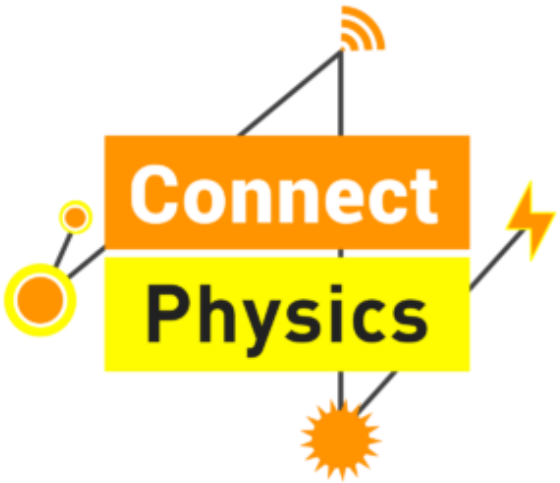
SEPnet
South East Physics Network



Connect Physics 2017-18 Evaluation Report. October 2018.

Prepared for the South East Physics network (SEPnet)
by Hope-Stone Research.

hope-stone research

For more information, visit http://www.sepnet.ac.uk/outreach/connect-physics/

SEPnet Outreach & Public Engagement is formed of ten partner university physics departments working together to raise the profile of Physics.

University of Hertfordshire
University of Kent
The Open University
University of Oxford
University of Portsmouth
Queen Mary University of London
Royal Holloway University of London
University of Southampton
University of Surrey
University of Sussex

Foreword

SEPnet is please to present the evaluation report from our latest workshops, **Connect Physics**.

Back in 2016 we set out to develop a set of workshops that brought in a new way of looking at physics in schools.

What is physics? Is it more than the bits of science that aren't biology and chemistry? Why do physics? What jobs and careers does it lead to, and why would that matter to me? How do you physics? It is only challenging maths? Is it only for the brainy students?

These were questions students at Key Stage 3 were asking and SEPnet was in a unique place to help schools answer.

Over the last two years, what started out as a set of ideas from our officers developed to these workshops thanks to the fantastic folk at **Science Theatre**. Without them these workshops would have never happened.

We tested our ideas and workshops at every stage with the **teachers** and **students** in our region who we wanted to work with in over 25 schools. Thanks to all your inputs, comments and suggestions, they were invaluable.

Thanks to **Helen Featherstone** for getting us going with our formative evaluation then Hugh and his team at **Hope-Stone Research** for carrying out the summative evaluation and writing this report.

Finally a big thanks to the **SEPnet Outreach Officers** and their **Undergraduate Ambassadors** for your enthusiasm in taking on such a different style of workshops.

This report brings all our learning together and gives SEPnet a start in how it continues to develop resources for its schools' programme.

Spoiler warning, we couldn't get enough data to measure **Science Capital** throughout the student population. It was the first time **SEPnet** was working on an evaluation of this scale. This in itself was a learning point and will influence how programmatic evaluation is done in future projects.

Read ahead to see how the project measured against all of our objectives and see feedback from teacher, students, officers and undergraduates across the region.

Very excited to see where the learning from this report and the workshops themselves lead to next.

Dr Dominic Galliano

SEPnet Director of Outreach & Public Engagement.

1. Introduction

Connect Physics is a school outreach programme aimed at increasing numbers of Year 8 students considering physics as a pathway to their future. It takes the form of a set of three workshops aimed at students, in particular those with medium to high science capital.

The workshops have been developed by Science Theatre on behalf of SEPnet and were tested in London in June / July 2017. This was part of a formative evaluation.

In the 2017-18 academic year the programme was rolled out across the South East and SEPnet wished to carry out a final round of testing as it its impact effectiveness. Nine of the SEPnet Outreach partners delivered the workshops to 23schools across the region. The workshops have been developed using the learning from the initial ASPIRES results that showed science capital is key to the selection of STEM subjects throughout GCSE and A-Level. The workshops, each with a particular message, aimed to maintain the science capital of target students. For those with medium science capital, these workshops should encourage them to view STEM as a pathway to a potential career, for those with high science capital, they will be encouraged to think specifically about physics.

SEPnet commissioned Hope-Stone Research to carry out an evaluation of the programme. What follows is are the findings from this work.

2. Research Objectives

SEPnet identified the following questions that the evaluation should address:

- Do the workshops work as a set? Does one of them have more merit over others?
- Are the messages being delivered differently across different types of students based on their type of school, science capital or location?
- How consistently are the workshops being delivered across the network? Does having different deliverers lead differences in messages?
- What's the best format for delivering the workshops?
- Are teachers happy with the content and delivery of the workshops?
- What learning outcomes students achieved as a result of taking part?

3. Research Method

The evaluation of the 2017-18 Connect Physics programme used a combined quantitative and qualitative approach.

Quantitative
The quantitative evaluation took place over four stages based on an online self-completion questionnaire aimed at all participating students taking part in the programme. Achieved sample sizes are shown in Table 1 below. Of the 23 schools who hosted Connect Physics workshops, 15 participated in the evaluation to varying degrees. In some cases this only involved responses from teachers and overall no single school completed all the stages of the evaluation process.

Stage 1: Baseline survey
Participating students were asked to complete a baseline survey that aimed to measure their knowledge of and attitudes to science using some of the *Aspires* methodology to measure science capital.

Stages 2 and 3: Post session surveys
After the first and second sessions; What Connects Physics? and Why Connect to Physics? Students were asked to provide feedback on the session and its impact on them.

Stage 4: Endline survey
After the third and final session students were asked for feedback on the session as well as answering the same questions from the baseline survey to measure any change in science capital.

Table 1. Quantitative samples for student surveys

Survey	Number of student responses	Number of schools in each survey
Baseline	469	12
Post What?	191	10
Post Why?	124	6
Endline	85	5
		Total: 19

Qualitative
The qualitative evaluation comprised the following:

Observation: Hope-Stone Research attended eight (8) sessions across a range of schools and delivered by a number of different outreach officers. See Table 2 below. At each observation student behaviour in response to the session content and delivery was noted, with a focus on engagement, enjoyment and wellbeing.

Student focus groups: Where possible, after each of the observed sessions a sub-sample of participating students (between 4-10 at each session) were invited to take part in a short (20 minute) focus group discussion about the session; what they liked, what they learnt, the session content and delivery, impact on attitudes towards physics and suggestions for changes and improvements**.** These discussions took place at school and were audio recorded for subsequent analysis.

Teacher individual interviews: Again, where possible the relevant teacher was asked their opinion on the session and its value to students and the school, as well as any possible improvements that

could be made. Each interview lasted around 20 minutes. Those teachers we were unable to interview or were at sessions not observed by the research team were invited to complete an online feedback form instead.

Outreach officer/ Facilitator feedback: After each observed session we conducted an informal conversation with the outreach officer and/or with their team members, either at the school or subsequently by phone. As with the teachers, those running sessions that were not observed where invited to complete an online feedback instead. We also conducted a phone group discussion with six of the outreach officers after the programme had been completed.

Table 2. Qualitative samples

Method	Number	Delivery Partner[1]
Observations	8	Kent, QMUL, Sussex, Royal Holloway, Oxford
Student focus groups	9	Kent, QMUL, Sussex, Royal Holloway, Oxford
Teacher IDIs	7	Kent, QMUL, Sussex, Royal Holloway, Oxford
Teacher online forms	17	
Facilitator IDIs / paired interviews	4	QMUL, Sussex, Royal Holloway, Oxford
Facilitator online forms	37	All

Measuring change

The design of this evaluation aimed to measure change in student science capital over the programme period, from before the first session through to after the third and final session. Participating students were asked the same core questions in each survey. Ideally the students involved in the study would be the same for each survey wave, however the response from schools was patchy with only one set of students completing all four questionnaires (and even here just five completed the endline survey).

Therefore, analysis has been conducted at an aggregated level to ensure sufficient sample sizes at each point but because of this it is difficult to truly understand the impact of the sessions over the long term. Additionally, there are many external factors likely to affect school students at this point in their life (Year 8) that this study does not take into account. That said the data do provide some indicative pointers as to how the sessions have had an influence on student science capital.

Where responses were in the form of scores out of 5, based on the size of the achieved samples, those scores where there is difference of 0.3 or more between the base line and endline can be considered significant.

[1] A full list of schools who took part in the research is shown in Appendix 1

4. Summary, Conclusions and Recommendations

4.1 Summary of Main Findings

Measuring change in student science capital
There was little or no measurable change in student science capital between the baseline (pre-sessions) survey and endline (post sessions) survey.

If we assume the project had impact, this lack of change could be down to one or both of the following possible factors:

1. That the samples were not sufficiently large enough or representative enough of students taking part in the Connect Physics sessions.
2. The student cohort who completed the feedback surveys already had a high level of science capital and increasing it would require greater input than the three one-hour sessions could provide.

It is worth noting that as we don't have a comprehensive assessment of science capital among Year 8 students we don't know if the participating cohort are typical of their year or above or below average.

Learning impact of the Connect Physics sessions
Although the survey data wasn't able to conclusively say changes in science capital had occurred, feedback from students and teachers clearly indicates that individual sessions had a strong and valuable learning impact. Nearly all students surveyed and talked to in focus groups said they both enjoyed the sessions and learnt new information and skills. Some students reported that the sessions had opened their eyes to physics as a more approachable subject than previously thought, provided an understanding of its role across many aspects of their lives and how it can contribute to a wide range of career options. Survey findings showed that, depending on the session, between a third and a half of students said they were more interested in physics as a result of taking part.

> *It kind of made physics more down to earth…like I can do this.*

Teacher motivations to take part
Teachers said they signed up to the sessions so that pupils are inspired to see physics as a subject they will continue to study. The sessions add value to the curriculum by putting physics into a wider context by demonstrating its practical applications beyond the classroom and its value in future study and work.

> *We want our students to see themselves as scientists, we want our students to be interested in science.*

Feedback on the sessions
Teachers were very happy with all three sessions, each delivered a new and useful approach to classroom learning. They felt the combination of real scientists presenting the sessions with practical, hands-on activities using resources unavailable at school was highly effective at engaging students. Teachers felt the How? session was probably the most engaging of the three, being seen

to deliver a perfect lesson in using investigation to understand the world around them, unconstrained by having to identify the correct answer as is usually the case in school learning.

> *I think it might be my favourite one…self-discovery, it's what teaching science is in particular.*

That said teachers believed that having all three sessions was necessary as each presented an important perspective on using science in a practical way.

Students very much enjoyed the activities; they liked challenging the facilitators to make connections and using new equipment in What? the elements of competition in the Why? session and making models and presenting their ideas in How?

> *I was enjoying myself so much in the physics lesson. When we tried to figure out the ropes and tube, how it was connected it was hard and fast, but I kept trying again and again and eventually I got it right I knew how they were connected. I would never forget this lesson in my Life, it was one of the best science fun lessons I had. Thank you to the physics team for this session I appreciate all you done for us. I would like to work part of physics as my future.*

From observation there were clearly moments where students were more likely to disengage; when too much reading and/or writing was required without a clear idea as to how this fed into something more interesting, or when facilitators gave long verbal explanations or instructions.

it was clear than in most cases (even when classroom discipline was poor) that students were very keen to engage with facilitators; asking questions and listening to the answers. Where sessions flagged a little was when there was only one facilitator speaking, or the interactive whiteboard was too text driven and hard to see.

Facilitators

Facilitators were praised by both students and teachers as being good presenters, engaging and accessible. With many young (student ambassador) facilitators running the activities school students could relate to them and not feel worried about asking questions.

