Ondata Research

Physics Mentoring Project
Annual Evaluation Report

Laura Thomas

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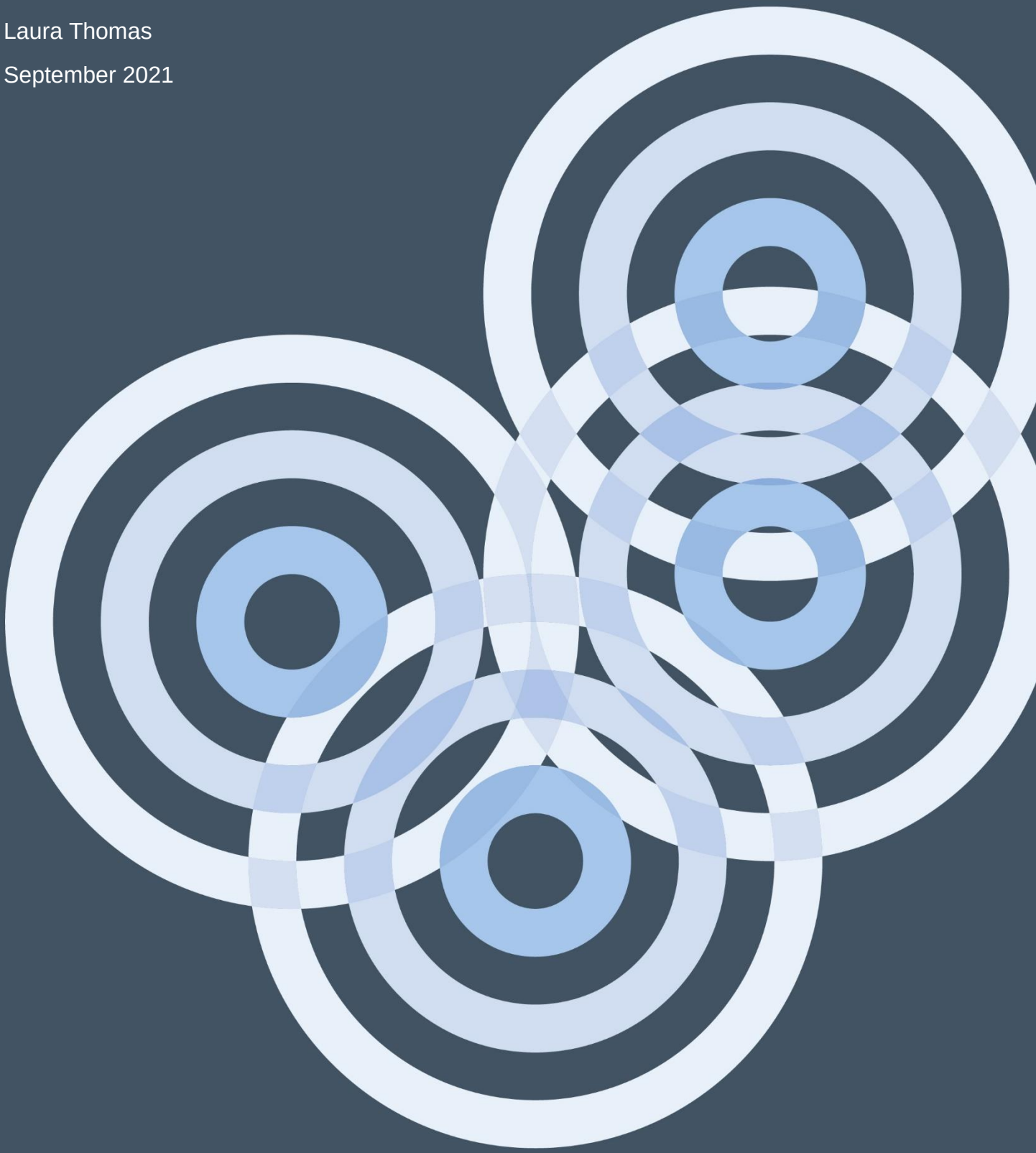

Contents

Executive summary 3
Introduction 7
Methodology 10
Results and discussion 13
Impact on mentees 13
Physics study post-16 13
Career intentions and aspirations 20
Confidence and resilience 24
Impact on schools 25
Impact on mentors 27
Conclusion and recommendations 30
Appendix A: Pre-participation survey questions 32

Executive summary

The Physics Mentoring Project (PMP) works with universities and schools to build effective partnerships with the aims of increasing the numbers going into A-level Physics in Wales and to support the personal and professional development of the university mentors.

The project ethos is described below:

> "Physics is instrumental in providing equity in understanding the world; being the language of how we move through it. Physics is relevant to all lives and experiences and should be available to all who wish to engage with it, regardless of background, protected characteristics or academic ability.
>
> "Physics is also key to unlocking transferrable skills, such as problem-solving, critical reasoning and numeracy, which can increase a person's enjoyment, safety and belonging in society and increase economic benefit. Physics skills can lead to an immeasurable number of careers and jobs, in a wide variety of fields."

The key groups engaged with via the PMP are schools (including teachers and pupils) and universities (via the academic leads and mentors).

Mentors are recruited from each of the following universities: Aberystwyth, Bangor, Cardiff, Swansea and University of South Wales. Not all of these universities have physics departments but they have a range of undergraduate programmes requiring a Physics A-level. The project team are based at Cardiff University with contacts in each of the participating universities providing a local link for the undergraduate and postgraduate mentors recruited to the project. These university contacts, and other stakeholders, contribute to the PMP via a steering group. The project team at Cardiff is comprised of Rosie Mellors (National Co-ordinator), Dr Chris North (academic lead), Dr Grace Mullally (Ogden Outreach Officer).

Once recruited, mentors participate in an extensive training programme, which has been iterated and expanded upon following each cycle of mentoring (2020-2021 is the fourth cycle of mentoring being run by the project). The impact of the COVID-19 pandemic on the project was extensive. Under normal circumstances training would take place in-person over a weekend. Instead, the training was redeveloped in order to be delivered online with a mix of synchronous and asynchronous elements. A further difficulty for the project was that it was unclear what mode of delivery they were preparing the mentors for. In Autumn 2020 the external circumstances surrounding the pandemic meant it was difficult to predict how the PMP would be able to interact with schools, if at all. In preparation, the PMP had a range of delivery models including in-person, blended and online only. Ultimately, the PMP made the

decision to focus on online-only delivery. The initial training sessions in November 2020 focussed on the theoretical framework to the project (the Science Capital Teaching Approach), mentoring theory and logistical aspects of working with schools (e.g. safeguarding). The follow-up training in January 2021 focussed on the practicalities of working with schools and introducing mentors to the content they were going to be delivering. In total, mentors participated in 23.5 hours of training, a significant increase from the previous cycle where the time spent was 16 hours.

As part of cycle 4 the PMP has worked with 125 mentees from 10 schools across Wales in the 2020-2021 academic year. Sessions were delivered remotely by mentors, with some taking place when mentees were at home during school closures with others running when they were back in school (in previous years mentors attended their allocated school for six weekly in-person sessions with a group of 6 mentees). Mentors were paired up, with one pair allocated to each school, allowing up to 12 mentees in each group (some schools had more than one group). Two schools who continued from previous cycles began their mentoring in Spring 2021 whilst the remaining schools joined from May with the final sessions being held at the end of the summer term.

During an incredibly difficult time, the PMP team worked to develop new relationships and maintain existing ones with schools. They were flexible to the needs of schools and understanding of their circumstances. This meant that the process of selecting mentees was more flexible this year and there was more fluctuation in attendance of the sessions due to the changes in teaching arrangements within schools. There were of course unprecedented pressures on the mentees themselves.

As in previous cycles, the evaluation aims to understand the impact on mentors, mentees and teachers.

Key Findings

- Following cycle 4 of mentoring, there has been an increase in interest in physics A-level amongst participants of **7.1%** (sum of responses “I definitely will” and “I probably will” to the question “How likely are you to choose Physics at A-level?”). This contrasts with the results from non-participating pupils from the same schools whose interest in Physics A-level has decreased by 2.4%.
- The post-participation survey results show a **9.5%** increase in interest in a science career amongst mentees (combined responses to “I definitely will” and “I probably will”. A smaller increase of 7.1% has been recorded for those who did not participate in the project.

