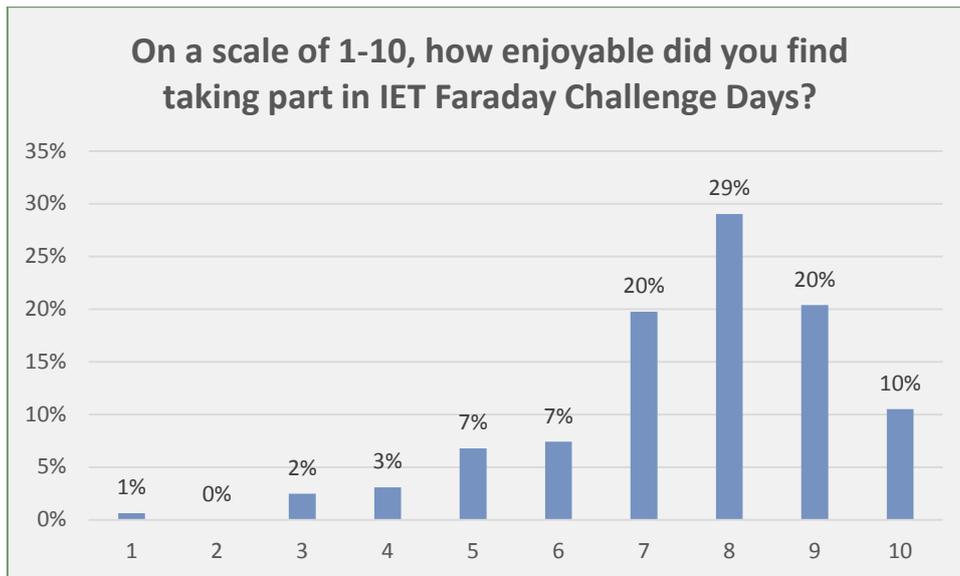
Enjoyment overall and satisfaction and with key aspects of IET Faraday Challenge Days

We asked participating students to describe what they liked most about their Challenge Day. Nearly a third of students indicated that the opportunity to code and program was the best part of the day, whilst the same proportion cited working in a team as the most enjoyable aspect. Other positive areas for students included designing and building (cited by 18%), the opportunity to learn new things (10%), creative freedom and independence (10%) and taking part in a challenging activity (8%).



Stage 2 survey, Challenge Day participants, Base n = 160

We then asked students to rate how enjoyable they found participating in their Challenge Day. 80% of participants scored this 7-10 out of 10, with 10% rating this the maximum score of 10 out of 10. Only 6% rated their enjoyment less than 5 out of 10. This suggests high levels of enjoyment amongst students.

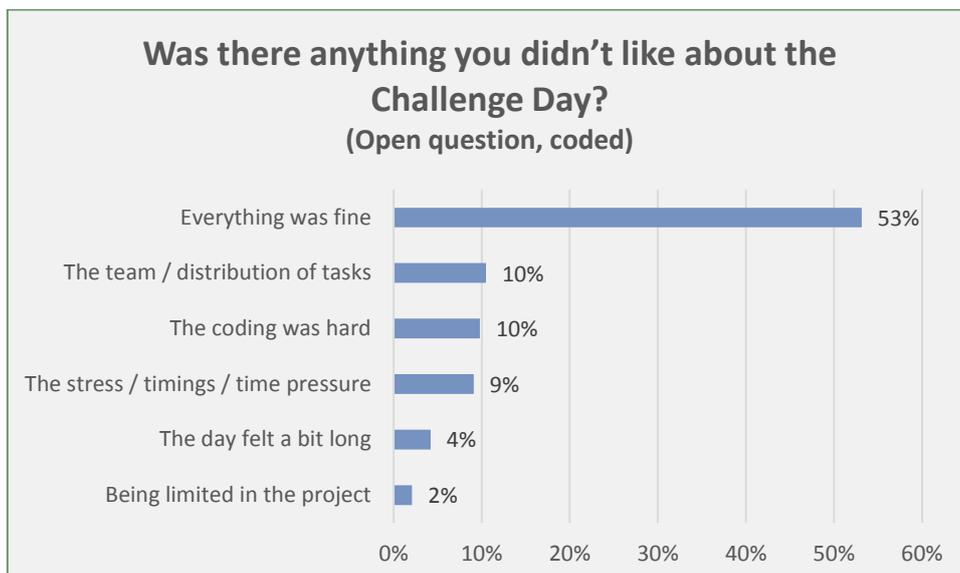


*Stage 2 survey, Challenge Day participants, Base n = 162
10 point scale: 1= Not at all enjoyable, 10= Extremely enjoyable*

Suggestions for improvements

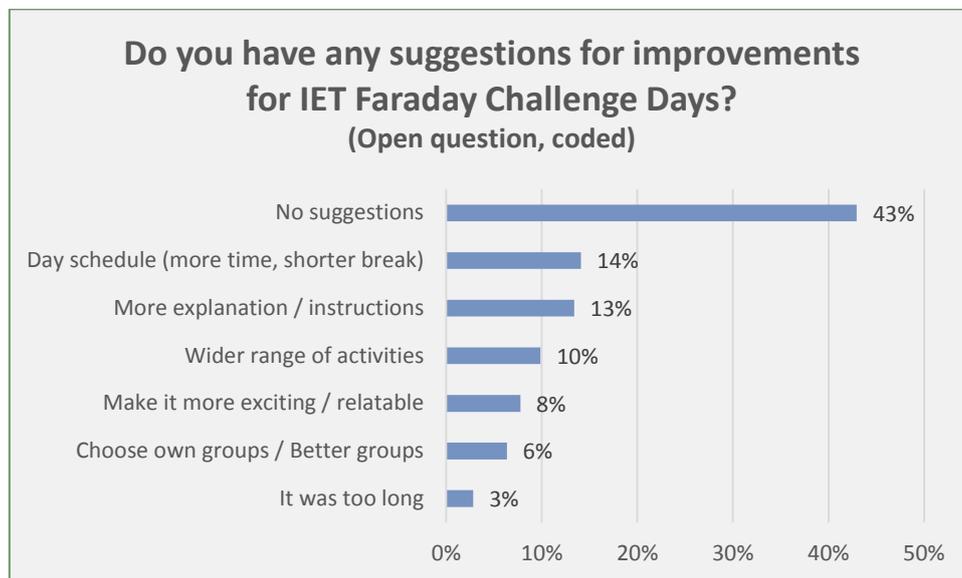
In order to explore areas of dissatisfaction, we asked students to describe anything they did not like about the Challenge Day. Significantly, over half of students reported that there was nothing they disliked about the day. Students who were able to identify aspects they were less keen on were most likely to mention teamwork issues (10%) and coding difficulties (10%).

It is worth noting that some teachers reported no or little experience with coding and programming amongst students prior to their participation, therefore it is unsurprising some students found this hard. Similarly, teamwork clashes were anticipated by teachers as students were still developing these skills, and were likely to be working in unfamiliar groups.