Delivery timing

Among teachers and facilitators (both outreach officers and student ambassadors) there was mixed opinion as to whether the sessions should be delivered over the course of a year or a term. The former has the advantage of creating more student interest over a longer period of time while the latter ensured that the learning could be re-enforced better, more easily linked to a classroom topic and sometimes easier to schedule with the school.

Session design

Outreach offices believed that the structure of What? Why? How? was a good one and effectively conveyed key messages about the use and value of physics specifically and science more generally. While the three sessions worked well as a whole, those who due to circumstances were only able to run one or two found these worked equally well on their own.

The resources to deliver the sessions were felt to be well designed and provide a useful addition to their current outreach activities. Indeed, some said that they would be solely using Connect Physics in their coming academic year. The resources were something they would struggle to create themselves (particularly the interactive elements). They contained key messages but were flexible enough to be adapted where desired.

Curriculum links
Outreach officers felt that the sessions provided value added to the curriculum rather than simply following it (something that is likely to make Connect Physics more future proof by not being too closely tied to content that changes regularly). However, the sessions do link to the curriculum through skills development and this could be something to emphasise when promoting to new schools.

Suggested improvements
Students frequently mentioned wanting more hands-on activities involving equipment rather than anything too paper based. From observation it was clear they enjoyed interacting with the facilitators, competing in teams and presenting their ideas. Any adjustments to the sessions that increase these elements would work well.

Teachers appeared very satisfied with the sessions; there were moments when they felt the pace of the session could be increased or supported by more visual material but by and large they felt the value added far outweighed any issues. Additionally, facilitators need to monitor their vocabulary to ensure all students fully understand the content. From observation, having back up activity for the more able would be helpful.

Support from SEPnet
Outreach offices appreciated the training they received given that the PowerPoint slides are quite sparse, particularly effective was training through observation of others running the sessions. Additional support suggested was:

- A shared list of demonstrations and physics examples on Dropbox
- More props to pass around
- Larger PowerPoint slide text
- Being able to change the pictures on slides to substitute with their own examples

Looking ahead
Outreach officers were keen to continue using Connect Physics either in combination with other programmes or in some cases, as their sole delivery platform. Having good impact feedback would help them both promote it to schools and internally as worthwhile doing, although some said that while they'd like to expand the activity, capacity was limited. In such circumstances they'd be more likely to work with more classes within the same schools rather than trying to promote to new schools.

4.2 Conclusions and Recommendations

CONCLUSIONS

It is useful to return to the original evaluation objectives to see how the SEPnet 2017-18 programme has performed.

1. Do the workshops work as a set? Does one of them have more merit over others?
The three workshops were considered by teachers, facilitators and our observation to build a diverse picture of the role physics can play in student's lives both now and in the future. Teachers saw each providing complimentary content to what is being taught in class and therefore were valued both individually and as a set. While the full benefit of the programme is only delivered if all three workshops are run with a group of students, individual workshops can also work on their own.

Each workshop has is strengths; students enjoyed How? the most as did some science teachers, as they saw the principles involved as universal rather than purely physics orientated. Students were least enthusiastic about the Why? session on careers but teachers were keen that students start exploring career ideas at this age. What? provide students with the understanding that physics is not just confined to the lab or classroom, but importantly it also gave students a chance to engage hands on with objects they wouldn't usually be able to use.

Outreach offices believed that the structure of What? Why? How? was a good one and effectively conveyed key messages about the use and value of physics specifically and science more generally. While the three sessions worked well as a whole, those who due to circumstances were only able to run one or two found these worked equally well on their own.

2.Are the messages being delivered differently across different types of students based on their type of school, science capital or location? How consistently are the workshops being delivered across the network? Does having different deliverers lead to differences in messages?
From our observations there was a high degree of consistency in the way the sessions were delivered in terms of content, format, use of additional stimulus (such as objects) etc. There were variations however; while in most cases there were two or more facilitators, but some were not always activity leading the sessions, something students would have preferred to have seen. Those with two or more actively engaging students created a more dynamic environment.

Not surprisingly classes with better discipline/ higher ability were more likely to have valued added in terms of additional content, for example opportunities to present their findings (How?) or conduct job interviews (Why?).

3.What's the best format for delivering the workshops?
As mentioned above having two or more delivering the workshop creates a livelier dynamic as well as allowing for more individual interaction between presenters and students. Minimising verbal explanations and maximizing hands on activities is always going to engage students more, especially those with lower ability or interest, or classes with poor discipline. Feedback was mixed as to whether the sessions are better delivered over one year or one term; the former provides a longer gestation period for ideas to embed (particularly if the school supports them via classwork)

but the latter may have more impact and focus, and again works better if tied in with current classroom teaching. Consulting with teachers as to the best approach is the most sensible way to decide, not least because scheduling sessions can be a challenge.

4. Are teachers happy with the content and delivery of the workshops?
Teachers were generally very satisfied with the delivery of the workshops as they provide content presented by experts with equipment that schools are unable to provide. It is always worth consulting with teachers over how it can best fit with classroom learning (if at all) and teachers need to know that they, not the outreach officers, are responsible for discipline.

5.What learning impact did the sessions have on participating students?
While there was no measurable change on student science capital across the sample there was clear evidence that students both enjoyed taking part and that they had learnt new knowledge and developed new skills. The survey data showed that they left the sessions more interested in physics and seeing its potential value to their future academic and work life.

RECOMMENDATIONS

There are a number of recommendations we would make that could potentially enhance the impact of the Connect Physics programme in 2018-19.

Communications and logistics

- For each set of sessions planned liaise with the school over what period of deliver the sessions should take place (e.g. one or three per term or half-term etc) to best fit with the science curriculum topics being covered.
- Discuss with schools where possible class topics could be aligned with the session content to enhance relevance to the curriculum if desired by teachers. For example, if the topic is forces, the outreach team could bring some activities or objects that link to this.

Session content

- Build in additional content for more able students rather than more of the same activity. For example, interviews in Why? rather than just more job applications.
- Reduce need for verbal explanation and increase visuals on PowerPoints, possibly adding video where appropriate to explain a task or provide an example.
- See if some of the paper-based activities can be enhanced through greater use of objects for hands on activities.
- Be careful with vocabulary and explain if any possible doubt over comprehension.
- Give students more control in What? when looking at connections so facilitators don't come over as the 'brainy' ones, and students as passive.

Session format

- Always try and run the sessions with two if not three facilitators playing an activity role in delivery.
- Have contingency options for shorter or long sessions (e.g. 30, 40, 60 and 90 minutes).

Support for outreach officers

- Create a knowledge bank for sharing best practice in successful activities and objects used.
- Design session slides for easy editing so university specific examples can be added.

Looking ahead

- Continue to evaluate impact of the programme to help with promoting it both with schools and internally.
- Capacity is restricted within universities, so expansion will have to come through either broadening delivery by involving more student ambassadors or more universities.

5. Main Findings

5.1 Measuring changes in student science capital

WHO TOOK PART?

Gender
Somewhat more males than females completed the survey. However, we can't be sure if this is true reflection of gender distribution in the participating schools or propensity to complete the questionnaire. The number of undisclosed gender may also have an impact on the reported gender balance.

Ethnicity
The study sample had a proportionally high number of non-white participants than the UK population as a whole, so in terms of reaching a diverse audience the programme has certainly achieved this. Again, it is possible that some ethnic groups have a higher propensity to fill in the surveys, and additionally some schools combined a very high proportion of BAME students, higher achieving sets and were willing to fill in the forms.

Table 3. Gender and ethnicity of student participants

		Baseline	What?	Why?	Endline
		n=474	n=191	n=124	n=85
Gender:	Female	46%	49%	42%	53%
	Male	50%	49%	53%	40%
	Other/Undisclosed	4%	3%	5%	7%
Ethnicity:	White	54%	40%	37%	19%
	Asian	18%	32%	37%	52%
	Black	9%	12%	6%	5%
	Mixed/ Other	13%	12%	17%	10%
	Undisclosed	7%	5%	5%	14%

Science ability
Students were asked to say what set they were in for maths and science. In many cases Year 8 students aren't graded for science but are for maths. While the figures tend to vary between surveys there does appear to be a propensity for students in higher science sets to have attended the sessions (or simply to have completed the feedback forms) and where setting in science occurs the majority of students are in the top set. This could be in part due to lower response rates from less able students but also possibly because teachers see these students as potentially benefiting the most from the sessions. See Tables 4a and 4b below.

Table 4a. School assessed ability for science

	Baseline	What?	Why?	Endline
	n=474	n=191	n=124	n=85
Top set	51%	50%	32%	18%
Middle set	29%	7%	6%	10%
Bottom set	10%	2%	4%	1%
No sets	20%	32%	47%	54%
Don't know	8%	9%	10%	17%

Table 4b. School assessed ability for maths

	Baseline	What?	Why?	Endline
	n=474	n=191	n=124	n=85
Top set	10%	64%	53%	52%
Middle set	29%	23%	30%	28%
Bottom set	51%	4%	9%	10%
No sets	4%	6%	7%	7%
DK	6%	3%	2%	2%

Confirming the above, the survey feedback indicated that while the majority of schools made it available to all Year 8s a number of schools only offered the sessions to higher sets or more able Year 8 students. See Table 5 below. However, this is based on survey data only as outreach officers didn't ask for class ability, something that will be done during the 2018-19 academic year.

Table 5. Which pupils took part? (Number of teacher responses n=6 What? n=5 Why? n=6 How?)

	All Y8 students	Higher science sets only	More able students only	Some Y8 students	Other years or parameters not specified
What?	3	1	1	1	-
Why?	4	-	1	-	-
How?	4	-	-	-	2

ATTITUDES TOWARDS SCIENCE

Self-assessed ability and ambition

There was no significant change in student opinion about perceptions of their own ability or ambition between the baseline and endline surveys. See Table 6 below.

Table 6. How much do you agree with each of the following statements?
(Mean score out of 5 where 5 = Strongly agree)

	Baseline	Endline
	n=452	n=76
People who are like me work in science	2.8	2.8
Anyone can become a scientist	3.7	3.5
I want to become a scientist	2.5	2.5
I would like to have a job that uses science	3.2	3.3
When I grow up, I would like to be a doctor or work in medicine	2.6	2.8
I see myself as a science person	2.9	3.0

Value of science to a career

There was no significant change in opinion on the value of science to a future career over the delivery period. That said the perceived value was already fairly high (3.9 and 4.0 out of 5) prior to the sessions, so increasing this would have been a challenge.