- There were broad ranging impacts on mentees, in addition to increased interest in Physics A-level and science careers. For example, there was increased scientific literacy (*"I have enjoyed talking about topics that we don't normally talk about in school, such as statistical analysis" and "I have learnt how to think like a physicist"),* there was a positive impact on science-related attitudes *("I have learnt a lot about careers in physics and how we use physics in day-to-day life. I know now that I will be using physics in the future")* and increased awareness of the transferability of science (*I enjoyed learning just how many [physics] skills can be used in every-day life and how to transfer those skills when needed into other stuff").* In general, mentees were much more aware that *"physics is part of our everyday lives"*.
- Mentors were able to build effective relationships with mentees. The prompts and structure to the sessions put together by the mentors supported this successful interaction and engagement. Through the regular reflections of both the mentors and mentees, the mentors were able to make changes to the sessions in response to feedback, and so tailoring the content and format closely to what the mentees wanted. Within the sessions, mentees felt they were listened to and provided with comment or feedback on their thoughts: *"Our mentors answered any questions we had".*
- The feedback on mentors from the schools was very positive. Teachers felt that the mentees *"really related to them [the mentors]"* and that the sessions were delivered to a high standard: *"the resources were well designed, well delivered and organised".*
- The PMP has been successful in achieving their objectives in relation to mentors and universities. Specifically, they have been able to raise awareness of teaching careers and having increased the mentors' confidence and employability skills. The PMP also contributes to achieving the partner universities' civic mission agendas through the support provided to schools and the impact on the mentees in relation to their attitudes and intentions towards physics.
- Each year the project team proactively reflect on the challenges and successes of the project and are enthusiastic collaborators in the evaluation process, using the information and recommendations constructively along with their own observations and reflections to improve upon the previous cycle. Continuing the positive results amongst mentees is a significant achievement when it was delivered against very challenging external circumstances.

Conclusion

The PMP has successfully impacted on mentees in terms of the attitudes and aspirations in relation to physics. Following participation there was an increase of 7.1% in those who "definitely will" or "possibly will" take A-level physics. The PMP has maintained the positive

impact on mentees year-on-year through a well-established cycle of reflection and iteration of training and the mentoring model. Mentees are increasing their confidence and resilience in relation to physics and becoming more open to a science-related career.

Schools are benefiting from participating through an improved image of physics within the school, opportunities for professional learning for teachers and deeper relationships with university students and staff. The partner universities are being supported in achieving their civic mission agendas through this relationship development, whilst mentors are able to experience personal and professional development.

The following recommendations are mainly minor enhancements. The overarching recommendation to the project is to consolidate on the significant amount achieved in cycle 4 with the move to online-only mentoring.

Recommendations

1. Provide schools with the option of in-person or online-only sessions. Having online-only sessions has worked well in cycle 4. Whilst there will be some schools who will prefer a return to in-person delivery, there may be those who for a variety of reasons would like to continue to engage online. This has the benefit of allowing schools from all across Wales, regardless of their location, engage with the PMP. This will also provide the project with flexibility in case of the return of restrictions.
2. Mentors would like an informal space to discuss issues arising with each other without the oversight of the project. For example, they are keen to get quick, informal guidance on aspects such as technical advice, feedback on planned activities and sharing experiences working with schools.
3. Revisit the information and guidance provided to mentors before and at the training sessions in order to ensure they have a clear understanding about the time commitment and personal commitment to completing the training and participating in the mentoring sessions.
4. Compared with previous years, mentors did not get the same level of information from teachers about the mentees before starting the sessions. In future cycles it would be useful to agree a description of the types of information mentors should be asking teachers for before they go into the first session.
5. Where possible, organise a visit to the mentors' university to link with them and see the facilities and take part in some physics-related activities. Mentors, mentees and teachers are keen to return to in-person visits to universities. The mentees are able to relate well to the mentors in the sessions but for some this experience of seeing the university facilities could make a further contribution to them considering further study at university.
6. In addition to the project-related recommendations, a review of the evaluation methodology and considerations of approaches to longer-term tracking of impact will be pursued by the evaluators and the PMP project team.

Introduction

The Physics Mentoring Project (PMP) works with universities and schools to build effective partnerships with the aims of increasing the numbers going into A-level Physics in Wales and to support the personal and professional development of the university mentors.

The project ethos is described below:

> “Physics is instrumental in providing equity in understanding the world; being the language of how we move through it. Physics is relevant to all lives and experiences and should be available to all who wish to engage with it, regardless of background, protected characteristics or academic ability.
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> “Physics is also key to unlocking transferrable skills, such as problem-solving, critical reasoning and numeracy, which can increase a person's enjoyment, safety and belonging in society and increase economic benefit. Physics skills can lead to an immeasurable number of careers and jobs, in a wide variety of fields.”

The key groups engaged with via the PMP are schools (including teachers and pupils) and universities (via the academic leads and mentors). To support the work of the project, a set of objectives are described below.

School students:

- Increase the number of school students intending to study physics post-16.
- Increase the number of girls intending to study physics post-16.
- Highlight the importance of transferrable skills and promote STEM careers to school students.
- Increase the confidence and resilience of school students studying Physics.

Schools/teachers:

- Increase the confidence of physics teachers in Wales, with a particular focus non-specialist physics teachers.
- Engage with Welsh secondary schools, both locally and nationally.

Student Mentors and Universities:

- Promote the teaching career to undergraduate and postgraduate university students.
- Increase confidence, develop employability skills, and provide experience for CVs of student mentors.
- Promote the partner universities civic mission agendas and the wellbeing goals of the Well-being of Future Generations Act.

Mentors are recruited from each of the following universities: Aberystwyth, Bangor, Cardiff, Swansea and University of South Wales. Not all of these universities have physics departments but they have a range of undergraduate programmes requiring a Physics A-level. The project team are based at Cardiff University with contacts in each of the participating universities providing a local link for the undergraduate and postgraduate mentors recruited to the project. These university contacts, and other stakeholders, contribute to the PMP via a steering group. The project team at Cardiff is comprised of Rosie Mellors (National Co-ordinator), Dr Chris North (academic lead), Dr Grace Mullaly (Physics Outreach Officer).

Once recruited, mentors participate in an extensive training programme, which has been iterated and expanded upon following each cycle of mentoring (2020-2021 is the fourth cycle of mentoring being run by the project). The impact of the COVID-19 pandemic on the project was extensive. Under normal circumstances training would take place in-person over a weekend. Instead, the training was redeveloped in order to be delivered online with a mix of synchronous and asynchronous elements. A further difficulty for the project was that it was unclear what mode of delivery they were preparing the mentors for. In Autumn 2020 the external circumstances surrounding the pandemic meant it was difficult to predict how the PMP would be able to interact with schools, if at all. In preparation, the PMP had a range of delivery models including in-person, blended and online only. Ultimately, the PMP made the decision to focus on online-only delivery. The initial training sessions in November 2020 focussed on the theoretical framework to the project (the Science Capital Teaching Approach), mentoring theory and logistical aspects of working with schools (e.g. safeguarding). The follow-up training in January 2021 focussed on the practicalities of working with schools and introducing mentors to the content they were going to be delivering. In total, mentors participated in 23.5 hours of training, a significant increase from the previous cycle where the time spent was 16 hours.

As part of cycle 4 the PMP has worked with 125 mentees from 10 schools across Wales in the 2020-2021 academic year. Sessions were delivered remotely by mentors, with some taking place when mentees were at home during school closures and others running when they were back in school (in previous years mentors attended their allocated school for six weekly in-person sessions with a group of 6 mentees). Mentors were paired up, with one pair allocated to each school, allowing up to 12 mentees in each group (some schools had more than one group). Two schools who continued from previous cycles began their mentoring in Spring 2021 whilst the remaining schools joined from May with the final sessions being held at the end of the summer term.