We asked students to suggest any areas for improvements. Again, a high proportion of students had no suggestions (43%), indicating high levels of satisfaction. The most commonly cited suggestions for improvements related to the schedule of the day (14%). Some students desired more available time on tasks to ensure they could complete these, whereas others suggested shorter breaks. However, 3% of students felt the day was too long which suggests only a small level of disengagement.

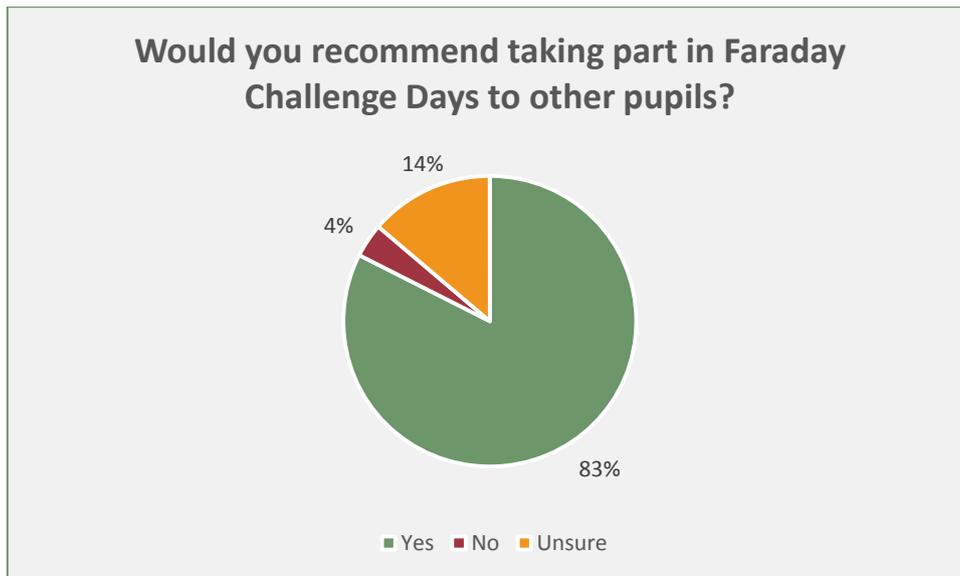
Additional explanations and instructions were also desired by some (13%). These students felt they needed more support, for example with coding or additional context to the tasks. 8% of students wanted tasks to be more exciting or relatable to them, suggesting some were less keen on the boating theme.



Stage 2 survey, Challenge Day participants, Base n = 142

Likelihood to recommend IET Faraday Challenge Days

83% of students who took part in IET Faraday Challenge Days reported that they would recommend it to other students suggesting high levels of enjoyment and satisfaction.



Stage 2 survey, Challenge Day participants, Base n = 160

Perceptions of the Challenge Day

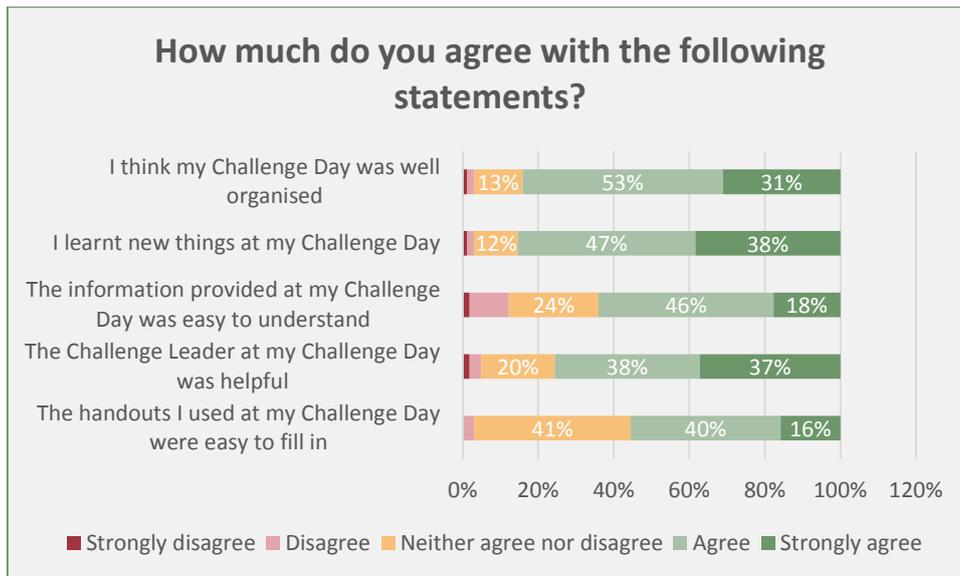
85% of students either agreed or strongly agreed that they learnt new things at their Challenge Day suggesting participation has had a positive impact on their skill and knowledge development.

84% of students agreed or strongly agreed that their Challenge Day was well organised, indicating high levels of satisfaction in the organisation of the day.

76% agreed or strongly agreed that their team leader was helpful, suggesting the majority of students were well supported on the day.

Whilst 64% of students agreed or strongly agreed that the information provided at their Challenge Day was easy to understand, 10% of students disagreed suggesting this may be an area which could be improved to ensure students feel adequately supported.

55% agreed or strongly agreed that the handouts they used at their Challenge Day were easy to fill out, whilst 41% neither agreed nor disagreed. This high proportion may suggest some students did not use the handouts.



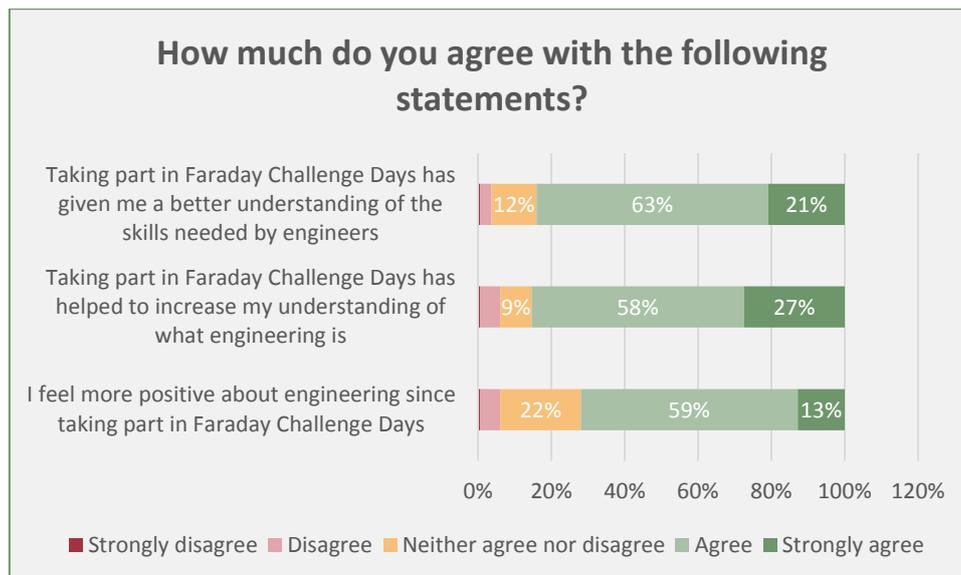
Stage 2 survey, Challenge Day participants, Base n = 163-164

Students' perceived impact of participation

When looking at students' perceived impact of participation in IET Faraday Challenge Days, 85% either agreed or strongly agreed that participation has helped to increase their understanding of what engineering is. This suggests that participation has impacted their understanding of the vocational application of STEM and expanded their awareness of engineering roles.