Table 7. Value of science to a career (Mean score out of 5 where 5 = Strongly agree)

	Baseline	Endline
	n=474	n=85
A science qualification can help you get many different types of job	4.0	4.1
It is important to study science even if you don't want a science job in the future	3.9	3.8

STUDENT SCIENTIFIC ENVIRONMENT

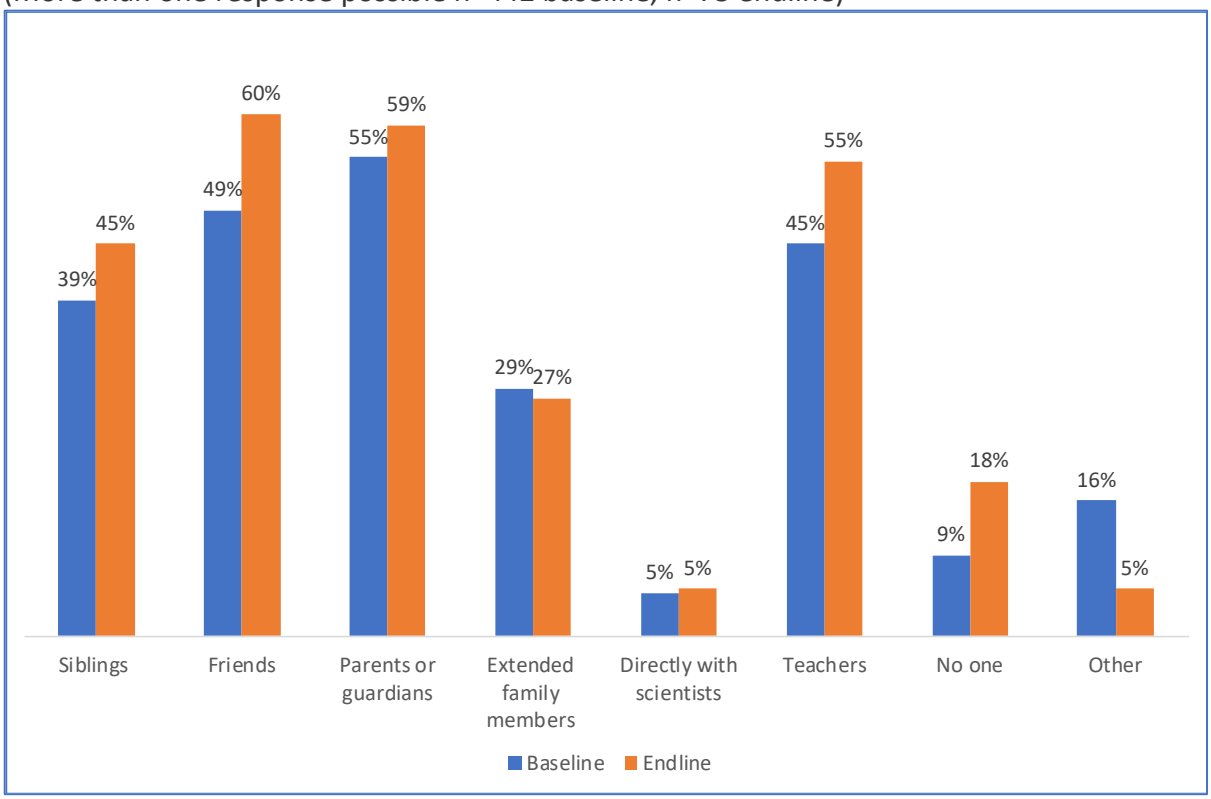
Talking about science when not in school:
There was a fairly high propensity among students to talk about science outside of school both before and after taking part in the sessions with 42 percent saying they do so at least once a week in both surveys.

Table 8. When you are NOT in school, how often do you talk about science with other people?

	Baseline	Endline
	n=447	n=74
Never or rarely (once a year)	25%	30%
A few times a year	12%	9%
About once a month	21%	19%
About once a week	29%	24%
Almost every day	13%	18%

Who do you talk to about science?
Students were most likely to talk about science with friends, parents and teachers. It is notable that talking to others appears to be higher in the endline than baseline survey, possibly because the endline survey took place soon after the final session but also possibly due to the interest it inspired in the participating students.

Chart 1. Who do you talk with about science?
(More than one response possible n=442 baseline, n=73 endline)



Knowing people in science
39 and 50 percent of students in the baseline and endline surveys respectively said they knew someone (a friend or family member) who works as a scientist or uses science in their job.

Student science confidence and attitudes
Students were asked in each survey a series of questions about their confidence in and attitudes to science. The resulting scores do not indicate any significant patterns of change over the period of engagement although in some cases more positive responses were given after sessions one and two (What? and Why?) but these increased scores were not maintained after the third session, How? As above, levels of confidence overall started fairly high, so it is possible that the three sessions would not make a difference to such students. That said, at the other end of the spectrum those who don't relate to or like science were not significantly more likely to be more positive by the end of the sessions than they were before taking part. See Table 10 below.

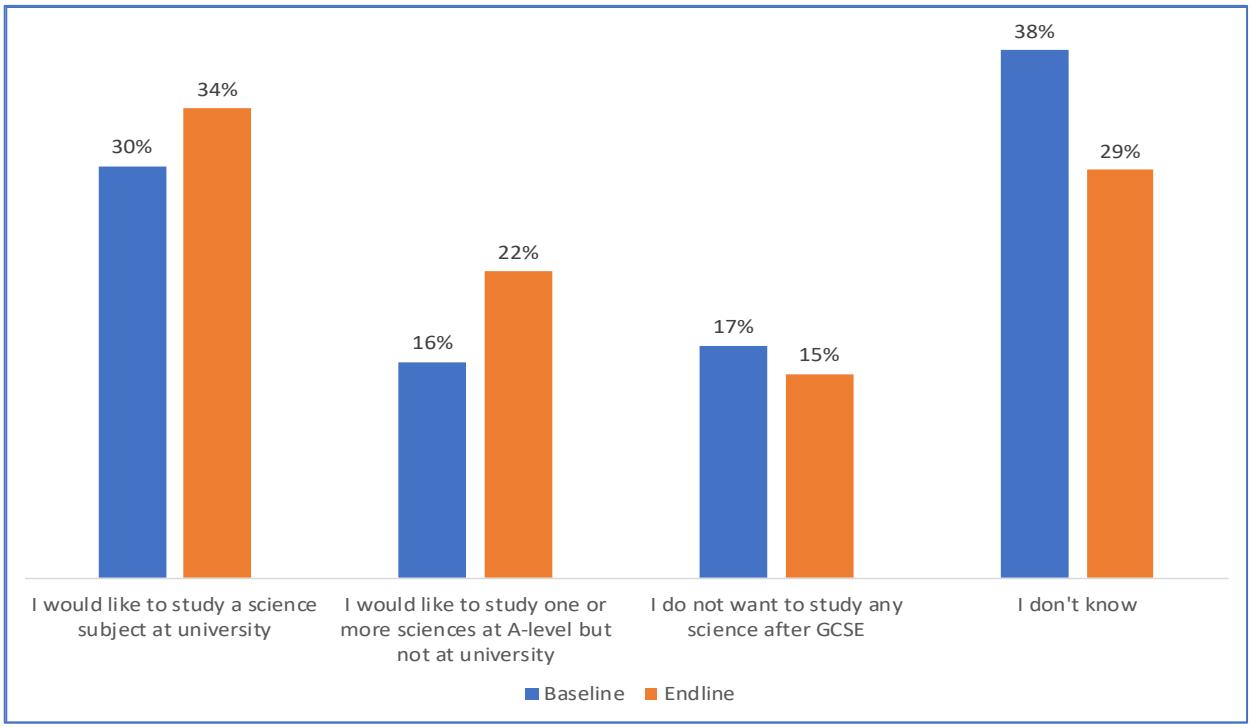
Table 9. Scientific confidence: How much do you agree or disagree with each of the following statements? (Mean score out of 5 where 5 = Strongly agree)

	Baseline	What?	Why?	Endline
	n=429	n=180	n=114	n=72
I know how to use scientific evidence to make an argument	3.4	3.9	3.6	3.4
I am confident giving answers in science lessons	3.5	3.8	3.6	3.3
I know quite a lot about science	3.5	3.7	3.5	3.4
Other people think of me as a science person	2.7	3.0	2.8	2.9
Science has no personal meaning for me	2.5	2.4	2.6	2.7
Doing science makes me unhappy	2.2	2.0	2.3	2.4
I understand what is taught in my science lessons	3.7	4.1	4.0	3.7

Future plans
There was a noticeable increase in the proportion of students saying they might work in a science related job in the future in the endline survey as compared with the baseline survey; 40 percent versus 30 percent. However, with the two samples being based on largely different participants it is hard to say for sure if this this change is significant.

Additionally, endline participants were more positive than those in the baseline about either taking science A Levels or studying science at university and were generally more certain about what path they planned to take. Again this could be attributed to the selection bias in the endline. See Chart 2 below.

Chart 2. Although it may be a long way off, which of the follow best describes your view? (Please tick ONE) (n=418 baseline, n=68 endline)



THE VALUE AND UNDERSTANDING OF PHYSICS

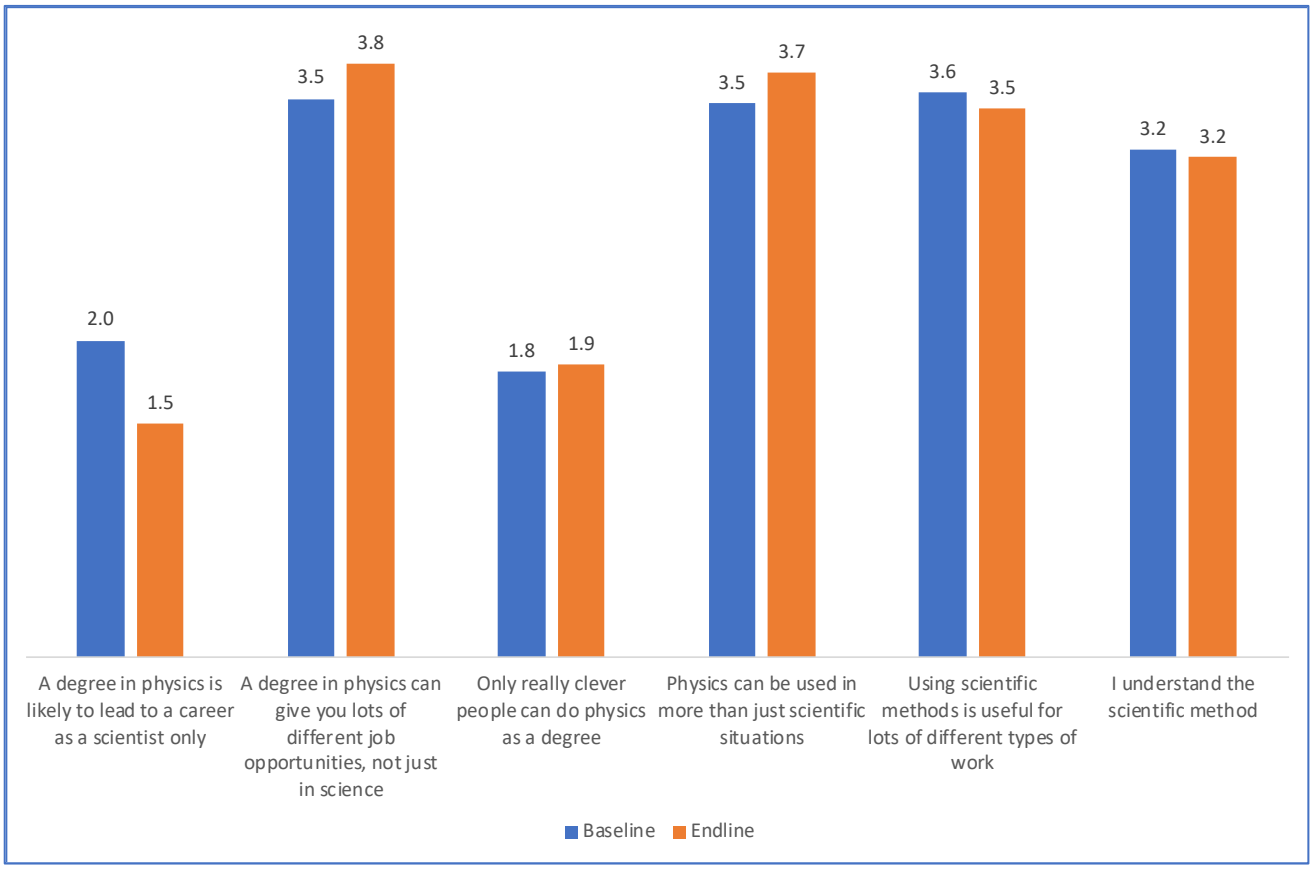
Value of physics

Some of the indicators of attitudes towards the value of science appear to have risen among students by the end of their programme of sessions. Although these findings should be treated with caution it does suggest that students have an increased belief that physics can offer more than just a career as a scientist.