During an incredibly difficult time, the PMP team worked to develop new relationships and maintain existing ones with schools. They were flexible to the needs of schools and understanding of their circumstances. This meant that the process of selecting mentees was more flexible this year and there was more fluctuation in attendance of the sessions due to the changes in teaching arrangements within schools. There were of course unprecedented pressures on the mentees themselves.

As in previous cycles, the evaluation aims to understand the impact on mentors, mentees and teachers. The following section describes the evaluation methodology.

Methodology

The evaluation methodology uses a Mixed Methods approach[1]. This has provided flexibility, especially when the delivery mode of the project was unclear. A range of qualitative and quantitative methods were used, detailed in table 1 below.

	Method	Purpose	Description
Mentors	Observations of training	To gain a better understanding of the training content and the project as it is presented to the mentors. Further, this was a chance to observe the interactions between the project team and the mentors.	Evaluator attended and observed the online sessions in November 2020 and January 2021.
	Training reflections/feedback	To understand the impact of the training on the mentors and to encourage mentors to reflect on the session content and any action they could take as a result.	Short set of questions completed at the beginning and end of each training session.
	Mentoring session observations	To understand the delivery model and how effective the interaction and engagement between mentors and mentees was.	Evaluator attended and observed online sessions at two different schools.
	Post-session reflections	To provide mentors a structured space in order to reflect on how the session went and what they could do to improve for next time.	Set of questions completed after delivering the session.
	Semi-structured interviews	To gain insight into the experience of the mentors both in terms of the training and delivering the mentoring sessions with schools.	A sample of mentors were interviewed following the completion of their set of sessions with schools.
Mentees	Pre- and post-participation surveys	To get an illustration of aspirations and attitudes of pupils in relation to physics A-level and STEM careers.	Pupils completed a similar set of survey questions pre- and post-participation. Pre-participation survey was used to help teachers with choice of mentees. Respondents included a non-participating group of pupils, which served to provide a natural control group for comparison.

[1] Cohen, L., Manion, L. & Morrison, K. (2018) Research Methods in Education. 8th Edition. Abingdon: Routledge

	Post-session reflections/feedback	To gain an understanding of their impressions of the sessions in terms of what they liked, what could be improved and what the key messages were that they took away.	Short set of questions on the session were completed at the end of the session or immediately afterwards.
Teachers	Semi-structured interviews	To gain insight into the impact of participation in the PMP with themselves and their pupils.	A sample of teachers were interviewed following the completion of their set of sessions with schools.
Project team	Semi-structured interviews	To understand the challenges and successes of the project management and in particular the impact of the COVID-19 pandemic on the project.	The National Co-ordinator and other team members were interviewed on their experiences of the project.

Table 1. Summary of evaluation methods

Data collection

Data collection was undertaken across cycle 4. Beginning with training observations in November 2020 and January 2021, continuing with survey returns as schools were recruited and then observations and reflections during the mentoring sessions, concluding with semi-structured interviews once the mentoring sessions had concluded in July 2021.

Informed consent was sought from participants with all data being handled according to GDPR requirements and using BERA's code of ethics[2] as a guide.

Data analysis

Quantitative data was analysed using both descriptive statistics and inferential statistics (e.g. paired t-tests) whilst qualitative data was analysed using reflexive thematic analysis[3]. Further information on the pre- and post-participation surveys analysis is detailed below.

The data analysed contained matched survey responses only. E.g. analysis of responses was only undertaken if the pupil had completed both the pre- and post-participation survey. Some took part in the mentoring programme and some did not. For those who didn't participate this offered a natural control group for comparison, as they have experienced the same school environment as those who took part in mentoring. The total number of survey responses is lower than previous years, the post-participation survey in particular, due to the many different pressures on schools due to the COVID-19 pandemic. However, seven of the ten schools

[2] British Educational Research Association (BERA) (2018) Ethical Guidelines for Educational Research, fourth edition, London. Retrieved from https://www.bera.ac.uk/researchers-resources/publications/ethical-guidelines-for-educational-research-2018

[3] Braun, V., Clarke, V. (2019) Reflecting on reflexive thematic analysis, Qualitative Research in Sport, Exercise and Health. 11:4, 589-597

taking part in cycle 4 are represented in the survey responses. The following tables summarise the gender and year group of the survey respondents. There were responses from 42 mentees and 42 from non-participating pupils.

Gender	Non-participating pupils		Mentees	
	n	%	n	%
Female	26	61.9%	28	66.7%
Male	13	31%	14	33.3%
Non-binary	1	2.3%	0	0%
Prefer not to say	2	4.8%	0	0%
Total	42		42	

Table 2. Gender of survey respondents

Year group	Non-participating pupils		Mentees	
	n	%	n	%
Year 9	20	47.6%	24	57.1%
Year 10	22	52.3%	18	42.9%
Total	42		42	

Table 3. Year group of survey respondents

In terms of comparing the make-up of the respondents in cycle 4 to those who participated in cycles 2 and 3, the gender split is similar, with females taking up a significantly higher proportion of responses. This is to be expected, as the PMP actively encourages schools to recruit female pupils. The main difference in cycle 4 has been the reduction in those from Year 11 who have participated and the increase in participants from Year 9. This has been the result of a refocussing of the targeting of pupils and will result in greater potential impact as pupils who take part in years 9 and 10 would have more time to develop their interest in physics.

	Percentage
BTEC Science	1.2%
Double Award Science	47.6%
Single Applied Science	1.2%
Triple Award Science/Separate Science	50%

Table 4. Responses to "Which science course are you taking?"

The split of the current science courses continues to be focussed on Double and Triple awards (Table 4). The responses to the key questions in relation to uptake of physics A-level and intentions around a science career are not statistically significant (p-value >0.05). This is unsurprising given the complex educational environment unfolding during the period of the PMP mentoring cycle. It was also the case this year that that non-participating pupil responses were not recorded for every school. However, the findings discussed in the following sections are consistent with previous years (especially around the different impacts found when comparing mentees and non-participating pupils) and combine different types of data, therefore they can still be considered valid. The following section discusses the impact of the project on the mentors, mentees and teachers drawing on a range of evaluation methods.

Results and discussion

Impact on mentees

The PMP's objectives for working with mentees in cycle 4 were to:

- Increase the number of school students intending to study physics post-16.
- Increase the number of girls intending to study physics post-16.
- Highlight the importance of transferrable skills and promote STEM careers to school students.
- Increase the confidence and resilience of school students studying Physics.

The first two objectives focussed on post-16 study can be examined using the pre- and post-participation survey data. The third, linked to career intentions and aspirations, can be reviewed using a mixture of the mentor and mentee reflections and teacher interviews as can the fourth objective around confidence and resilience.

Physics study post-16

In order to better understand the intentions toward post-16 study, pre- and post-participation surveys have been completed (see the methodology section for further information on the surveys themselves). The surveys consist of a short set of questions around the pupils' study and career intentions (see Appendix A for survey questions). One of the key questions is around their intention to choose Physics A-level. This information is provided back to the individual schools to assist the teachers in choosing who to take part in mentoring. Schools are encouraged to choose those who have the capacity to take Physics A-level but who are perhaps unsure about whether or not to take it. This means those who respond "definitely not" to whether they would choose physics A-level are not generally pursued for participation. Figure 1 summarises all responses for cycle 4 in the pre-participation survey.