Similarly, 84% of students agreed or strongly agreed that their participation has given them a better understanding of the skills needed by engineers, suggesting students have increased their understanding and awareness of STEM careers.

72% of students indicated that they felt more positive about Engineering since taking part in IET Faraday Challenge Days which suggests that participation has a positive impact on young people's attitudes. As noted by several teachers, this is likely to have positive knock-on effects in regards to students' likelihood to pursue STEM subjects at GCSE onward and to participate in other STEM activities.



Stage 2 survey, Challenge Day participants, Base n = 163-164

Teacher perceptions of the impact of IET Faraday Challenge Days

Growing interest for STEM subjects and programming

Most teachers observed an increased interest for STEM subjects and a higher engagement in learning following their students' participation in IET Faraday Challenge Days. Others noticed an increased interest in using programming equipment:

Yes they are more interested [in programming], they have been coming at lunchtime to see if they can borrow a Micro:bit to take home. There is certainly an interest.

Computer Science teacher

[I've noticed] marginal changes, such as asking more questions and seeming more interested in science, but I thought that was nice even though marginal.

Science teacher

One teacher went as far as talking about a "buzz about science" in their classroom, echoing another teacher who reported major changes for some of their lower ability students who significantly benefited from participation in the day in regards to their engagement:

Definitely with the lower ability people in particular it has a positive impact. Their behaviour is better, they've been getting on better with the [coding] designs, they're more engaged with the work, there's a better response with ideas and they've been improving their work.

Maths teacher

Another teacher reported that the event had had a role in some girls gaining confidence to participate in other STEM extra-curricular activities:

A few girls go to the Robotics Club now, I think that [participation in IET Faraday Challenge Days] has played a part in why.

Science teacher

Increased awareness of STEM related careers

A number of teachers reported an increased awareness and interest in STEM career options from students, which suggests yet another positive and longer term impact of IET Faraday Challenge Days on attitudes towards STEM. This was linked to the real-world focus of tasks on the day which highlighted the vocational application of STEM, as well as the opportunity to meet an expert STEM team leader.

They are more aware of what STEM is and more aware of the sector and its industry. I think the majority of those who took part are more aware of this.

STEM coordinator

I think they've increased in confidence and their likelihood to chat about science careers with me.

Science teacher

On the day it peaked their interests [in a STEM career]...there was even a girl who said she might look at it in the future.

High achievers coordinator

I think possibly yes [it increased their interest in a STEM career] just in terms of when you talk to them about what they want to do, they're thinking about science and they're thinking about options for year 9. Lots who took part have been vocal about taking double or triple science for GCSE and they talk about STEM careers.

Science teacher

Confidence boost

Along with more interest for STEM subjects and careers, another key positive impact of participation that teachers highlighted was the increased confidence levels they'd seen in their students. A vast majority of teachers said that the event had significantly helped students become more self-assured, both with their own abilities and in relation with working with other people. This was particularly noted for some of the lower ability students who participated.

Some have come out of their shell a bit more. We had a celebration ceremony for all those involved and awarded the trophy to the winning team. I think they have a stronger confidence in their own abilities, for the students that did take part.

High achievers coordinator

One student in particular seems to really have grown in confidence and enthusiasm. He was one of the lower ability but I think the fact that he was very much involved in the day, I'm sure that gave him confidence... I think things like that will last.

STEM coordinator

One student in particular was complimented for his coding skills, and he wasn't necessarily a more able student so I think that built his confidence.

High achievers coordinator

Soft skills

Many respondents reported that taking part in the Challenge Day had been beneficial for their students in regards to the development of new skills, both personal and practical.

Teamwork: Working in collaboration with other students and team building were commonly cited as essential skills which students had developed and were still displaying following their

participation in a Challenge Day. One respondent in particular explained this change as a result of improved communication stemming from being part of a team:

Their whole behaviour has improved and communication is a key part of that.

Maths teacher

Furthermore, confidence with team working went hand-in-hand with some students developing new friendships, as one respondent reported:

Doing a project like that for a day in a team, they had to work with unfamiliar people so new friendships were developed.

STEM coordinator

Autonomy and problem-solving: Many teachers believed that taking part in the Challenge Day helped their students become more independent in their work as well as more able to seek out solutions by themselves rather than expecting to get straightforward answers when encountering a problem.

I also believe the students became more independent and more able to deal with situations.

Computer Science teacher

Organisation skills: Some of the tasks students took part in on the day were thought to promote and develop organisational skills, as students were encouraged to take on managerial roles:

I think on the day, students who took on the role of project manager developed organisational skills. I think they all learnt something from it that they could use if they were to do a similar task again.

Computer Science teacher

Technical skills

Along with softer and personal skills, many teachers supported the view that their students had developed and improved practical and technical skills such as programming and coding.

Programming and coding: Teachers reported significant improvements in skills including design and technology, as well as advanced programming and coding as a result of participating in a Challenge Day. Some students had no experience in coding or programming before and were now showing an increased ability and confidence in both these areas.

All the students who took part are more confident in IT and Computing, and their Computing teachers mentioned that.

Science teacher

[Students who took part in a Challenge Day] are currently working on programming in Python and some of the students have been showing me more advanced projects than I would expect from their cohort.

Computer Science teacher

They've become more confident with programming and they've learnt more about the design process as well.

Physics teacher

Long term effects

Due to the short nature of the event, the majority of respondents were mostly hesitant to talk about *long term* effects in their students' skills, abilities and attitudes. They generally found it hard to firmly assert that participation in IET Faraday Challenge Days had led to durable and deep-rooted changes in their students. This was due to the brevity of the event but also due to the fact that some teachers hadn't seen their Challenge Day students since then.

Hard to say, one off-events don't always impact learning. But for some of them I think it will have a long term effect.

High achievers coordinator

A few teachers did nonetheless talk about anticipated long term changes for some of their students, implying a deeper and stronger impact than previously suggested:

I expect to see long term changes because it has made them realise how school subjects can tie into their futures.

STEM coordinator

"Long term definitely because once you've got confidence in something and start achieving it, it makes you feel like you're good at it and once you feel you're good at it then that's a real boost. Just being selected has made them feel good."

Science teacher

Short term or long term impact, this distinction should in no way lessen the many positive effects teachers noticed their students benefit from. Many of the teachers who were cautious in describing *long term* impacts were still likely to highlight areas of change and improvement which speaks volumes about the numerous ways participation in a Challenge Day positively impacted students.