Using the scientific method

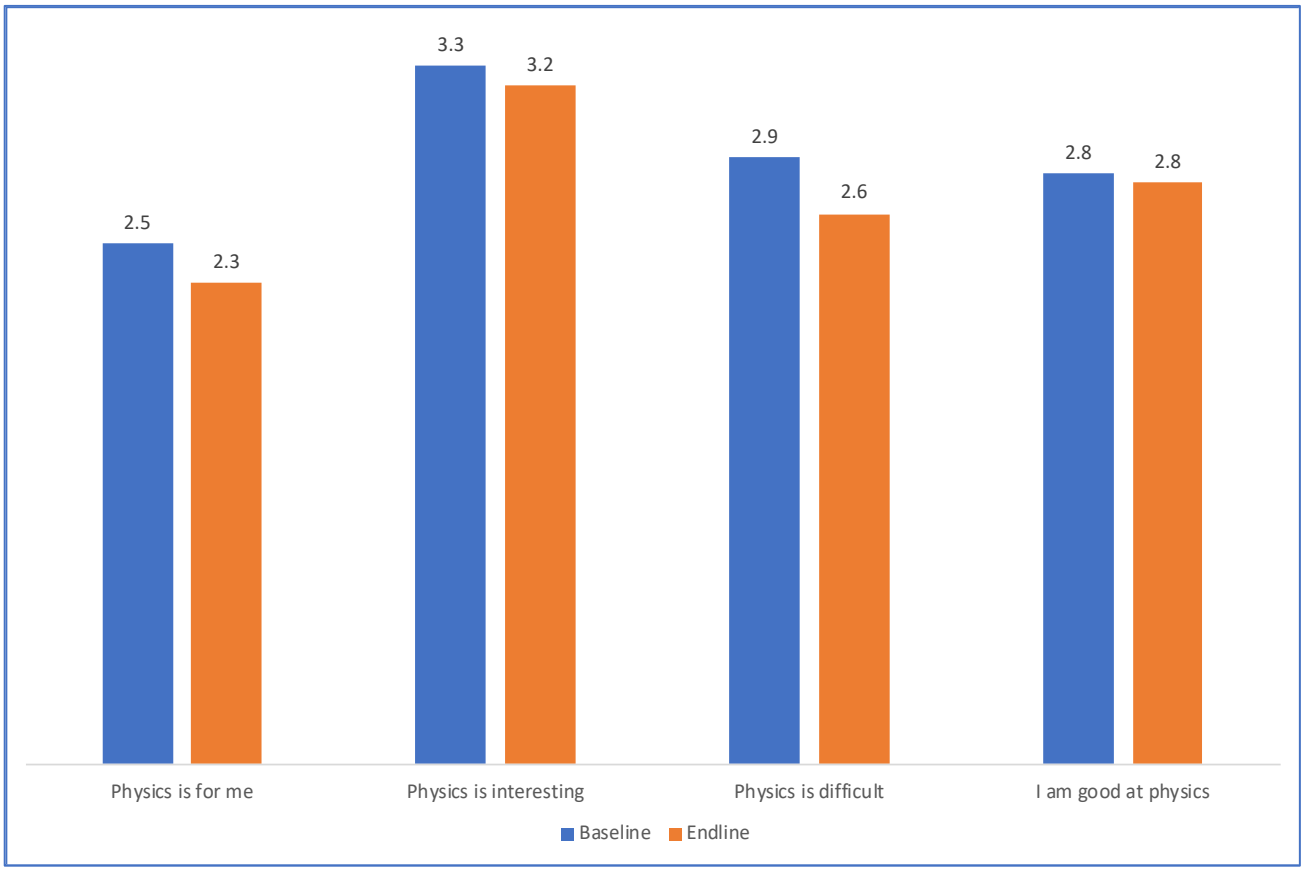
Despite the final session being dedicated to the scientific method there was no change in perceived understanding, perhaps suggesting a reasonable degree of confidence in the first place? See Chart 3 below.

Chart 3. Thinking about physics how much would you agree with each of the following statements? (Mean score out of 5 where 5 = Strongly agree, n=416 baseline, n=67 endline)



Based on statements about how students feel physics is for them it would appear that the sessions have minimal impact. See Chart 4 below.

Chart 4. Thinking about physics how much would you agree with each of the following statements? (Mean score out of 5 where 5 = Strongly agree; n=416 baseline, n=67 endline)



5.2 Feedback back on the Connect Physics sessions

This section provides feedback from the following sources about the sessions overall and individually:

- Student surveys and focus groups
- Teacher surveys and interviews
- Facilitator surveys and interviews
- Session observations

Part 1. Overall feedback

The following reflects feedback from teachers and facilitators, along with generic observations of the sessions. There is less student feedback in this section as they were primarily asked to comment on individual sessions only but where applicable their feedback has been included.

A. Student feedback

Stimulate interest in science
Students in the post session focus groups felt the sessions had stimulated their interest, demonstrating that science isn't all just maths and written work, and is actually accessible and practical rather than just theoretical

> *It kind of made physics more down to earth…like I can do this.*
>
> *How physics applies to the real world.*

Facilitators
Students were very positive about the facilitators, seeing them as likeable, inspiring and knowledgeable.

> *She had lots of enthusiasm*
>
> *Made me feel more 'sciency'.*
>
> *She made me want to go up and do it…they made you feel like you were good at it and might be successful.*

In some focus groups students said it was better to have more than one presenting to create variations in delivery style and voice, as well as providing more one to one engagement. When this didn't happen students wondered why not, given they were perceived to be experts; their talent was wasted just standing there.

They should have got more involved, maybe they should have rotated it...so each one could present a different thing.

Instead of just standing there and switching on the lights, they could have taken it in turns.

Gender of the facilitators didn't spontaneously come up in the focus group discussions with students except in one case where all three facilitators were female.

It's better to see that more women and getting into science because when I was younger it was nope but that's changed… because I watched the Big Bang Theory.

B. Teacher feedback

Why take part?
Participating teachers were asked why they had decided to have the SEPnet teams bring the Connect Physics sessions to their schools. The primary reason was for pupils to learn in a different way, closely followed by the hands on, practical element of the sessions and that external presenters tend to create greater pupil interest. Least mentioned was the physics element of the sessions. See Table 10 below.

Table 10. We are interested in finding out why you booked the Connect Physics sessions. Please indicate how important each of the following reasons were for booking, where 5 = a very important reason, 1 = not at all important. (n=6 teachers)

Reason	Mean score out of 5
It was an opportunity for pupils to learn in a different way	4.0
The hands on, practical, element of the session attracted us	3.7
Having external presenters creates greater pupil interest	3.7
It was free	3.2
It was an opportunity for pupils to use resources not usually available at school	2.8
We had taken part in a previous SEPnet run session	2.5
The topics covered are part of our curriculum this academic year	2.5
We were attracted by the physics element of the session	2.2

In the interview conversations with teachers some also mentioned the difficulty in getting students to take A level Physics and they hoped that these sessions would make the subject more appealing by making it more accessible.

We want our students to see themselves as scientists, we want our students to be interested in science.

To give students a love for physics before they fall out with it, as many students, particularly girls, do.

It is another level of energy, I have to be Miss, I have to be a teacher…I have to behave by the rules.

I love physics but it's not enough for me to say, I need someone else to say it…I needed someone else to give some ideas and to have some fun, and it was fun.

Additionally, some teachers felt the Y8 curriculum is quite easy to get through so having some additional supporting content is useful to have.

Value of the sessions

Teachers saw the sessions as a value way to show how science is relevant, having real scientists (but don't look like stereotype scientists) deliver this message is an additional bonus.

The idea that they can see science isn't just in a school environment that it's out there everywhere, that people are problem solving everywhere and that involves science and that's incredible value.

It allowed the pupils to work in groups and identify Physics rather than just be told where Physics is and learn the theory.

Giving them a better understanding of what real scientists do, not just what you do in school.

Further benefits were cited as…

- Seeing some technology not available in schools
- Generating an interest in and understanding of the importance of physics
- Applying physics to everyday life
- Linking ideas in physics
- Experiencing being taught by someone with specialist knowledge
- Making physics appear less the 'hard science' to students to being more accessible and therefore worth considering continuing as a subject

Supporting current teaching

The sessions provided a valuable complimentary addition to what is being taught in class. While in most cases the topic of the session wasn't something that would be taught to Year 8 students it was agreed that having science presented in this way provides context to the very content driven nature of the curriculum. There was some overlap in key words used in the curriculum and in one case the topic of mechanics tied in nicely with the How? session.

In the survey teachers reported a mixed approach to how the sessions linked in with either current classwork or any session specific preparation. The most common response for What? and Why? (n=8) was that the class hadn't done any preparation and physics and its wider connections was not a topic. Conversely the second more cited response was that the topic had been covered before and again, no specific preparation was done before the session. Given that physics as a topic in Year 8 may only occur once a term at best, trying to tie this into the Connect Physics sessions is probably too complicated for many teachers. Indeed, some sessions we observed were not run as part of a regular science lesson at all, instead they formed part of general subject taster days. Only in one case in the qualitative evaluation did we find a class that had been covering physics at the same time as the sessions (over the course of half a term) and the feedback on this combination was very positive.

Facilitators

The facilitators were praised as being good at working with the students, answering questions and competent at handling the class.

> *[The officer] is excellent. She engages with the boys very well and is very enthusiastic.*
>
> *The enthusiasm and interest they all bought to the session was contagious, excellent.*
>
> *Very passionate and engaging. Inspires others.*

Providing resources

A number of teachers thought that having the session slides available online would be potentially useful if they chose to run them themselves in future years or with students who didn't attend the externally run sessions.

Logistics

There was very little negative feedback around this aspect of the programme. Only one teacher commented that because the outreach team arrived late the time available for the session had to be cut short.

Delivery

Most teachers believed the one session per term was the best format, although some who were covering physics within a specific half-term period were inclined to think that 3 sessions in one term would be better as it could link in with the classroom topic.

Looking ahead

All teachers who responded said they'd wish to have Connect Physics sessions at their school in the future and all were likely to recommend such sessions to other teachers.

C. FACILITATOR FEEDBACK

Session design
Outreach offices believed that the structure of What? Why? How? was a good one and effectively conveyed key messages about the use and value of physics specifically and science more generally. While the three sessions worked well as a whole, those, who due to circumstances, were only able to run one or two found these worked equally well on their own.

The resources to deliver the sessions were felt to be well designed and provide a useful addition to their current outreach activities. Indeed, some said that they would be solely using Connect Physics in their coming academic year. The resources were something they would struggle to create themselves (particularly the interactive elements). They contained key messages but were flexible enough to be adapted where desired.

Delivery timing
Facilitators (both outreach officers and student ambassadors) had mixed opinion as to whether the sessions should be delivered over the course of a year or a term. The former has the advantage of creating more student interest over a longer period of time while the latter ensured that the learning could be re-enforced better, more easily linked to a classroom topic and sometimes easier to schedule with the school.

Impact
When asked to give their overall assessment of each session facilitators were fairly consistent in agreeing that pupils enjoyed and actively engaged with the activities. Only the case of How? did they feel pupils didn't learn as much about physics as in the previous two sessions. See Table 10 below.

> *It depends on how I'm meant to interpret the question. I would say they learnt about the process of doing science, but not anything specifically about physics.*

Table 10. To what extent do you think the session delivered the following?
(Score out of 5 where 5=Completely delivered)

	What? n=22	Why? n=6	How? n=8
The pupils enjoyed the session	4.2	4.3	4.3
The pupils learnt something new about Physics	4.3	4.3	3.4
Pupils actively engaged with the session	4.5	4.3	4.3

Age appropriate
Facilitators felt the all three sessions were pitched at the right level for Year 8. One suggested that running the sessions prior to when students are considering their A-Level choices (i.e. Year 11) might be more effective in encouraging the uptake of Physics.