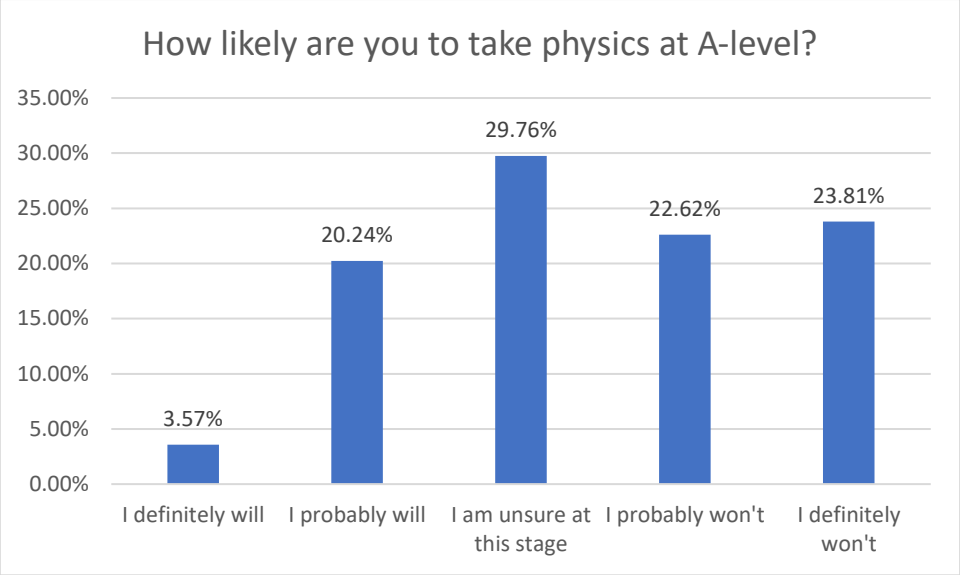

Figure 1. Responses to the pre-participation survey question "How likely are you to choose Physics A-level?"

The levels of those indicating they “definitely” or “probably will” is similar to previous cycles, in cycle 4 this is around 24%.

Science course	Mentees	Non-participating pupils
Triple science	73.8%	26.2%
Double award science	23.8%	71.4%
Single applied science	0.0%	2.3%
BTEC Science	2.4%	0.0%
Unknown	2.4%	0.0%

Table 5. Reponses to post-participation survey question “Which science course are you taking?”

The results in table 5 continue the trend seen in cycles 2 and 3, where mentees were much more likely to be taking triple science and this is a common route if pupils intend to take science A-levels.

Based on these initial findings, they are all consistent with those seen in previous cycles where the number of survey responses were much greater. So even though the number of responses to the surveys were smaller this year, they are following a similar trend to previous cycles.

The impact of participation on the mentees' intentions to take physics A-level is now examined in more detail. In the following figures, the respondents are split into groups based on whether or not they participated in mentoring.

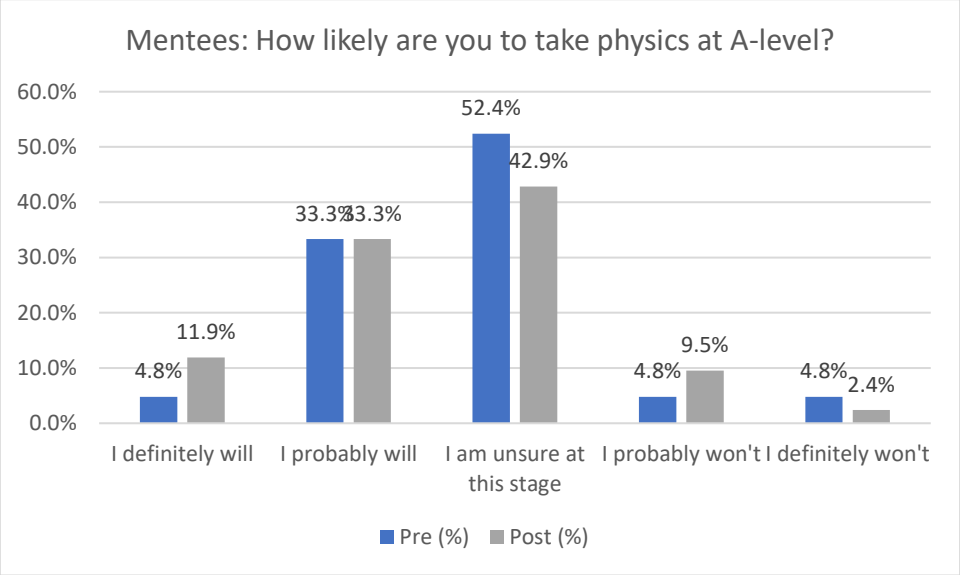

Figure 2. Mentees' responses to "How likely are you to take physics A level?" pre- and post-participation

	I definitely will	I probably will	Unsure at this stage	I probably won't	I definitely won't
Pre-participation	4.8% (n=2)	33.3% (n=14)	52.6% (n=22)	4.8% (n=2)	4.8% (n=2)
Post-participation	11.9% (n=5)	33.3% (n=14)	42.9% (n=18)	9.5% (n=4)	2.4% (n=1)
Difference	+7.1%	0%	-9.7%	+4.8%	-2.4%

Table 6. Mentees' responses to "How likely are you to take physics A level?" pre- and post-participation

Based on these survey results on the intentions of mentees, the PMP has made a positive impact in relation to the objective to increase the numbers going into physics post-16. Those responding "definitely will" and "probably will" has increased from 38.1% pre-participation to 45.2% (Figure 4 below examines the movement between categories in more detail). Given the disruption to teaching during cycle 4 and the uncertainty over the model of mentoring, it is a significant achievement for the project to have recorded an increase in interest in physics A-level amongst mentees. For comparison, these results are very similar to those recorded for cycles 2 & 3 where 12% of mentees responded "definitely will" and 37% "probably will".

In order to further understand whether this can be attributed to the participation in the PMP, these results can be compared to the natural control group of pupils from the same schools who did not take part in the project. They have experienced the same teaching circumstances as the mentees and been through similar pressures in their education due to the COVID-19 pandemic.

	I definitely will	I probably will	Unsure at this stage	I probably won't	I definitely won't
Pre-activity: non-participating pupils	2.4% (n=1)	7.1% (n=3)	7.1% (n=3)	40.5% (n=17)	42.9% (n=18)
Post-activity: non-participating pupils	2.4% (n=1)	4.8% (n=2)	19% (n=8)	28.6% (n=12)	45.2% (n=19)
Difference	0%	-2.4%	+11.9%	-11.9%	+2.4%

Table 7. Comparing pre- and post-survey responses by non-participating pupils

In comparison to the mentees, there has not been the same increase in those saying they "definitely will" or "probably will". For non-participating pupils this reduced: from 9.5% to 7.2%. See table 8 for details. A comparison between mentees and non-participating pupils is summarised in figure 3.

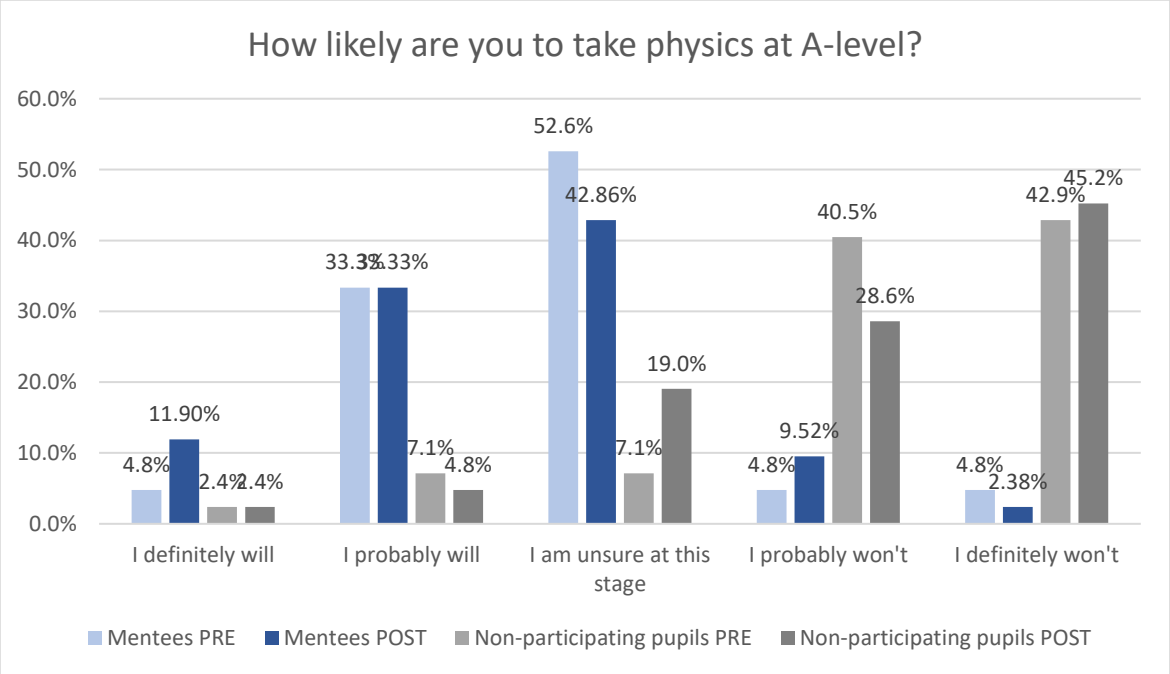

Figure 3. Comparison of pre- and post- survey responses by mentees and non-participating pupils