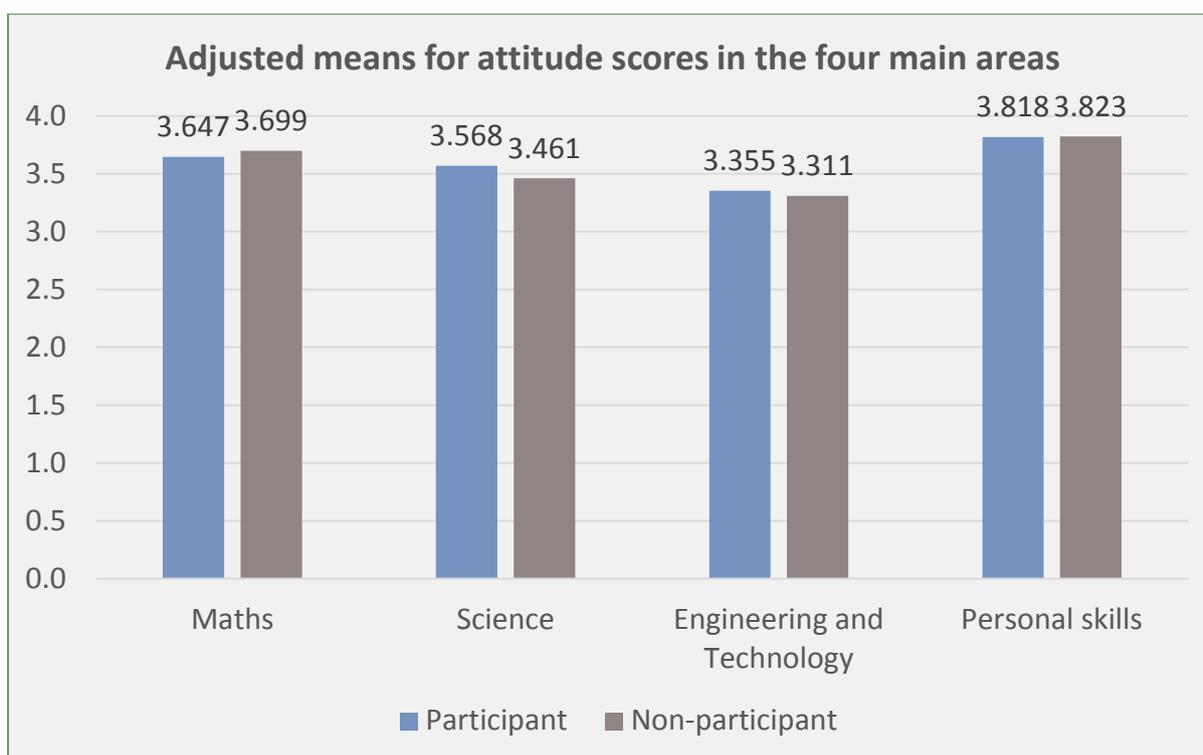
Quantitatively exploring the impact of IET Faraday Challenge Days

The IET was looking to better understand the impact of involvement in a Challenge Day on perceptions and attitudes towards STEM. In order to measure this impact of participation in a Challenge Day, a two-group pre-test/post-test experimental design was administered.

A one-way ANCOVA was conducted to determine a statistically significant difference between IET Faraday Challenge Day participants and non-participants on four sets of statements relating to i) attitudes to Maths, ii) attitudes to Science, iii) attitudes to Engineering and Technology, and iv) attitudes to personal skills, while controlling for any pre-existing differences between Faraday Challenge Days participants and non-participants. For the technical details of the ANCOVA, please refer to Appendix 1.

ANCOVA results

A combined average score for each of the four areas was collated. This score was adjusted in the ANCOVA analysis to account for any pre-existing differences in attitude between the Faraday Challenge Days participants and non-participants, and are shown in the chart below.



Base n = 93 – 113

The ANCOVA analysis revealed that there are no statistically significant differences between IET Faraday Challenge Days participants and non-participants when looking at attitude to Maths, Science, Engineering and Technology, and personal skills. However, participants generally scored higher on attitudes to Science and to Engineering and Technology in comparison to the control group. This suggests that, even though there is no statistically significant difference, IET Faraday Challenge Days may have an impact on attitude towards Engineering and STEM.

The lack of a clear impact might reflect the nature of the event itself. Participating teachers mentioned that it is harder to attribute any changes in attitude to a short one-day event than to longer events, with any impact likely to be less pronounced. In addition, the relatively short time span of the research may mean that it is unable to detect any changes in attitude, as they are likely to emerge over a longer period of time. Nonetheless, teachers reported an increased interest for STEM subjects and a higher engagement in learning following their students' participation, which suggests a positive and longer term impact of IET Faraday Challenge Days on attitudes towards STEM.

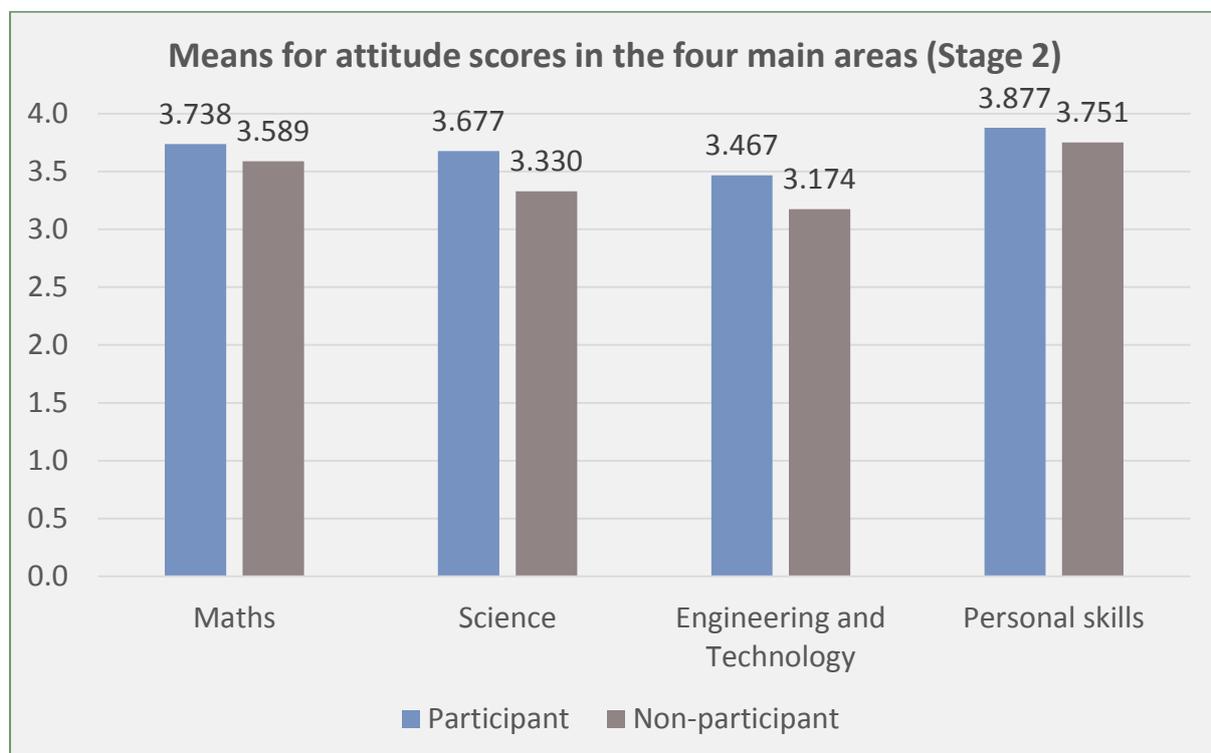
In addition to the timeframe for impact to establish, the statements used to measure the attitude towards Engineering and STEM are relatively generic. The questionnaire tries to extrapolate the impact from any changes observed in the level of agreement of attitudinal statements relating to STEM. This approach accounts for potential respondent bias, i.e. avoiding socially accepted answers, but it may have obscured the outcomes. For instance, students may not link any Mathematics skills to a short one-day event without an obvious Mathematics component to it.