However, another suggested that the message that physics/science and possible career options is as important for younger students as it is for those who are older.

Programme format
Facilitators were asked about the structure of running the programme in three sessions over three terms and whether there might be an alternative more effective option.

The feedback suggests that having three sessions is better than a single session that might overwhelm students.

> *I like the three sessions. I think they engage better when the session is shorter.*
>
> *This way is fine, it allows a lot of content to be delivered and gives constant reminders of physics as opposed to one session which could be forgotten more easily.*

That said some felt that three over a single term would ensure the messages are better remembered between sessions.

> *I think the kids would forget if it's just 3 sessions over a whole year. Maybe 3 sessions over a shorter period?*
>
> *If the sessions are too far apart they won't be seen as relating to each other so perhaps have the 3 sessions over a smaller time period.*

The consensus appears to be that spreading them over the school year is probably on balance the most effective approach.

> *It seemed to work well having one per term - the majority of students remembered me from the previous visit.*
>
> *I think this is appropriate because if the students had all the information at once, it would be forgotten quickly. Revisiting the information helps consolidate the things that students learn.*
>
> *I think this is a good approach as the children were excited to see us again so there was just enough time between sessions for them to remember us and be excited about what activity we're doing next but not being too frequent for them to be bored by us.*

Support from SEPnet
Facilitators said the training was good to have at the awayday as the PowerPoint slides are quite sparse. It was also good to have practiced running the session beforehand, although for some, watching someone else present it first would have been even better[2].

Facilitators were asked what, if any, additional support could be helpful in delivering better sessions in general, suggestions made were:

- Ensure teachers know they are still responsible for class behaviour
- A shared list of demonstrations and physics examples on Dropbox
- Software that isn't blocked by the school computer servers OR that can be run independently of the school system
- More props to pass around
- More visual demonstrations such as short videos

In terms of the **presentation materials** some said the PowerPoint slides should be larger, so students could see them better. Additionally, facilitators like to give examples of their own research work as they can see that school students respond well to these 'real' examples. Being able to change the pictures on slides more easily was therefore suggested.

Curriculum links
Outreach officers felt that the sessions provided value added to the curriculum rather than simply following it (something that is likely to make Connect Physics more future proof by not being too closely tied to content that changes regularly). However, the sessions do link to the curriculum through skills development and this could be something to emphasise when promoting to new schools.

Resources for schools and teachers
Having online resources for teachers to follow up with, perhaps including links to good material for further exploration was suggested by some. Also suggested was an online forum where students and teachers from different schools could compare, collaborate and/or compete with one another.

D. Observation feedback

There were a number of factors that influenced the quality of the sessions; student behaviour and teacher control, environment, pace of the session, confidence and number of facilitators, availability of practical examples and resources, activity format and time available.

Student behaviour
In some sessions students were prone to being disruptive and with limited teacher control meant the facilitators had to engage in discipline rather than delivering the

[2] This happened in some of the sessions we observed

sessions, often at the expense of those students who did wish to take part. This was most noticeable when the session was being delivered to general classes under the supervision of a teacher they wouldn't usually have. In some classes boys were very vocal and dominated the discussions either without being asked or by being more willing to put their hand up. In some cases, this led to girls not contributing despite clearly being willing and able to do so.

> *Something about it that could have been done differently - maybe they could have asked people who weren't putting their hands up - when most people don't understand in lessons they just keep their hands down.*

Environment
The whiteboards used were often too small and washed out with too much light, making seeing the content hard to read for those towards the back of the classroom. In some case the seating configuration didn't lend itself to the session, for example seating in squares with their backs to the facilitators.

Pace
In some cases, students required more explanation while others picked up the instructions quickly. Where there were more facilitators or science teachers present these differences could be acted on more quickly. Otherwise some of the explanations for the activities were quite long (see activity format below). Having activities ready and available for the more able would ensure they remained engaged while the remainder catch up. Again, a discussion with the teacher beforehand to establish student ability would be helpful for facilitators.

Facilitator numbers and confidence
The outreach offices and many of the student ambassadors observed were very confident in delivering this kind of content, as well as controlling classes of 30+ students. However, in some cases the delivery was left to inexperienced facilitators, something that students picked up on, and made them feel that the session delivery was awkward and less than professional. It was also observed that the better sessions benefited from having two or more active presenters; the use of more than one voice better holds student attention and enables them to be more hands on in helping students with the activities and answering questions.

> *More fun with different personalities.*

> *The atmosphere went down a bit because the other one wasn't there.*

Facilitators held student attention better when they moved around, rather than just staying at the front of the class. This also enabled those at the back of the room, facing away from the front (on tables with chairs facing each other) or trying to avoid engagement to be involved more (whether they like it or not).

Allied to this is the need for clarity over what role the teacher should play; discipline only or a more proactive role working with the delivery team and students. In some sessions the teacher did get involved and in one school she had organised some Year 12 students to come and play a supporting role too. Some of these older students were helpful in discussing the Year 8 student's ideas, others were very passive and didn't appear to add much to the session.

Having young student ambassadors also appeared to add value, people the school students could more easily relate to than older facilitators who may come across as external teachers.

> *They are closer to our age so understand we might have lots of questions.*
>
> *They probably know more about school life so able to get our attention.*

They also gave students more courage to present their ideas, feeling less intimidated and/or worried about getting it wrong than if the session had been run by their teacher.

Pitching at the right level

Overall students appeared to quickly grasp how to carry out the tasks and activities after the facilitator had explained them. There were some case where students didn't understand the language or words used, particularly in the What? session, for example 'Transverse' and 'Longitudinal' and facilitators need to be sensitive to vocabulary levels, explain words that might be unknown for some students.

While more able students had longer attention spans, facilitators need to be cognisant that the less able are likely to quickly switch off if there's too much talking and not enough doing.

Availability of resources and examples

Having enough materials for students to use, or share between two helps ensure student engagement, any situations where students haven't got something to do leads to disruptive behaviour or switching off.

Activity format

In most classes that were not higher achievers, any talking that lasted more than five minutes lead to students disengaging (slumping, checking phones, chatting, messing about). Written exercises and other printed stimulus were far less effective at engaging interest that objects and tactile activities. Activities that involved an element of challenge (linking words in What?) or competition (job interviews in Why?) were highly engaging but need to be balanced with ensuring all students have a chance to contribute rather than the most vocal or keen.

Time
Generally, facilitators timed the sessions well, delivering all the core content without rushing. However, in some cases sessions had to be reduced down to 30 or 40 minutes and while this was achievable it does compromise the quality of the session.

Student preparation
In many cases students clearly hadn't been prepared for the session, and teacher interviews supported this observation, in that the topics in the sessions rarely connected with what was being taught in school. However, having an idea in advance from the teacher of what students may have been covering that might relate to the session would provide a useful introduction or added value to the teacher for subsequent classroom learning.

What they learnt
From observation students appear to have learnt or developed skills in some or all of the following areas:

- Broader science vocabulary
- The universality of physics
- Working in groups
- Explanatory skills
- Role of scientific equipment
- Science is for girls/women
- Science can be fun
- Science is practical

Connect Physics USP
The sessions provide two key deliverables not available at school:

- Making physics accessible
- Expert scientists
- Strong female scientist role models
- Demonstrations using new equipment

Part 2. Individual sessions

Session 1: What Connects Physics?

A. Student feedback

Based on survey responses from n=191 students and post session focus groups.

When asked to describe the session in up to three words students most cited the '*What Connects Physics?*' sessions as fun and interesting. In the focus groups, students further described the session as practical with some real wow moments.

You don't see lightening in a room too often.

The examples looked pretty cool.

Enjoyment
Nearly all (91 percent) surveyed students said they enjoyed the session to some degree with 55 percent saying they enjoyed it very much. The message that physics is not just for the classroom came across well as did the idea that physics has many connections in everyday life rather than just an abstract subject to learn.

> *I enjoyed the session today. It was interesting and insightful - it taught me that physics is in your everyday life - that it's not just about movement and joules, science-stuff and Newton.*

> *I liked the exercise with two words on the board - I didn't know how the opposites could have a connection or how they related.*

Learning
As well as enjoying the session most (94 percent) said they had learnt something, with 48 percent saying they had learnt a lot. When asked about three specific learning outcomes,

students were most likely to say the session showed them how physics connects many different topics. See Table 11 below.

Table 11. How much do you agree or disagree with the following statements about the Connect Physics session? (n=155)

Outcome	Mean score out of 5
It showed me how physics connects many different topics	3.6
It showed me that studying physics might be useful even if I don't want to be a scientist	3.4
It showed that physics is useful for understanding how things work	3.4

Impact

When asked to give more detail about the most surprising or interesting elements to the session it was again the connections made between different objects that most caught their imagination.

> *That they could relate two random things (e.g. A donkey and a potato) to Physics.*
>
> *That physics is connected to so many different things.*
>
> *That there is a scientific connection between everything on the earth.*
>
> *They proved that you can link nearly everything to do with science.*

They also picked up on how physics has applications across a huge spectrum.

> *Physics can be used in everyday life and how things work in life and outer space and mostly everywhere.*
>
> *I have a better idea of what physics is now - before the session I didn't really have a good idea, just knew that it's something to do with earth - now I know that it's about the earth, atmosphere, forces and the knowledge of nature.*

Many enjoyed the experiments and using the equipment supplied by the facilitators.

> *I liked the part when the people used the laser to make the radio work.*
>
> *I found the magnet experiment very interesting.*
>
> *I learned about the plasma ball which was very interesting.*

When the girl and boy told us to put on some glasses and look at some light then we saw some of the rainbow and colour s*pectrum.*

Some felt the session was good in demonstrating how physics can be useful for future work (even though this session wasn't specifically about this topic).

That there are lots of connections to physics from all around us and that taking physics can give you more jobs in life.

You can do Physics for many different non-science related jobs.

In one case a student felt the session helped demystify physics making it seem less difficult than originally believed.

Physics has a wide variety of different topics that can be learned and that it is not that hard once you get used to it.

Although this was not always the case.

Even though it does make it more fun it doesn't exactly make it easier.

Watching the demonstrations was also of interest.

Watching people demonstrate the practicals.

In some sessions facilitators provided more information about the scientists featured in the connections grid, and this was noted and appreciated by students.

The most interesting thing I learnt during the session was the background information on the most famous physicists' lives.

That Galileo the great scientist is absolutely amazing in addition to that I leant that he was nearly killed.

There was a scientist called Edward Hubble and he named the space telescope, Hubble. He was also a great physicist.

In addition, quite a number of students described specific scientific knowledge they had acquired as a result of attending the session.

I like that they knew all the answers to my questions and this helped me learn more and gain more knowledge.

Learning about different atoms and particle and about force and a lot more.

Antimatter is caused but the positrons being reversed but can only be made in certain quantities due to the fact the matter eliminates all the antimatter this was extremely interesting.