For mentee group, there has been movement across Figure 3 from right to left, meaning that they have become more positive about the potential of taking Physics A-level, with the effect on mentees being much more positive. It also shows a decrease in the mentee group of those who are unsure, with an implication being that through the mentoring programme they have a better understanding of what is involved in a Physics A-level and whether it is right for them.

The data from mentees has been examined in more detail to examine the movement between categories in the pre- and post-participation surveys.

- Those who were “I definitely won’t” pre-participation have moved into “I probably won’t” and “I probably will”.
- Those who were “I probably won’t” pre-participation have all moved into “unsure”.
- Those were responded “unsure” pre-participation have split across the categories post-participation, with some staying “unsure” with others moving to “probably won’t” and some to “definitely” and “probably will”.
- The majority of those who were “probably will” pre-participation have remained so post-mentoring, with some movement to “definitely will” and “unsure”.
- The one person who responded “definitely will” pre-participation has moved to “probably will”.

In general, there is an indication that mentees are becoming more open to physics as they move through the categories.

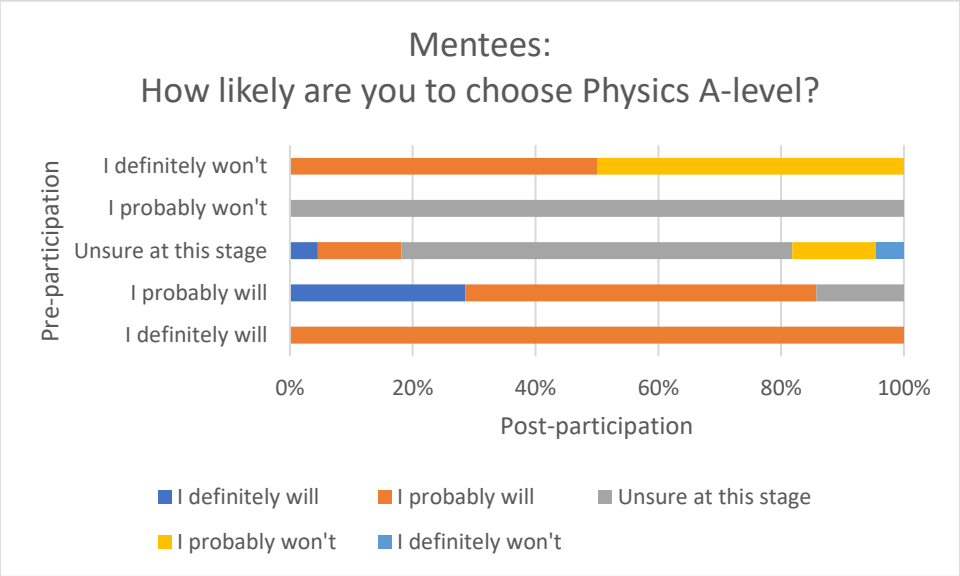

Figure 4 Movement between responses from mentees to the pre- and post-participation surveys in response to the question “How likely are you to choose Physics at A level?”.

When comparing these responses to those of the non-participating pupils, there are many more instances of pupils staying in the same categories, particularly those in the “definitely won’t” and “probably won’t” categories.

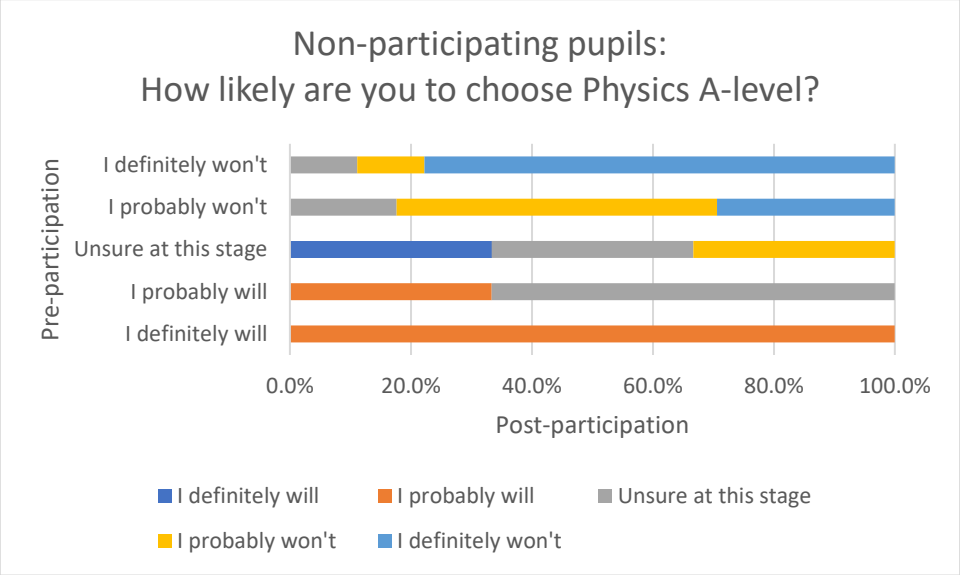

Figure 5. Movement between responses from non-participating pupils to the pre- and post-participation surveys in response to the question “How likely are you to choose Physics at A level?”.

The results from mentees in cycle 4 can be compared with the responses to the same question from previous cycles. Across each iteration of the project, there is a continued positive impact. Following participation, there are more mentees responding “definitely” or “possibly” and those responding that they are “unsure”, “probably won’t” or “definitely won’t” has been reducing. Although there is an increase in the numbers unsure in cycle 4, this could be down to the increased mentees coming from Year 9. Each year the project team proactively reflect on the challenges and successes of the project and are enthusiastic collaborators in the evaluation process, using the information and recommendations constructively along with their own observations and reflections to improve upon the previous cycle. Continuing the positive results amongst mentees is a significant achievement when it was delivered against very challenging external circumstances.