However, when the research asked students about *perceived* impact of participating in IET Faraday Challenge Days, it indicated a strong positive impact. This implies that, in fact, participation in IET Faraday Challenge Days is likely to have a positive impact on students' perception and attitudes towards Engineering.

Moreover, the perceptions and attitudes of the target audience, i.e. children aged between 12 and 13 years old, can be influenced by many other factors, and differ on any given day. For example, the timing of the questionnaire coincided with exam periods, which may have skewed their views more negatively. Likewise, the increasing complexity of the STEM curriculum over the academic year may also result in more negative views, while involvement in IET Faraday Challenge Days may result in participants underestimating the degree to which their skills have improved due to the complexity of the challenges encountered.

Participants score higher on attitude towards STEM than non-participants

Notably, participants seem fairly similar to their wider cohort, with only a small proportion involved in a STEM club or coding³. Following participation in IET Faraday Challenge Days, findings from Stage 2 reveal that participants appear to be ahead of their peers in the four areas, particularly in Science, and Engineering and Technology.



Base n = 93 – 113

³ See profile of respondents

Although there are no statistically significant differences, participants scored higher on several statements than non-participants following Stage 2 as outlined below. This suggests that participation in Faraday Challenge Days may promote a more positive perception of STEM, and of future career options.

Maths

When exploring attitudes to Maths, results reveal that participants were more likely to consider choosing a career that uses Maths (51% participants vs 45% non-participants). Similarly, they were more likely to strongly agree with any statement relating to the fact that they would do well in Maths.

Statements measuring attitude to Maths	Participants	Non-participants	% difference
I am the type of student to do well in Maths	61%	52%	+9%
I would consider choosing a career that uses Maths	51%	45%	+6%
I am good at Maths	68%	65%	+3%
I am sure I could do advanced work in Maths	51%	49%	+2%
I can get good grades in Maths	74%	73%	+1%

Base n = 93 - 160, % of those who agree or strongly agree

Science

When exploring attitudes to Science, results show that participants were significantly more likely to see the value of knowing about Science in helping them earn a living compared to non-participants (70% vs 52%). Additionally, participants were also more likely to see a role for Science in their future career and were more likely to feel they would do well in Science.

Statements measuring attitude to Science	Participants	Non-participants	% difference
Knowing about science will help me earn a living	70%	52%	+18%
Science will be important to me in my life's work	51%	35%	+16%
I am sure I could do advanced work in science	55%	39%	+16%
I am sure of myself when I do science	59%	44%	+15%
I expect to use science when I leave school	61%	46%	+15%
I would consider a career in science	56%	43%	+13%
I know I can do well in science	70%	57%	+13%
I will need science for my future work	50%	39%	+11%
I can handle most subjects well, but I cannot do a good job in science*	67%	66%	+1%

Base n = 93 - 160, % of those who agree or strongly agree

**Reversed scale; percentage of those who disagree or strongly disagree*

Engineering and technology

When exploring attitudes to Engineering and Technology, results show that participants were significantly more likely to be curious about how electronics work than non-participants (62% vs 41%), and to agree that knowing how to use Maths and Science together will allow them to invent useful things. This may relate to the more practical elements of the Challenge Days, which may have provided participants with a better awareness of real-world applications of engineering.

Statements measuring attitude to Engineering and Technology	Participants	Non-participants	% difference
I am curious about how electronics work*	62%	41%	+21%
Knowing how to use maths and science together will allow me to invent useful things*	69%	52%	+17%
I would like to use creativity and innovation in my future work	52%	40%	+12%
If I learn about engineering, then I can improve things that people use every day	65%	53%	+12%
I believe I can be successful in a career in engineering	39%	28%	+11%
I am interested in what makes machines work	56%	45%	+11%
Designing products or structures will be important for my future work	31%	22%	+9%
I am good at building and fixing things	52%	43%	+9%
I like to imagine creating new products	65%	61%	+4%

Base n = 93 - 162, % of those who agree or strongly agree

Personal skills

When exploring attitudes to personal skills, results reveal that participants were more likely to score higher on any of the confidence statements, particularly with regard to working under pressure and adapting to unexpected circumstances. This may reflect the competitive nature of Challenge Days, which exposed students to a challenge while under time pressure. Moreover, this boost in confidence has also been observed by some teachers.

Statements measuring attitude to Personal skills	Participants	Non-participants	% difference
I am confident I can work well under pressure	60%	47%	+13%
I am confident I can make changes when things do not go as planned	78%	66%	+12%
I am confident I can help my peers	81%	71%	+10%
I am confident I can achieve my goals	78%	70%	+8%
I am confident I can work well with new people	70%	62%	+8%
I am confident I can work well in a team	81%	76%	+5%
I am confident I can listen to others' opinions when making decisions	87%	83%	+4%

Base n = 93 - 162, % of those who agree or strongly agree

Changes in attitudes towards STEM

Although we have not been able to identify an impact using the ANCOVA analysis, there is a percentage point increase across a number of statements measuring team members' attitudes to STEM, suggesting a positive change in attitudes amongst these students. This is particularly noticeable for statements relating to a pursuit of a career in STEM.

When exploring attitudes to Science, results reveal that participants were 2% more likely to think that science will be important to them in their life's work following their participation in IET Faraday Challenge Days. They were also more likely to consider a career in Science (1% increase), which suggests their participation in Challenge Days has had a positive influence on their future career choices and attitudes to Science.

Statements measuring attitude to Science	Stage 1	Stage 2	% increase
Science will be important to me in my life's work	48%	50%	2%
I would consider a career in science	54%	55%	1%

Base n = 113, % of those who agree or strongly agree

When exploring attitudes to Engineering and Technology, results show that participants were more likely to believe that they can be successful in a career in engineering, suggesting that their participation in IET Faraday Challenge Days has had a positive influence on their future career choices. Moreover, participants were more likely to like imagining creating new products, potentially relating to encountering the practical elements of their Challenge Day.