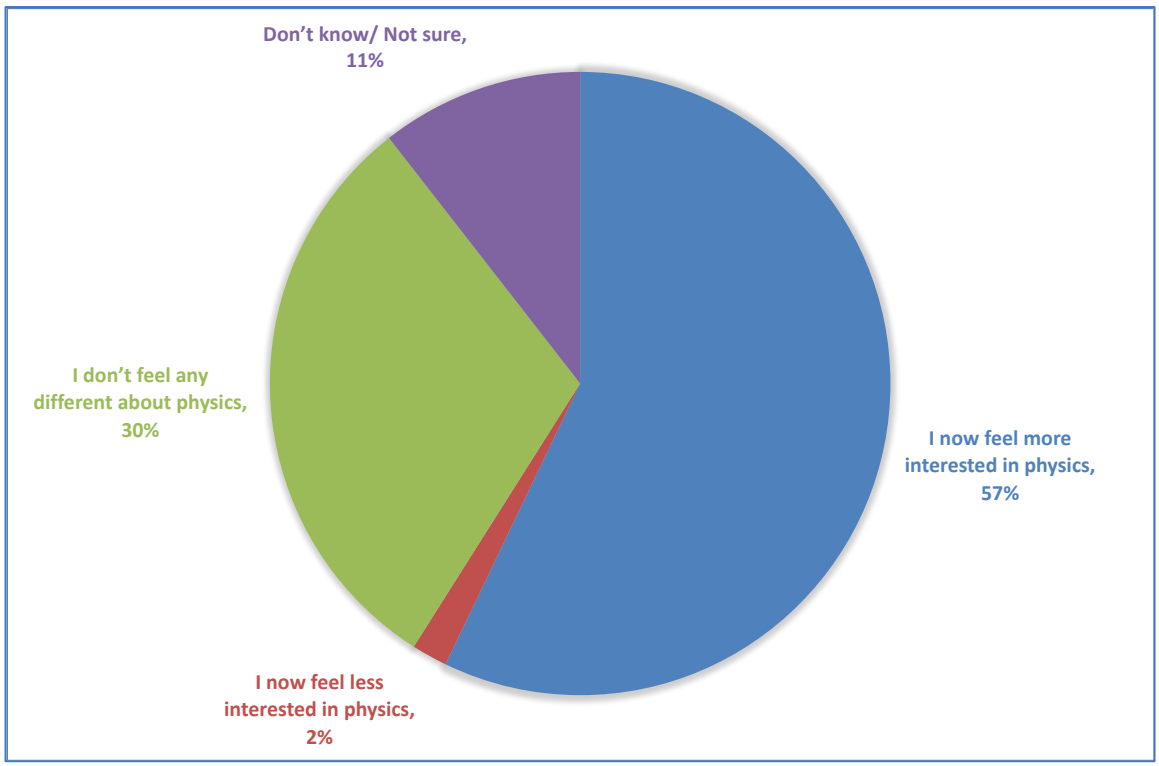
And in one case…

The session makes you want to go and learn some more things about Physics.

Attitude towards physics

As a result of taking part in the What? session well over half (57 percent) of students said they felt more interested in physics. See Chart 5 below.

Chart 5. Which of the following statements best applies to you? As a result of the Connect Physics session…(n=161)



However, in the post-session feedback discussions with students, a number of girls said they found physics harder to relate to than the other sciences, particularly biology. While the sessions do make a point of relating the content to everyday lives, ensuring this

happens as much as possible will help to engage those who wouldn't otherwise be drawn towards physics.

Suggested improvements
The most cited improvements to the session were more experiments and activities, particularly where students can get involved (rather than having things demonstrated to them). Other ideas put forward were:

- Less written activities – these were compared to an English lesson by one student
- A longer session
- More time for questions and answers
- An explanatory video
- Less time on the initial grids

B. TEACHER FEEDBACK

Teachers described the What Connects to Physics? session as; interesting, well prepared, engaging, interactive, well resourced, valuable and different.

Value to students
Of the five teachers who responded to the survey all completely agreed that the What? session helped pupils understand the link between physics and other topics. They also agreed the pupils both enjoyed it and increased their knowledge about physics. Least agreed with was the session teaching pupils how to apply practical skills to problem solving? session. See Table 14 below.

Table 12. How much would you agree or disagree with the following statements about the What Connects Physics session? (5=Completely agree, n=5 teachers)

Outcome	Mean score out of 5
It helped my pupils better understand the links between physics and other topics	5.0
My pupils generally enjoyed the session	4.2
It helped my pupils build their knowledge about physics	4.2
It helped my pupils change the way they see the value of science outside of the classroom	4.0
It helped my pupil's understanding of potential of physics when thinking about choosing their subjects to study at GCSE	3.4
It helped my pupils learn how to apply practical skills to problem solving	2.8

Session format and content
All believed the session to be appropriate for Year 8 students. One teacher liked the idea of making links between physics and other subject areas, while another praised the session for its hands-on activities that helped keep students engaged.

Suggested changes or improvements
Teachers made a number of suggestions that highlighted the need to ensure single tasks didn't go on too long, that there is enough equipment for students to work with and generally have more hands-on activities if possible.

> *The card sorting task was a little repetitive. I feel that doing this 2 or 3 times was sufficient.*
>
> *The equipment to student ratio was too large. Not all students got to use the infrared camera or the spectrometers for example. Some demonstrations took a lot of time to show to the students leading to some going off task whilst they waited.*
>
> *It would be good to spend less time on the connections quiz and more time up and experiencing using different equipment.*
>
> *Perhaps more opportunities to complete practical work or encourage students to work in groups.*

One teacher suggested that having some form of video introduction to explain the process of making connections before starting the task would be helpful.

C. FACILITATOR FEEDBACK

Based on n=22, (10 outreach offices, 12 undergraduate ambassador survey responses), five interviews and a follow up discussion with six of the outreach officers.

Nearly all facilitators in the survey feedback rated their experience of delivering this session as positive, which given that in many cases (15) it was the first time they'd delivered, is encouraging.

> *It was really well received by the students - they were the right level of rowdy (enthusiastic but not disruptive). Second time I had run this workshop so I felt more confident with the material.*
>
> *It was the third time I was delivering the session so I felt confident with the material. The students mostly really got into it. We had some issues in the last session with a lower ability group - when we moved onto the connections game one girl said something along the lines of "of course you'll be able to connect any two things together, you've been to uni for years and are really clever" so we let*

her beat us (she asked us to connect crystals to something and we said we couldn't but we could connect diamonds).

The students engaged well with the activities. The students had a mix of abilities, but having the students group together meant that everybody got a similar experience.

Because working with the students is really nice, they're all lovely and genuinely interested in the activities which are also well planned out and engaging.

The students were well-behaved, I was well prepared, had good support from a Post Graduate student and the students enjoyed the session. The teachers were appreciative.

It was an enjoyable experience and the class received the workshop positively and showed some interest in physics.

Most of the students engaged really well with the activity. Especially building the chains. Coming up with suggestions themselves and testing me and the undergrads.

Because it got the students engaging and learning more and was fun to teach and explore the way they thought and to be able to guide them where needed was a massive learning experience.

There is nothing like seeing the reaction of students when they first see something like a plasma ball. The excitement, confusion and curiosity to understand how it works is amazing.

Those that didn't go so well were due to poor class control by the teacher or insufficient support to ensure students were engaged.

Found it quite tough running a workshop with a class of that size with only one other ambassador and no whiteboard. But the kids seemed very engaged and keen to get involved. Found it tricky to focus their ideas in the right direction.

Did four sessions - the first three went really well but the fourth was awful. The teacher had no control over the class and they were just super disruptive and didn't pay attention at all (when we walked in they were just finishing a practical and throwing their safety goggles/lab books at each other).

On the whole the students got involved with the activities and seemed to be enthusiastic about taking part, however there was on class that just did not want to do anything and getting them to try was incredibly difficult.

For one, handling the material for the first time was challenging.

> *I enjoyed using my brain again but did find making the connections difficult to do under pressure at the front of the class, especially fitting in a demo - need more practice and some better demos.*

Suggested improvements

- More levels to the What? connections game and/or an option for students to do it themselves.
- Offer a demonstration or scenarios of how to go from one word to another in What?
- More explanatory notes on the PowerPoint notes pages.

> *The groups have needed longer on the connecting wall game each time I've done it. I didn't find the accompanying PowerPoint very useful - it would have been better to have context in the PowerPoint notes.*

- More demonstrations in the session rather than so much time on the connections PowerPoint.

> *Include more demonstrations of physics. we included one demonstration and students were more eager to participate in this than anything else*

> *Add another element maybe, the activity could've been seen as a bit tedious for the whole session, otherwise it was great*

- Provide student learning objectives for the teacher.
- A vocabulary list.

> *Verbally telling the students what some of the words meant e.g. Hertz, plasma wasn't helpful for all the students. I recommend a little Connects Physics booklet, nicely designed with information printed e.g. the ISS/HUBBLE/DIAMOND with short sentences. Also relevant equations so that students want to keep the booklet for revision purposes.*

- Give students connections questions in pairs, or threes to make them make different connections.

> *Otherwise it is all about how 'clever' the (male) physics student appears (in my session today).*

- Some visual aids to the introductory part explaining what physics is and possibly some additional training for facilitators to deliver this.

- Better examples for students to understand the process before doing their own connections.

  Students to make the word connections in their own group at some stage (with the words they have on the distributed bits of paper), after an example on the board with the class, in addition to the class-led word connections. Perhaps format of class-led example on the board, group make connections between 2 of their own words on paper distributed, then one or two groups' example are fed back to the class, finishing with class-led physics word connection.

- Different, easier levels.

- A wider variety of the connecting words.

- The timer on the game to be louder.

- Less ambiguous answers on some of the grids (where there are 2 possible answers).

There was concern among some of the outreach officers that having presenters make connections between words was counterproductive as it only serves to demonstrate that scientists are clever (as students see it this way) rather than scientists being 'like us' and accessible. The process might be more inclusive and empowering if the students themselves could have a task to find physics in everyday objects and/or activities instead. If this was not possible, having the teacher more involved in the process instead.

D. Observation feedback

Having fewer connections and more time for demonstrations would have engaged students more and capitalised on the biggest benefits of having the sessions; external speakers and resources.

To keep focus a short demo could be conducted as soon as the first group is established – as the demonstrations grab student attention and make them realise that the session isn't going to be all paper work (something they wouldn't know at the beginning).
It could be helpful to have a way to write a note or visually model this activity for the pupils. Having a flip chart for modelling the connections challenge for example.

The idea of making a connection from A to B was instinctively appealing and students made efforts to create difficult links where possible; for example black hole to cow, internet to dustbin. Students were keen to see how the connection could be made but many started losing interest if the facilitator talked for more than a few minutes.

However, when the demonstrations were given even the most disruptive became engaged and literarily gave wow as their response on seeing the Van der Graaf generator, the rainbow glasses, infra-red camera, the balloon kebab and the plasma ball. This was the highlight of the session for most and the best moment for getting and holding attention of large and diverse groups of students.

They not only enjoyed the demonstrations but were quiet enough to hear what the facilitator had to say about them and in many cases students asked questions. This Q&A element could play a greater role, given the knowledge the SEPnet team brings. Having demonstrations interspersed throughout the session may be the best way to ensure regular re-focusing when students are easily distracted.

Session 2: Why Connect with Physics?

A. Student feedback

Based on survey responses from n=124 students and feedback from post-session focus groups.

As with What? when asked to describe the session in up to three words students most cited the 'Why Connect to Physics' sessions as fun and interesting although a small minority did say it was boring. See image below.

Enjoyment

91 percent of students completing the survey said they enjoyed the Why? session to some degree with 47 percent saying they enjoyed it very much. They liked a range of things about the session including:

- Problem solving
- More communication than writing
- Working as a team and discussions with others

- The selection process - thinking about matching people to jobs
- Learning what skills to look for
- Pitching for the job - the interview (where this happened)

Learning

Most (92 percent) said they had learnt something, with 46 percent saying they had learnt a lot. When asked about specific learning outcomes, students were most likely to say the session showed them how physics connects many different topics but nearly as many believed it showed them the wider value of studying physics and how physics is useful understanding how thing work (interesting given the Why? session did not really cover this topic. See Table 13 below.