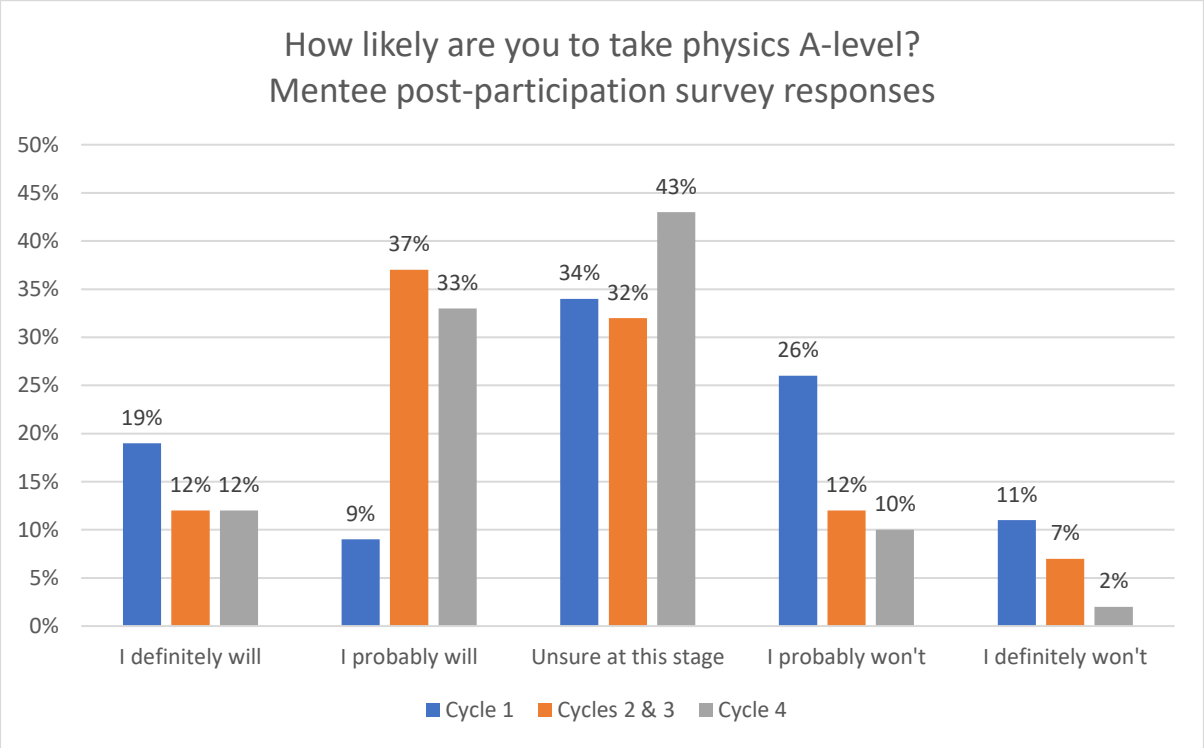

Figure 6. Comparing responses of mentees to "How likely are you to take physics A-level" across all 4 cycles to date

The following section considers the impact on the mentees’ career intentions.

Career intentions and aspirations

The PMP uses the Science Capital Teaching Approach (SCTA)[4] as a theoretical basis. This means the content of the sessions are tailored to the mentees to "broaden what counts" in order to help them see how science is all around them and connected with their own lives.

It is understood that those with low science capital are less likely to go into a STEM career or have an interest in science, compared with those who have high science capital[5]. There are many different aspects that contribute to someone's science capital and this can change over time. The different aspects can be summarised as:

1. What you know (Science literacy).
2. How you think (Science-related attitudes and values).
3. What you do (Out of school science behaviours).
4. Who you know (Science at home)[4].

The mentors are introduced to the SCTA as part of their training and supported in developing suitable activities for the sessions with mentees. It was clear they were able to apply the principles of science capital in practice in order to increase the mentees' science capital.

In general, the mentees found the session content relevant to them, *"I enjoyed how the physics that was talked about actually related to our hobbies"* and it is clear that the mentors were able to personalise and localise the sessions (this links to the first pillar of the SCTA[4]). From the perspectives of mentors, they talked about the research projects based in local universities (for example LIGO and gravitational waves, CERN and particle physics) in order to give the mentees a sense of what people local to the mentees were working on. This also served as an example of teamwork and collaboration in physics. There were various instances where the project has touched on several of the science capital dimensions (from the third pillar of the SCTA[4], by influencing these dimensions you can build someone's science capital):

- Dimension 1: Scientific literacy – *"I have enjoyed talking about topics that we don't normally talk about in school, such as statistical analysis" and "I have learnt how to think like a physicist."*

[4] Godec, S., King, H., & Archer, L (2017). The Science Capital Teaching Approach: engaging students with science, promoting social justice. London: University College London.
[5] Archer, L., Dawson, E., DeWitt, J., Seakins, A., & Wong, B. (2015a). "Science capital": A conceptual, methodological, and empirical argument for extending bourdieusian notions of capital beyond the arts. Journal of Research in Science Teaching, 52(7), 922-948.

- Dimension 2: Science-related attitudes, values, and dispositions: *"I have learnt a lot about careers in physics and how we use physics in day-to-day life. I know now that I will be using physics in the future."*
- Dimension 3: Knowledge about the transferability of science – *"I enjoyed learning just how many [physics] skills can be used in every-day life and how to transfer those skills when needed into other stuff.*"

A common outcome reported by mentees was that they have become much more aware that *"physics is part of our everyday lives"*.

In terms of the format of the sessions, the mentees enjoyed being able to interact and discuss topics with each other and the mentors via the chat function (normally via MS Teams). There was a definite sense of teamwork and the development of a relationship between the group, even with the sessions being online:

"I liked the activity and working as a group even though it was online. I liked how much we discussed".

The prompts and structure to the sessions put together by the mentors supported this successful interaction and engagement. Through the regular reflections of both the mentors and mentees, the mentors were able to make changes to the sessions in response to feedback, and so tailoring the content and format closely to what the mentees wanted. Within the sessions, mentees felt they were listened to and provided with comment or feedback on their thoughts: *"Our mentors answered any questions we had".*

Whilst the mentees enjoyed the high level of interactivity, the most common suggestions for future sessions was the inclusion of more quizzes. Mentors were able to monitor their feedback and where possible they actively incorporated suggestions from the mentee reflections.

There was significant careers-related content in the sessions. For example, one activity was film-based where the mentees watched a range of people talking about their careers and how physics was involved. They then had to guess the jobs and many mentees were surprised at the resulting careers as they hadn't expected physics to be present.

In addition to gathering information on post-16 study, as part of the pre- and post-participation surveys information about the respondents' science career intentions are captured (figure 7).

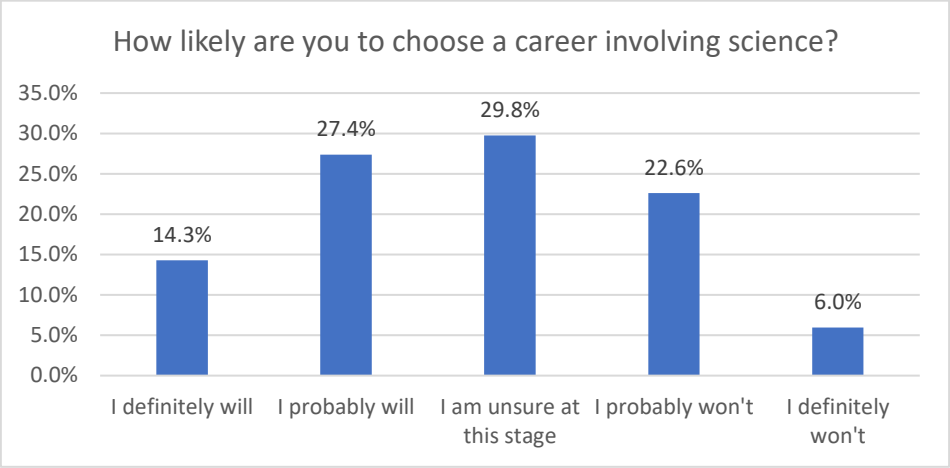

Figure 7. Responses to the pre-participation survey question "How likely are you to choose a career involving science?"

In the pre-participation survey over 40% of respondents were considering a career involving science (compared with 36% in cycles 2 and 3[6]). The post-participation survey results show a 9.5% increase in interest in a science career amongst mentees (combined responses to "I definitely will" and "I probably will". A smaller increase has been recorded for those who did not participate in the project (see Figure 8 below).