Statements measuring attitude to Engineering and Technology	Stage 1	Stage 2	% increase
I believe I can be successful in a career in engineering	35%	37%	2%
I like to imagine creating new products	59%	60%	1%

Base n = 113, % of those who agree or strongly agree

When exploring attitudes to personal skills, there is an increase in participants' confidence to work well with new people. This may reflect competing schools' attending host schools, in addition to students working with unfamiliar peers, encouraging teamwork and collaboration with new people. A confidence boost in this area, and in other areas, has also been observed by teachers, as reported in earlier sections.

Statements measuring attitude to Personal Skills	Stage 1	Stage 2	% increase
I am confident that I can work well with new people	68%	69%	1%

Base n = 113, % of those who agree or strongly agree

Teachers' overall impressions of the Challenge Day

Overall, all teachers expressed high praise for their Challenge Day, with all reporting it was well-prepared, well-resourced, engaging and inspiring for students who took part. The opportunity for some students to use equipment that they hadn't previously had access to, as well as the exposure to coding and real-world application of STEM was emphasised as particularly motivating. It was thought to be a fun and exciting way to encourage engagement with STEM beyond classroom teaching.

I liked the way that the introduction really engaged them and made them realise the importance of it all. It can be hard to do STEM every day in school, and I feel like this really inspired them.

STEM coordinator

I think coding is something that is really relevant to these girls, potentially to their futures. I think it's not something that we do very well in school, at least not in Science. I think it gives them a real-world context to what they are learning. I hope that's something they might now consider in the future.

Chemistry teacher

The variety of hands-on activities was considered to be highly engaging, with several expressing surprise that no students lost interest - something they had experienced with other activities - despite the length of the Challenge Day. The activities were thought to promote a strong level of teamwork and friendly competition which was well facilitated by the team leaders. Students were encouraged to take on different roles, such as project management, presenting or using the Micro:bit, which helped to build confidence.

It was really good, they really enjoyed it and seeing them getting up and involved was great as they are not really a participating year group...But they got really involved and competitive, and they took on different roles than we would normally anticipate and students who are not the most confident were choosing roles where they had to manage others.

Science teacher

We as teachers saw quiet students who don't really like getting up in front of classes, they were up with the team, they were presenting it and really enjoying it.

STEM coordinator

Teacher perceptions of students' enjoyment

Teachers reported that all students enjoyed taking part in their Challenge Day, with many highlighting that their students had expressed keen interest to take part again or in similar STEM activities. Several reported that students who were inexperienced with coding or using the Micro:bit felt challenged by the tasks, but were well supported and able to pick up these skills quickly leading them to gain a strong sense of achievement by the end of their Challenge Day. The opportunity to try something new was particularly exciting for these students, who wouldn't have had access to such resources or competed with different schools otherwise. The sense of freedom and independence was also noted by students, who enjoyed being given creative control of tasks.

They talked about it for a while afterwards and are keen to carry on doing STEM challenges like this in the future. They've carried on meeting up with each other.

Science teacher

It was really positive, they found it challenging but lots of them said they wanted to take part in a future event. So they were overwhelmingly positive about it. We asked for comments from them, and they said they enjoyed the coding, and problem-solving. Generally they wanted to do it again. All of them mentioned doing more things to do with STEM subjects. For some of them it was a brand new thing that they hadn't experienced before.

High achievers coordinator

Structure of the day

The structure of the day was highly praised by all teachers as both organised and engaging. Many reported they were impressed with how smoothly the day ran, which they attributed to the strong organisation of the team leader. All reported that the day was set out in manageable chunks which kept students engaged and on task. The introduction was thought to be clear and helped to ease students into the day, and the time allocated to each element encouraged focus and efficiency. Teachers reported that the day felt fast-paced, such that there was no room for disengagement whilst students were given a level of flexibility to take creative control of the direction of tasks.

[The structure of the day] was spot on, it was manageable chunks and at every stage the pupils knew exactly what was going on and what was happening next...It forced them to be really efficient.

STEM coordinator

I liked the organisation, and the fact that it was an open-ended task so they could have designed anything. They were engaged and it was fast-paced, there was no opportunity for boredom. We got positive feedback from staff who attended.

Science teacher

Team leaders

The success and positive experience of Challenge Days was strongly attributed to the team leaders. Teachers described their team leaders (a mix of male and female) as organised, confident, knowledgeable, approachable and enthusiastic. They were praised for building a strong rapport with students and demonstrating a high level of expertise which ensured students were supported and inspired. Teachers felt that team leaders pitched tasks at an appropriate level and were able to adapt to students who required more intervention. Several also noted the benefits of meeting someone working in a fun and creative STEM job.

He was awesome! His manner with the kids, his knowledge of his subject, the plan of the day...He seemed to know when to and when not to help. He's obviously very experienced, he was just absolutely superb. I give him one hundred out of ten!

Science teacher

Brilliant. Great with the kids. The way he engaged and interacted with the kids...He gets them thinking, it's total engagement.

Computing teacher

The leaders really inspired the pupils. At the beginning the teachers thought that what they were giving to the pupils was really ambitious, and [the team leaders] said that it might look a lot now but they'll get through it. They really motivated the children and the children all over-achieved, they were fabulous!

STEM coordinator

Theme

The majority of teachers liked the theme of this year's Challenge Day, with many indicating it was engaging for students. The boating theme was thought to be realistic and relevant, allowing students to recognise the need, importance and application of STEM in the real-world. It was thought to generate recognition of STEM job opportunities through the provision of a vocational context which several suggested was missing in the everyday curriculum.

Several teachers reported that the theme was broad and unique enough to allow for creative idea generation and for a range of different tasks. It was largely considered to be appropriate for the age group as well as both genders. The introduction to the theme in particular was noted as exciting and inspiring.

I loved the theme, it was brilliant, it was something different. I loved the video that explained what was going on. I thought that was great.

Physics teacher

Nonetheless, there were a few teachers who were less keen on the theme. These teachers felt it was less accessible and less engaging than previous themes as students were likely to be unfamiliar with boating. One teacher thought a lack of knowledge around the theme meant students were somewhat limited in their ability to complete tasks or apply their experience effectively. Provision of information sheets on the theme (e.g. industry facts or job roles) to support the tasks was thought to be beneficial in this regard.

The theme was not as good as the previous year because yachting is not something every child gets into. Last year they had to come up with an idea and market that idea for selling...they had their imagination and could do whatever they wanted. The previous year was more enjoyable than this year. I think it's a lack of knowledge on the topic, it would have been nicer if they could relate to the topic.

Computing teacher

Despite this, other teachers thought the unfamiliarity of the theme was a positive, as it exposed them to new ideas and challenged them further by putting them outside of their comfort zone.