Table 13. How much do you agree or disagree with the following statements about the Connect Physics session? (n=93)

Outcome	Mean score out of 5
It showed me how physics connects many different topics	3.5
It showed me that studying physics might be useful even if I don't want to be a scientist	3.4
It showed that physics is useful for understanding how things work	3.4

Impact

The most cited responses to the question 'What was the most surprising or interesting thing you learnt during the session?' was how studying physics can lead to a wide variety of jobs and not just leading to a job as a scientist.

> *The most surprising or interesting thing I learnt during the session was that when you study physics, it can be applied to many different jobs.*
>
> *Being a game developer is a type of science. When I found that out that was #EPIC!!!!1*
>
> *That a degree in physics doesn't mean you have to be a scientist.*

Others felt they had learnt more generally about what it takes to be selected for a job.

> *As much as I learnt about physics, I also learnt about how to get a job as one and how to read job descriptions.*

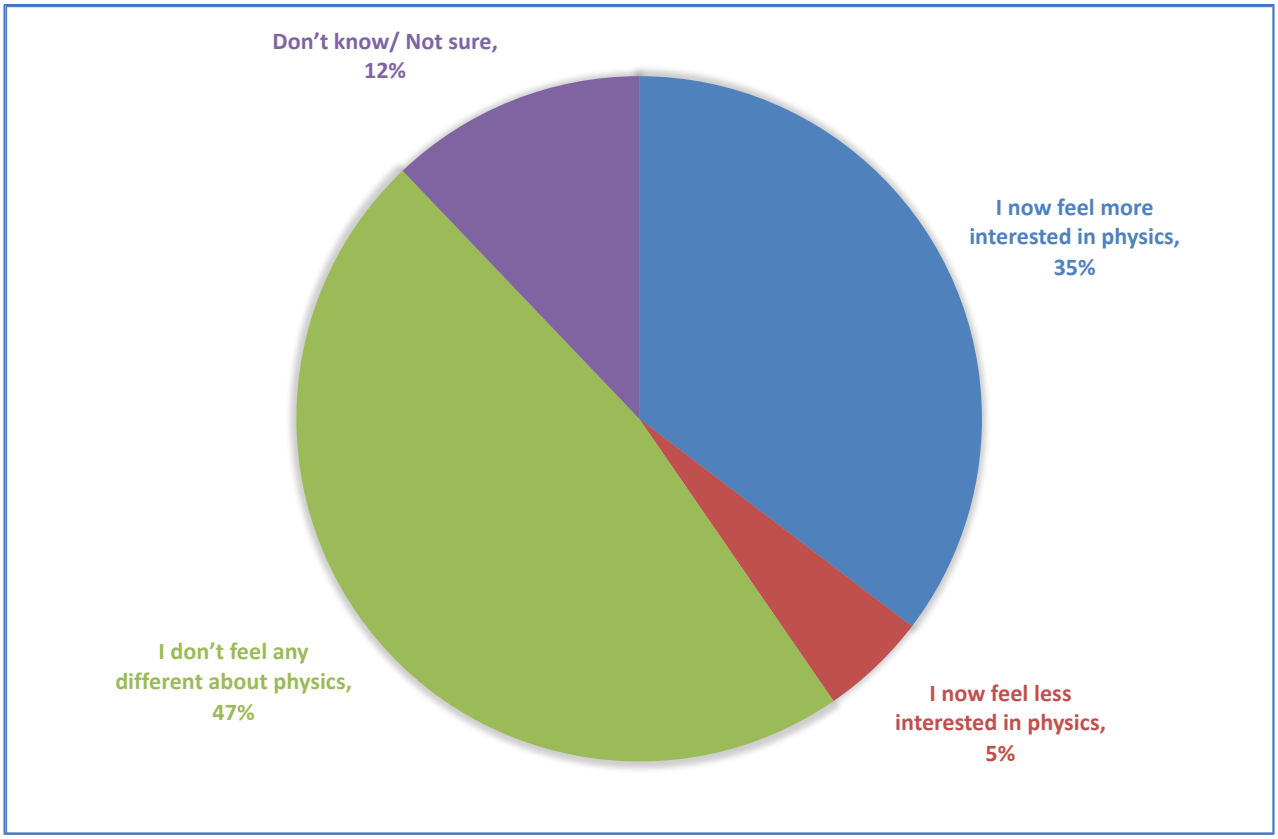
And a few felt they had learnt more about physics more generally.

> *I learnt that dark matter is strings and can make a laser bend over it.*

Attitude towards physics

As a result of taking part in the Why Connect? session around a third (35 percent) of students said they felt more interested in physics. See Chart 6 below.

Chart 6. Which of the following statements best applies to you? As a result of the Connect Physics session…(n=99)



Suggested improvements

While most expressed satisfaction with the session there were a number of suggestions to make it more engaging that included:

- Less written activities
- Video examples of jobs
- More discussion
- More creative activities - rather than just one
- Job seeking role playing
- Less focus on jobs requiring physics
- More learning about physics rather than jobs

B. TEACHER FEEDBACK

Based on n=5 survey responses plus one interview

Teachers described the Why Connect to Physics? session as; engaging interesting, interactive, thought provoking and inspiring.

Value to students

The five teachers who responded to the survey were most likely to agree that pupils enjoyed the session and helped them better understand the link between physics and other topics. See Table 14 below.

Table 14. How much would you agree or disagree with the following statements about the What Connects Physics session? (5=Completely agree, n=5 teachers)

Outcome	Mean score out of 5
My pupils generally enjoyed the session	4.6
It helped my pupils better understand the links between physics and other topics	4.4
It helped my pupils learn how to apply practical skills to problem solving	4.2
It helped my pupils build their knowledge about physics	4.0
It helped my pupils change the way they see the value of science outside of the classroom	4.0
It helped my pupil's understanding of potential of physics when thinking about choosing their subjects to study at GCSE	4.0

The benefits teachers felt the session delivered were:

- Exploring a range of job opportunities that students had not heard of
- Showing how physics can lead to many career paths
- Connecting schools to higher education
- Students get a different outlook on physics and not just what is taught in lessons

I think it's great to get them thinking about science as a career and getting them into STEM early is super important.

Session format and content

Teachers felt the session brought up to date knowledge of careers opportunities using science. Additionally, its interactive nature and use of role play made it engaging and relevant.

Resources

To really build on the sessions and link to the curriculum teachers felt that having supporting resources would be useful. One suggestion was to link the sessions with

science vloggers, showing the kinds of things scientists do and enabling students to post questions to them.

Suggested changes or improvements
One teacher suggested including video clips of graduates with jobs explaining how they got there from secondary school. She also suggested a more dynamic start - perhaps with a quick brainstorm on what jobs you could do if you do science – the most jobs wins. Or a list of jobs and ask which is the odd one out. Another felt the game could be less repetitive and a third felt it would have benefited from being longer.

C. FACILITATOR FEEDBACK

Based on survey n=7, (4 outreach offices, 3 undergraduate ambassadors), two interviews and a follow up discussion with six of the outreach officers.

Nearly all rated their experience of delivering this session as positive and students generally were considered to engage well with the session.

> *The students reacted really well to the game.*
>
> *We had a much better experience than last time - the deputy head of science sat in with the fourth class (who were disruptive when we did workshop 1). The students all seemed to get into it, and the head of science said how much she like it.*
>
> *The students were engaged with all the activities and seemed to enjoy it.*

However, in at least two cases poor discipline and a lack of teacher control meant the session was harder to deliver than it could have been.

> *There were some students that very much wanted to take part and have a go but as the day progressed attention waned, and the students became more unruly with the teachers not particularly able to instil any classroom management.*
>
> *For those that did take part in the class, it did appear that they enjoyed the session and became invested in their recruited candidates.*

Suggested improvements

- Provide examples of jobs physicists/ science related jobs for use in the Why? introduction.

- Add real-life examples.

> *Add some real-life examples. I mentioned the physics undergrads that became a TV weather-presenter ("They do the analysis too, and don't only present!"), and*

another in medical imaging. Maybe get the kids to say what real-life physicist they most relate to?

- Extend or amend the session to allow time for mini-interviews on top of the attributes exercise as this creates a more realistic scenario when applying for a job. One delivery team added an additional element that if there was a draw between 2 candidates students had to make a verbal pitch for choosing their candidate – much as you might do in an interview, so creating understanding that jobs are won by a combination of attributes. This added value for the more able students.

  I ran out of time at the end to do a wrap-up. I need to figure out a better way to get them to do the mini interviews if we do them, so it doesn't take up too much time.

- A more effective way of introducing the recruitment game to reduce the amount of talking required.

  I found it took a while to get into the recruitment agency game - there was a lot of explaining to do beforehand. Not sure anything can be done about this thought because it's needed.

- Better visuals (something common across all sessions was poor lighting combined with small text/screen, making seeing the content hard for those students at the back of the room)

  The way the score calculator displayed on the screen meant that the score multipliers were really hard to see so I had to spend time reading them out.

D. Observation feedback

Session content

The Why? session on careers required a rather long verbal explanation and overall was quite text orientated. Having a punchier start, perhaps with video content might have created a more dynamic session, although once students understood the competitive nature of the task they then became much more engaged. If they'd know it was going to be a competition from the beginning they may have got up to speed faster in their desire to know how to win.

We observed that that in some cases the candidates who gave the weakest interview (scored the least) still got the job based on their skills profile. This outcome either requires further explanation or needs addressing. It also wasn't entirely clearly how the interviews were scored and therefore what expectations were. Having an example here would be beneficial.

In at least two schools the idea of a games developer requiring science was very engaging and this example could usefully be used in future sessions as clearly this possible career is something of considerable interest to many (particularly male) students.

Session 3. How do we Connect to Physics?

A. Student feedback

Based on n=85 survey responses and two focus groups.

Enjoyment

74 percent of students in the survey said they enjoyed the How? session to some degree with 30 percent saying they enjoyed it very much. This is a noticeably lower figure than for the previous two sessions although the sample is based on fewer schools and therefore fewer sessions. However qualitative feedback suggests that students enjoyed this session the most. Key things they liked were the hands-on activities and the fact that the process didn't lead towards a known conclusion instead it allowed them to experiment with no parameters or boundaries.

> *Do something physically, just makes it more interesting.*
>
> *It was way more interesting that then other one (careers) because not everybody wants to be in the careers they were showing.*
>
> *I was enjoying myself so much in the physics lesson. When we tried to figure out the ropes and tube, how it was connected it was hard fast but I kept trying again and again and eventually I got it right I knew how they were connected. I would never forget this lesson in my Life, It was one of the best science fun lessons I had. Thank you to the physics team for this session I appreciate all you done for us. I would like to work part of physics as my future.*
>
> *It wasn't just staring at the whiteboard, you were doing stuff.*
>
> *There wasn't just a method we had to follow, we got to try our own thoughts.*
>
> *We weren't told this is how it's done, this is how we are going to do it, and this is what you'll do to do that.*
>
> *Nice to know there isn't just one dead end answer…this time we didn't know what was going to happen in the end.*

They liked thinking about how the different designs worked and how other ideas could contribute to their own.

> *Really interesting how many different ways people thought.*

Learning

Most (81 percent) said they had learnt something, with 27 percent saying they had learnt a lot, again, lower than the figures recorded for the previous sessions. The most citied learning outcome among students was that the session showed them that studying physics might be useful even if they didn't want to be a scientist. This was mentioned marginally more than the core session objective of demonstrating the scientific method. This could be explained by many students believing they already know the scientific method (some that was raised by students after one of the sessions). See Table 14 below.

Table 14. How much do you agree or disagree with the following statements about the Connect Physics session? (n=60)

Outcome	Mean score out of 5
It showed me that studying physics might be useful even if I don't want to be a scientist	3.3
It showed that physics is useful for understanding how things work	3.2
It showed me how physics connects many different topics	3.1

Impact

Students were asked to say what had most surprised or interested them in the session. Many were quite literal and said they enjoyed making the models and testing out various options, but there were three common themes running through the feedback:

- The idea that there can be more than one answer
- What the scientific method is
- How the scientific method can be used outside of a science context

That there is never one answer, endless theories but as you can't bring substances such as black holes into your classrooms you can only make educated guesses and are always welcome to ask why.