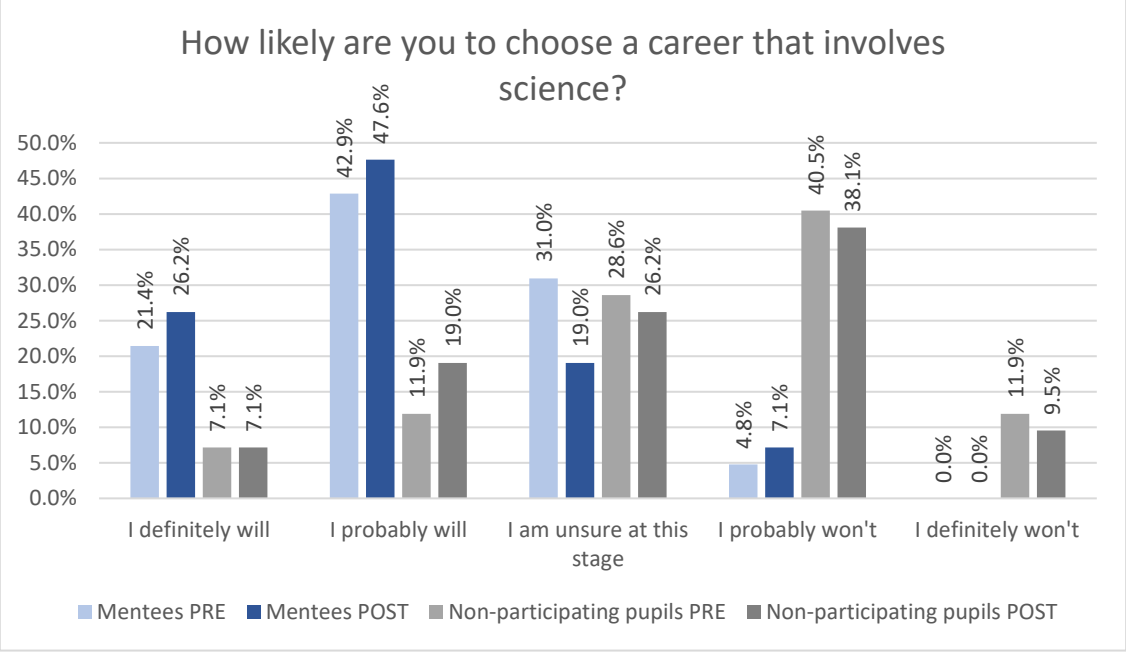

Figure 8. Comparison of pre- and post- survey responses by mentees and non-participating pupils

[6] Thomas, L. & Rushton, E.A.C. (2020). Physics Mentoring Project/Prosiect Mentora Ffiseg Final Evaluation Report.

In the reflections/feedback mentees discussed how they appreciated being able to get a sense of the different career options available to them and to recognise that there are many careers which use physics and feel comfortable that they will be engaging with physics in the future in some form. This was echoed in the interviews with teachers. They felt the mentees had broadened their knowledge of the kinds of jobs and careers available and have a greater awareness of opportunities outside their own town and family bubble. This can be seen in the increased interest in science careers in the post-participation survey responses of mentees.

As with the physics A-level intentions, the movement between categories pre- and post-participation is reviewed for mentees (Figure 9) and non-participation pupils (Figure 10).

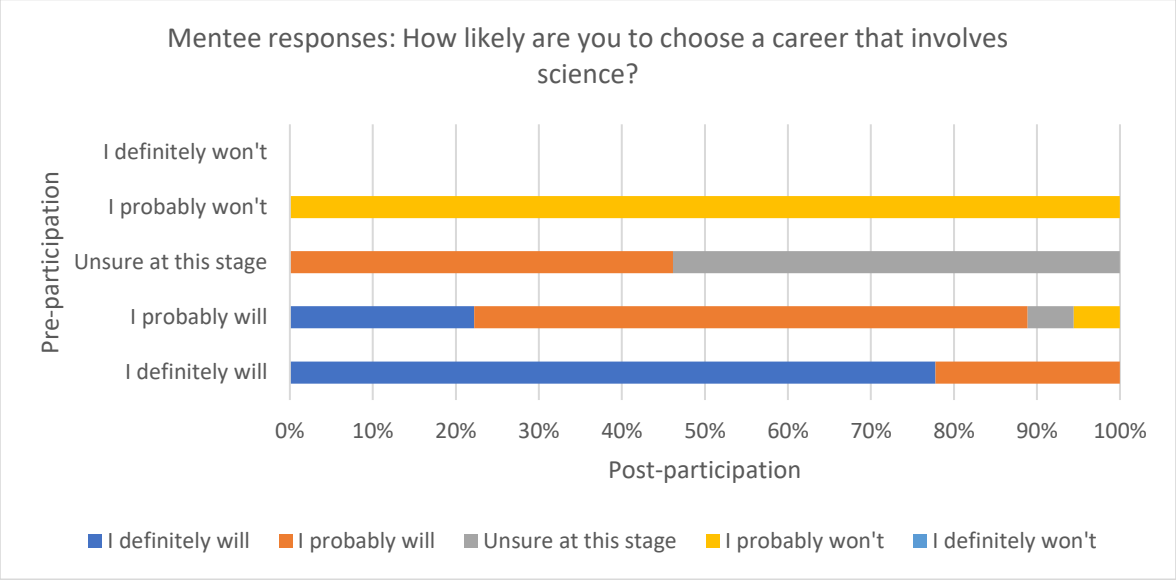

Figure 9. Movement between categories pre- and post-participation for mentees in response to the question "How likely are you to choose career that involves science?"

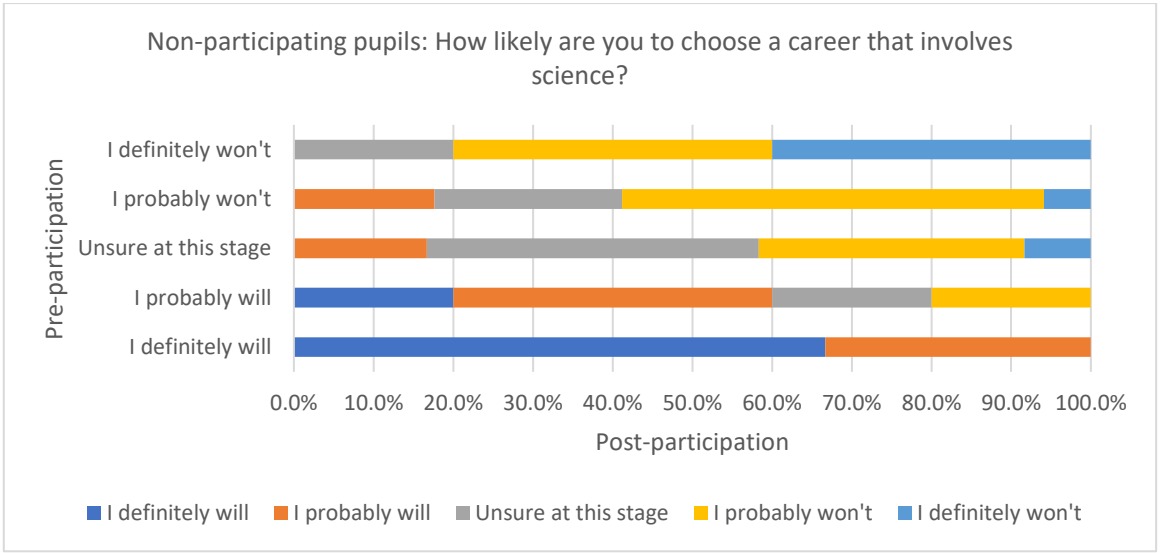

Figure 10. Movement between categories pre- and post-participation for non-participating pupils in response to the question "How likely are you to choose career that involves science?"

Compared with non-participating pupils, mentees had a more positive attitude towards science careers to begin with. This connects with what we know about their GCSE choices, with double and triple science being more likely, therefore we would expect there to be a more positive attitude in this grouping. However, post-participation we see positive movement in general for mentees whilst non-participating pupils were moving down through the categories towards "definitely won't".

Confidence and resilience

The final objective in relation to schools students is around their confidence and resilience in relation to physics. The interviews with teachers touched on wider impact on mentees, including the realisation for some that travelling away from home for study might not be as scary or difficult as some mentees may have previously thought. In addition, being able to hear about the experiences of a range of different people (including the mentors and those featured as part of the different activities) has impacted on mentees in terms of having the confidence to follow their own interests and consider their options for the future.

Mentees have reported increases in confidence. This has been highlighted as something which is linked to seeing the relevance of physics to them. Teachers have commented that mentees have received a confidence boost through being chosen to take part as the teacher is expressing their belief in them to take physics at A-level. These aspects are also supported by:

- Opportunity to work in smaller groups.
- Improved communication and problem-solving skills.
- Increased confidence in their own abilities.
- Increased awareness of the opportunities available to them in terms of future study and careers.[7]

It is clear that the mentoring experience has impacted on mentees in a range of different ways. From their intentions around post-16 study to their future careers. There are also immediate effects in relation to their enhanced perception of physics and increased confidence with the subject. There are wider benefits to the schools and teachers involved, discussed in more detail in the following section.