It was something different, in the real-world so didn't just relate to teenagers. It was a more grown-up topic. They had to come up with solutions, it's not something they will do on an everyday basis.

Computer Science teacher

Teachers were asked whether there were any particular topics or themes they would like to see covered in a Challenge Day in the future. Many indicated that themes which were culturally relevant, real-world and also relatable for students were of most interest. Suggestions included:

- Animals e.g. veterinary care
- Space e.g. exploration of Mars or tourists visiting the Moon
- Environment e.g. recycling
- Alternative energy e.g. wind farms
- Agriculture e.g. farming industry

Team performance

Teachers felt that students developed key team-working skills during their Challenge Days. Students were encouraged to take on different roles across the tasks which ensured they felt involved and valuable to their team. Several teachers noted that students who were ordinarily quiet or less outgoing felt confident to take on leading roles, such as presenting. Others highlighted the sense of community generated on the day and saw the opportunity for students to work with peers they wouldn't normally interact with as a key benefit. Overall, the Challenge Day was thought to facilitate collaboration and healthy competition.

There were lots of different tasks to get involved with so it encouraged teamwork and encouraged children who were slightly quieter to come out their shell a little bit and get involved with other pupils around them.

Maths teacher

All teachers thought the level of complexity on the day was appropriate for their participating students. The use of real life scenarios to provide valuable context to the tasks, the introduction of the Micro:bit and the structure of the day helped to ensure students felt able and supported. Students could decide on the level of complexity in which to approach tasks, ensuring all abilities were able to participate. The tasks were thought to effectively challenge students without feeling overwhelming. Nonetheless, several teachers believed the lower ability students within their cohort would have struggled with the complexity and behavioural requirements of the day such that they would need more adult supervision and support if they were to take part.

I actually thought the challenge itself, in terms of what they were asked to programme, they could make it as easy or difficult as they liked, so some of them programmed things quite complex whereas others made something quite simple. So it played to their strengths, but if students were new to it they could still get something out of it. It was accessible for all students.

Physics teacher

It was the right level for students. It's quite hard to set up tasks where at first it feels challenging but scaffolded to bring it within ability. I also thought that the Challenge was the right level in terms of how broad it was, yet it was specific enough to use real life situations.

Science teacher

Problems faced

Only two teachers reported encountering any problems on the day. These related to logistics, including an attending school turning up late and technical issues setting up a projector for the introduction. Overall teachers felt the day ran smoothly, with several citing the detailed list of instructions on what was needed for the day and the early arrival of the team leader to set up as reasons for this. Likewise, there was nothing teachers disliked about the day with many expressing high levels of enjoyment.

Meeting teachers' expectations

All teachers reported that IET Faraday Challenge Days met their expectations as it was engaging, fun and well organised. Teachers were pleased that students were able to take part in an activity which approached STEM in a different and interactive way. Teachers who had participated for the first time were most likely to suggest that the event had exceeded their expectations.

It exceeded my expectations, it was an amazing activity. As a careers teacher, you have people come in a lot for STEM activities but this was so interactive, it was brilliantly organised. [What did you expect?] I didn't realise it was going to be quite as hands-on and they worked quite independently and they took it really seriously.

STEM coordinator

Yes [it met my expectations]. I expected it to engage the children and for them to really enjoy it, and up until today they are still talking about it.

Computing teacher

Yes, [the students] really enjoyed it. The fact that there was a prize, that was fantastic. Students were challenged with something they wouldn't do every day, plus it was something extra out of lessons. They could see how their learning has real life applications. Some of them might not have considered this as a career before but I think it made them think about the careers they could do in the future. It might make them think about the pathways they will take in Year 9.

High achievers coordinator

Likelihood to recommend

All teachers reported that they would recommend IET Faraday Challenge Days to other schools, with several confirming that they already had. Reasons to recommend included:

- Raising awareness of STEM careers amongst students
- Positive promotion of STEM
- Beneficial enrichment activity for students less likely to have access to such opportunities and resources
- Minimal involvement needed from the school or teacher in regards to chaperoning
- Opportunities to interact with the community and local schools
- Opportunity for students to meet an expert and STEM role model
- Ability to develop skills including coding and soft skills

- Learning in a new and creative way which also supports the curriculum

Overall, teachers felt the Challenge Day was inspiring to students and a unique opportunity to promote the real-world application of STEM.

Yes, definitely [would recommend it]. They are a great way of getting kids interested in engineering, it's off timetable, they are excited about new people coming in with new resources. It is a different and maybe more direct opportunity to get kids interested in STEM.

STEM coordinator

Yeah I would definitely because it's a great day for students, great way to interact with community, I'd happily host another one. It's good for school, students and rest of school to see it happening.

Physics teacher

Yes, it teaching students good skills in terms of teamwork, logical thinking, it's different. It brings them skills they will need in life. It could help students with choosing the right GCSEs or career path.

Computer Science teacher

Likelihood to participate again

All teachers reported that it was highly likely they would sign up again to take part in a Challenge Day, with several reporting they had already applied for next year's event. Others planned to set up STEM clubs in anticipation of next year's event.

I have filled in the form already, and I have a list of students who want to take part. I will organise a little STEM club in lunchtime as well.

Computer science teacher

Only a few barriers to taking part were envisaged. This included if Challenge Days clashed with exam periods or if schools were unable to host leading due to additional costs, travel considerations and teacher cover.

Absolutely will be [signing up again]. One of our aims of the school is to provide students with exciting opportunities and make sure they can learn beyond the classroom. One of the limiting factors for us is that we are a rural school, so the fact that they can come to us is great. Obviously funding wise, the fact that it is free but really worthwhile means that we would definitely apply again.

High achievers coordinator

The majority of schools reported that they would be interested in using the DIY Faraday Challenge Day resources to run their own event, although some were more certain in their likelihood than others. 2 schools were already using the DIY resources however they were adapting the materials to fit their needs. The resources were used as a guide to help schools create tasks in STEM lessons or develop similar activities which were shorter in length or which catered to a larger group of students.

We have used them as inspiration and adapted them. We run STEM days for all year groups from 7-10 and for every one of those STEM days the resources have been referenced as a guide.

STEM coordinator

Teachers who were less likely to use the DIY resources cited workload as a barrier, such that they anticipated they would not have the time to organise a Challenge Day. Others thought they would be limited in their access to resources such as Micro:bit and queried whether the IET would be able to provide equipment on loan. A number of teachers suggested that as one of the key benefits of Faraday Challenge Day was having a STEM professional visit the school, they would be less inclined to run the day themselves as they felt this would be less exciting and inspiring for students.

No I probably wouldn't [run a DIY day myself]. I like the external person to come in and deliver it as it gives it a different twist. If I'm doing it it's just another one of my lessons but someone coming in from the outside makes it a special day and gives more weight to it and definitely more exciting.

Physics teacher

One teacher suggested they would not be confident in running the day themselves as they felt they lacked the necessary expertise and experience. They suggested additional support or a workshop on how to run an event would be useful, including videos, a schedule of the day and access to equipment.