About how much evidence, explanation, thinking and re-thinking is needed to present a correct scientific theory.

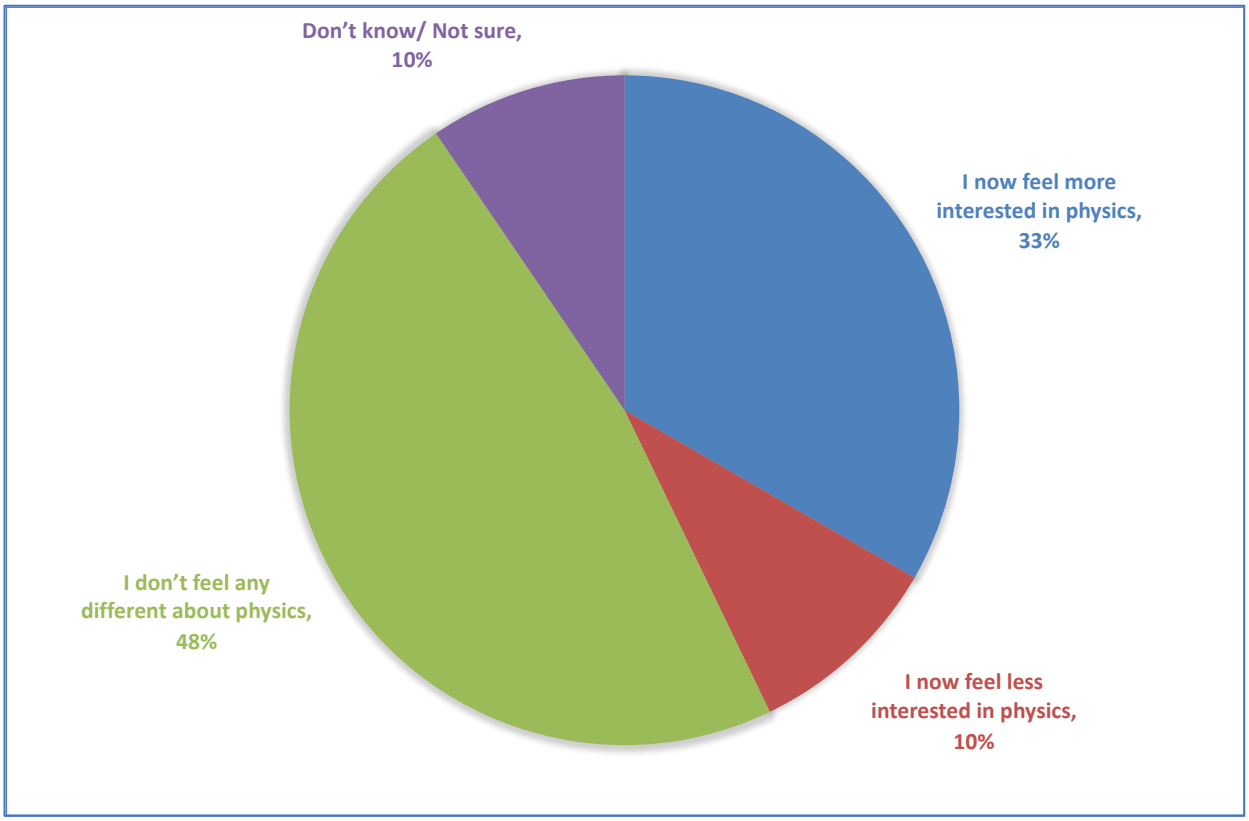
I learnt that if you apply the scientific method to a certain hypothesis, you can figure out missing variables or aspects to a situation.

Physics can be used in what we would assume 'non-scientific' situations. You need to use logic and common sense too.

Attitude towards physics

As a result of taking part in the How Connect? Session a third (33 percent) of students said they felt more interested in physics. See Chart 6 below.

Chart 6. Which of the following statements best applies to you? As a result of the Connect Physics session…(n=63)



Suggested improvements

The only suggested improvements were to have known who the mechanism worked, although a few students in the focus groups believed they'd worked it out anyway.

> *I know I got it right.*

> *I wanted to see what was inside.*

B. TEACHER FEEDBACK

Based on n=5 survey responses and 2 interviews

> *I think it might be my favourite one…self-discovery, it's what teaching science is in particular.*

Teachers described the How to Connect to Physics? session as; engaging, intriguing, interesting, interactive, practical, creative, fun, dynamic and inspiring.

Value to students
Teachers agreed that pupils enjoyed the session and it helped them better understand the link between physics and other topics. See Table 15 below.

Table 15. How much would you agree or disagree with the following statements about the What Connects Physics session? (5=Completely agree, n=6 teachers)

Outcome	Mean score out of 5
My pupils generally enjoyed the session	4.8
It helped my pupil's understanding of potential of physics when thinking about choosing their subjects to study at GCSE	4.5
It helped my pupils learn how to apply practical skills to problem solving	4.3
It helped my pupils change the way they see the value of science outside of the classroom	4.3
It helped my pupils better understand the links between physics and other topics	3.8
It helped my pupils build their knowledge about physics	3.8

The benefits teachers felt the session delivered were cited as:

- Helping pupils realise they enjoyed physics.
- Practical problem solving with investigation and questioning skills in a fun environment.
- Collaborative working.
- Thinking outside the box with no known answer - all too often in school a single correct answer is required but life isn't always like that, exams are set up to do this, so this approach is valuable to the learning process. Often science teaching is often around yes/no answers rather than multiple answers. Unexpected answers are also valuable in understanding the world around them.

  I quite liked the fact there were multiple ways to do it.

  I liked that students were not familiar with the session content so were never sure until the end what the answer would be. This kept students engaged and trying to work out options – some students created up to 4 different models to test out.

Session format and content
Qualitative feedback suggested that although the model was the most popular element having the other parts to the session were essential to provide the necessary context. For example, peer review is something they often do in class but is usually based on exam questions and is about right and wrong only. Having ad hoc conversations between groups provided further skills in communication and ideas development.

Suggested changes or improvements
Teachers suggested the following improvements to the How? session:

- Include a practical example of how the problem they are solving links to a real-world physics problem.
- Make it clearer to students why they are doing the activity over and above for fun.
- Ensure there's time for the presentation element at the end.

All of them were really willing to show what they'd done.

C. FACILITATOR FEEDBACK

Based on survey n=8, (3 outreach offices, 5 undergraduate ambassadors), 2 interviews and a follow up discussion with six of the outreach officers.

Nearly all facilitators rated their experience of delivering this session as positive with good student engagement. It was felt to be a good session to finish on, as it left questions unanswered, which is so of the case in scientific research. It was also felt to be useful in building student confidence in being willing to guess and deduce, rather than always seeking a single correct answer.

Everyone was engaged with the activity and seemed genuinely intrigued and excited to discover how the tubes worked.

There were 4 or 5 students that really didn't want to participate but on the whole they really got into it with some even trying to convince others that they had the correct answer to the problem.

The majority of children were engaged in the activity and were eager to figure out how the mystery tubes worked using the scientific method. While going around and talking to the children I found most with smiles on their faces and successfully working in small teams to figure out the challenge. A small portion were not interested at all which wasn't surprising as not everyone is interested in science.

Suggested improvements
Two suggestions for change were made:

- Smaller holes for the models or thicker string so they don't pull out when being tested
- Some good examples of using the scientific method
- A simpler version for Year 8 students

D. OBSERVATION FEEDBACK

Having time to allow students to present their findings really adds value to the session. In the one session where this took place girls appeared more reluctant to stand up and talk

about their findings than the boys and required some encouragement from the facilitators. When one group did so, they were asked some legitimate if rather difficult questions, which suggests that facilitators need to ensure a more structured approach where any questions asked are put to all teams so one team doesn't feel picked on.

6. Appendices

Appendix 1. List of participating schools in the evaluation, partner universities and responses for each

School	University	Baseline	What? Pupils	What? Teacher	What? Facilitator	Why? Pupils	Why? Teacher	Why? Facilitator	Endline Pupils	How? Teacher	How? Facilitator
Lampton	RHUL	-	28	-	-	34	1	-	24	1	-
Kings College Guildford	Surrey	50	-	-	3	-	-	-	-	-	-
Lilian Bayliss	QMUL	61	26	-	2	-	-	-	-	-	-
Oaks Park	QMUL	33	18	1	1	9	1	-	5	-	1
Beal High	QMUL	24	25	1	2	19	1	1	-	1	-
Howard School	Kent	34	17	1	1	23	-	-	-	-	1
Preston Manor	RHUL	-	7	-	2	-	1	-	-	-	-
St Edmunds	Kent	98	5	1	2	-	-	1	-	-	1
Hawley	RHUL/Surrey	-	-	-	1	-	-	-	-	1	-
Upton Court	RHUL	42	-	-		-	-	-	37	1	1
St Edwards		-	-	-	2	-	-	-	-	-	-
Toynbee	Southampton	25	11	1	1	-	-	-	-	-	-
St Richards	Sussex	31	33	1	2	21	1	1	-	-	-
Coopers	Kent	10	-	-	-	-	-	1	-	-	1
Overton Grange	Surrey	31	-	-	-	-	-	-	-	-	-
Mayfield	Portsmouth	-	-	-	-	-	-	1	14	-	1
Trafalgar	Portsmouth	-	-	-	1	-	-	2	2	1	3
Oxford Spires	Oxford	25	21	-	-	18	-	-	-	-	1
Portsmouth Academy	Portsmouth	-	-	-	2	-	-	-	-	-	-
TOTAL		**464**	**191**	**6**	**22**	**124**	**5**	**7**	**82**	**5**	**10**

Appendix 2. List of participating schools in the project, partner universities and which term workshops were delivered

SEPnet Partner	Name of School	Number Students Taking Part	Workshop One	Workshop Two	Workshop Three
Herts	Horringer Court Middle School	60	Term 1		
Herts	Westley Middle School	30	Term 1		
Kent	Coopers School	120	Term 2	Term 3	
Kent	St Edmund's Catholic School	120	Term 3	Term 3	Term 3
Kent	The Howard School	120	Term 2	Term 2	Term 3
Oxford	Oxford Spires Academy	30	Term 3	Term 3	Term 3
Portsmouth	Mayfield School	25	Term 1	Term 2	Term 3
Portsmouth	Portsmouth Academy for Girls	100	Term 1		
Portsmouth	Trafalgar School	100	Term 1	Term 2	Term 3
QMUL	Beal High School	30	Term 1	Term 2	Term 2
QMUL	Lilian Baylis Technology School	60	Term 1		
QMUL	Oaks Park High School	30	Term 1	Term 2	Term 3
RHUL	Lampton Academy	30	Term 1	Term 2	Term 3
RHUL	Preston Manor School	30	Term 1	Term 2	Term 3
RHUL	The Windsor Boys' School	180	Term 2	Term 2	Term 2
RHUL	Upton Court Grammar School	180	Term 2	Term 3	Term 3
RHUL / Surrey	Hawley Place School	30	Term 1	Term 2	Term 3
Southampton	The Toynbee School	30	Term 2		
Surrey	Bourne Community College	30	Term 1		
Surrey	Kings College Guildford	60	Term 1		Term 3
Surrey	Overton Grange School	30	Term 3		Term 3
Sussex	Cardinal Newman Catholic School	380		Term 3	
Sussex	St Richard's Catholic College	30	Term 2	Term 3	
TOTALS		**1835**	**22**	**15**	**14**