It's the logistics of setting it up and I don't personally know if I have the confidence or expertise to set it up, like micro:bits and things like that as it's not something I'm very confident with. [What could the IET do to encourage you further?] Perhaps give me some training...on how to use things like loggers, and coding and whatever was relevant to the Challenge. I know there's lots of online support but if there was a central meeting for schools doing the DIY challenge to come and see what the Challenge was and borrow some resources that could be returned after.

Science teacher

Improvements to IET Faraday Challenge Days

During the qualitative interviews, we asked teachers whether they desired any additional support from the IET or if they had any suggestions for improvements to Faraday Challenge Days. In the first stage of the research - prior to each school's Challenge Day - several teachers indicated that more information regarding what the day would entail would be useful in the lead up to the day. This suggestion came from teachers who had never taken part in Faraday Challenge Days before, who were more likely to report a sense of apprehension as they were unsure what to expect. Useful information included the level of complexity of tasks, how tasks link to the curriculum, coding and programming skills required, as well as any requirements of the teachers on the day. Nonetheless, these teachers reported that it was easy to contact the IET for more information when required and communication was prompt.

Although it was generally acknowledged that the IET provides sufficient information to participating schools, whilst maintaining a level playing field by ensuring schools are unable to prepare for the tasks beforehand, first time participants felt somewhat in the dark and subsequently less supported overall. Other teachers felt limited in their ability to promote the event to other staff members or to get buy-in from subject teachers who were resistant to letting students out of lessons.

I don't know much about the day currently, I would like more information about it including my involvement and about the tasks. If I was told about what the day would involve, I would be able to make the teachers aware about it.

STEM coordinator

Several teachers felt that prior information on the tasks would allow them to better engage and excite students in the lead up to the day. Others suggested that the provision of videos of past Challenge Days to show students would help to generate enthusiasm.

What would be interesting is if we could show students a video clip of past years, that would really help as I could get an idea of what the kids will actually be doing as well. If I knew more information I would have changed what info I would give to the children. I don't feel like I got much detailed info...it may have given me more to inspire them to apply to take part.

Science teacher

I think a video to get them enthusiastic at the start, not giving too much away but just a video to explain what an engineer is, what science is all about, what maths is all about and link it to the relevance of why they're going to be doing this Challenge...just to big it up and make it relevant to them.

Science teacher

Some teachers were interested in having students undertake research or prepare for tasks beforehand, as they felt this would be more engaging and would allow students to get the most out of the day. Others wanted to ensure their students had adequate coding skills.

It'd be nice to have a little challenge to research something before they go in and then they can bring that knowledge to enhance the ideas they come up with. Perhaps something they could do in STEM club or a bit of a lesson.

STEM coordinator

Those who had taken part in IET Faraday Challenge Days before, in addition to those who attended a training day, felt more relaxed in the lead up to the day. They had some prior knowledge on what the day was likely to entail and knew it would require minimal involvement from staff. Repeat entrants were also more likely to enjoy the mystery of the tasks, perhaps as they felt more secure that students would be adequately supported and were more aware of the benefits of maintaining the competitive edge.

It mustn't be predictable because as soon as it becomes predictable the teachers start being able to prepare the students... If everyone goes on a level playing field that's best. I like the fact it's kept secret so no-one knows what they're going to be doing.

Physics teacher

In stage 2 of the research - after schools had participated in their Challenge Day - the large majority of teachers had no suggestions for improvements, indicating high levels of satisfaction.

No I don't [have any suggestions for improvement]. I thought it was fabulous, I thought it was one of the best opportunities that I've ever experienced. [Why?] It was partially [the team leader] because he was really awesome and partly that it was really well planned, the day ran really smoothly.

Science teacher

No [suggestions for improvement], the Challenge Days are always really well run and enjoyable. Other companies come in and do STEM challenges, but this is always the best.

STEM coordinator

One teacher suggested a clear schedule or time guide to help keep students on track, as well as examples to help creativity. This was thought to be of particular use for lower ability students who require more support:

A clear time guide handed out early for students who were struggling to focus on what they needed to do. Make it explicitly clear what they need to do as at times it was a little vague - which is good for higher ability pupils, but for lower ability they need a bit more direction to focus... Overall they were alright with coding but they also needed to do a packaging part which they weren't doing well, so maybe show an example of other scenarios so they get an idea of what to do.

Maths teacher

Conclusion

All schools who took part in the research reported high levels of satisfaction with IET Faraday Challenge Days, with student participants rating their enjoyment an average of 8 out of 10. 83% of participants indicated that they would be likely to recommend taking part in IET Faraday Challenge Days to other students, again demonstrating high levels of student satisfaction with the experience.

While the ANCOVA analysis did not identify a *statistically* significant difference between Faraday Challenge Day participants and students within the control group in regards to their attitudes towards STEM, participants were still found to have scored higher on most attitude aspects than non-participants. Furthermore, a positive change in attitude following participation in the season was observed, most noticeable in students' attitudes towards science and engineering careers. This suggests that participation in Faraday Challenge Days may contribute to a positive shift in perceptions of STEM.

Qualitative interviews revealed that teachers believed that participation in IET Faraday Challenge Days had had a positive effect on their student team members. This varied from increased engagement with learning overall, the development of technical and soft skills, increased interest in STEM subjects, further participation in STEM clubs and activities, and an interest and awareness of STEM careers.

Survey findings identified that students who took part in IET Faraday Challenge Days perceived a positive impact on their awareness, knowledge and attitudes to STEM as a result of their participation:

- 85% of participants either agreed or strongly agreed that they learnt new things at their Challenge Day suggesting participation has had a positive impact on their skill and knowledge development
- 85% either agreed or strongly agreed that participation has helped to increase their understanding of what Engineering is
- 84% of students agreed or strongly agreed that their participation has given them a better understanding of the skills needed by engineers
- 72% of students indicated that they felt more positive about Engineering since taking part in IET Faraday Challenge Days

In order to continue to aid positive perceptions of STEM as well as overall satisfaction with participation in IET Faraday Challenge Days, we would recommend the following:

- Develop case studies or Challenge examples to ensure first time entrants are aware of what to expect on the day, as well as to help further promote IET Faraday Challenge Days to other schools
- Create videos or encourage schools to facilitate previous contestants to share experiences and advice with new team members to foster excitement, increase engagement and ease apprehension

Overall, schools taking part in IET Faraday Challenge Days attributed positive change in their students to involvement in the activity with many reporting that it was particularly valuable in exposing students to real world application of STEM.

Appendix 1 - Assumptions ANCOVA

In order to run the ANCOVA, the following assumptions need to be met:

- DV on continuous scale
- IV two or more categorical groups
- Independence of observations
- No significant outliers
- Normal distribution residuals
- Homogeneity of variances
- Linearity of covariate
- Homoscedasticity
- Homogeneity of regression slopes

All assumptions were checked with the appropriate tests, and where appropriate accounted for if violated.



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