[7] Thomas, L. (2021) Physics Mentoring Case Study – impact on schools. Available: https://physicsmentoring.co.uk/impact-case-studies/

Impact on schools

Despite the project running during a time of uncertainty, the schools participating had a positive experience with the project. The feedback on mentors from the schools was very positive. Teachers felt that the mentees *"really related to them [the mentors]"* and that the sessions were delivered to a high standard: *"the resources were well designed, well delivered and organised".* For schools continuing from previous years, the quality of the sessions was also felt to have been maintained following the shift to an online mode of delivery.

Importantly, teachers didn't feel as though the workload was too much. In fact, having the sessions online reduced some of the time spent on organisational aspects compared with previous years. However, in some cases there were technical issues in relation to the sessions which impacted both on the teachers' and mentors' time. This included issues with connectivity and internet signals dropping out, along with limitations on the controls available to mentors during sessions. E.g. some were unable to open and play films saved in the Teams space being used by the school. Unfortunately, this seems to be outside the control of the schools and the PMP. The role of teachers shifted slightly this year, as previously they weren't necessarily present in sessions. For cycle 4 teachers were in all sessions and whilst some would sit in the background and observe, others would nudge and encourage the mentees to attend the sessions and participate in the discussions.

Despite the changed mode of delivery and the external circumstances due to the COVID-19 pandemic, there continues to be a range of benefits available to schools participating in cycle 4. This includes:

- Increased profile of physics within the school community. One of the continuing schools commented on how participating has helped to *"improve the image of physics in the school."* The school's involvement in the project was featured as part of a BBC Wales news item and pupils participating have had the chance to go on a range of physics-related trips.
- Opportunity for professional development of teachers supporting the project: One the teachers interviewed is a biology teacher and definitely felt the benefit of being involved in a physics-related project in order to *"increase my own awareness of and teaching physics and exploring different ways of interacting [online]"*.
- The development of a relationship with a university. In particular, the opportunity for pupils to work with undergraduate and postgraduate students and for teachers to develop links to universities. The online mode of delivery for cycle 4 has meant some schools have been linked with universities elsewhere in Wales, something teachers

have felt have benefited their pupils in order to encourage them to study further afield. Schools are keen to see a return to university visits to help solidify the relationship and impact on mentees.

The PMP has worked with schools across Wales during a very difficult year. Continuing schools have been joined by schools participating for the first time. There will have been opportunities for teachers who have attended sessions to experience some professional development. Participating in the PMP has been a positive experience for schools and teachers were keen to be involved in order to give their pupils additional opportunities over and above their regular learning experiences in order to help them see the relevance of physics to their lives and see the potential of where it could take them. Importantly, by providing a link to mentors and universities mentees have been challenged to consider further study and careers beyond what is available locally to them.

Impact on mentors

Mentors are recruited annually by the project team based at Cardiff University. The applicants are from universities across Wales and are made up of both undergraduate and post-graduate students. The main requirement is that they have undertaken physics A-level or equivalent.

Those who are accepted into the PMP as mentors participate in an extensive training programme. Expectations of applicants need to be managed by the PMP as not all those who complete training will necessarily go on to be paired with a school. Thirty-nine mentors completed the training and 21 were placed in schools (with three of these being partnered with two schools). Therefore, the training programme is designed to support the personal and professional development of the mentor regardless of whether they ultimately go on to mentor in schools. Although mentors only receive a bursary if they go on to run mentoring sessions in schools.

The mentoring training covers a range of topics, including the theory of Science Capital[8], mentoring theory and aspects relating to equity and inclusion. Mentors from previous years share their experiences and a lot of the training includes discussion aspects, either via the chat-box or break-out discussions. Mentors commented on the positive environment of the training sessions. They felt that the discussions were open and honest and they were successfully managed by the project team in an inclusive way.

As discussed, the training supports the mentors' personal and professional development. Specifically, this relates to skills such as time management, communication and organisational skills. Mentors have also been given the opportunity to complete a level 4 qualification on 'Increasing Engagement with Physics through Mentoring", accredited by Agored Cymru. Only open to those participating in PMP, twenty-one mentors have begun the qualification. Mentors have three years to complete the qualification, which, when completed, will provide another addition to their CVs. The existence of the level 4 qualification also seems to have had a positive impact on the confidence of mentors within the sessions. In one case a mentor experienced IT issues which delayed the start of the session but instead of feeling off-balance, the mentor felt calm and confident in delivering a successful session. They attributed this to the detailed preparation prompted by the level 4 qualification.

As part of cycle 4, being part of the PMP project has connected mentors with a wider community of like-minded people, which has made them feel less isolated at a time when they

[8] Archer, L., Dawson, E., DeWitt, J., Seakins, A., & Wong, B. (2015). "Science capital": A conceptual, methodological, and empirical argument for extending bourdieusian notions of capital beyond the arts. Journal of Research in Science Teaching, 52(7), 922-948

were carrying out their own studies at home or in accommodation away from home. The mix of people from different stages of study and from different universities works well. However, in terms of timing, the training and mentoring sessions ran at times where there were clashes with assessment deadlines or exams. This was a stressful experience for some as they had not expected the commitment to be as time-consuming as it turned out to be. However, the mentors felt able to raise these issues during the course of the year with the project team and felt supported.

In addition to the possibility of delivering mentoring sessions in schools, mentors were able to work with the project team to develop video mentoring resources. These were then made available to all mentors to include as part of their sessions. Due to the COVID-19 restrictions, it was not possible to finalise all five planned films before the sessions began. The five films were linked to the weekly themes, with four of the five films having been completed. Those are: 'My physics journey', 'Thinking like a physicist', 'Collaboration, teamwork and communication' and 'Where physics can take me'. The films were a valuable addition to the mentoring sessions (two were used in the sessions: My physics journey', 'Thinking like a physicist') and formed the basis of discussions with mentees and one in particular confounded their expectations in terms of physics careers and how physics is relevant to their own lives. These will continue to be valuable resources in future years.

For those mentors who have gone on to deliver sessions in schools they have felt as though the training has prepared them to go in with confidence. As discussed in the earlier section on 'Impact in schools', teachers have been impressed with the high standard of their sessions. Being paired with another mentor to deliver the sessions with schools has worked especially well for cycle 4, the project team have an intention to carry this forward into the next cycle of mentoring. This has been useful when there have been times when there have been technical issues or where the mentees have perhaps been a bit quieter than expected. The sessions are delivered by a lead mentor and the other as a backup or support, with these roles alternating between sessions. In terms of the delivery style, if there are quieter periods, the mentors can have a conversation between themselves, allowing the mentees to listen and contribute when they feel comfortable. It has also meant that there is someone paying attention to the chat box and mentees felt as though the mentors were interested in what they had to say.

For some mentors who are thinking about going into teaching this experience is particularly helpful in order to manage their expectations about what teaching involves (49% of mentors were planning to go into a teaching career, with 23% considering it as a possibility). For some postgraduate students this experience has developed their interest and confidence enough to

encourage them to undertake additional teaching as part of their post-graduate responsibilities. However, all mentors who take part are able to discuss this experience as part of their CV and in job applications and interviews. It has also opened up new potential careers, for example around science engagement and communication. With regards to their personal development, mentors are more likely to use self-reflection more widely in their lives. The experience has encouraged them to stop and reflect about the situation they find themselves in and to consider how to proceed.

The PMP has been successful in achieving their objectives in relation to mentors and universities. Specifically, they have been able to raise awareness of teaching careers and having increased the mentors' confidence and employability skills. The PMP also contributes to achieving the partner universities' civic mission agendas through the support provided to schools and the impact on the mentees in relation to their attitudes and intentions towards physics.

Conclusion and recommendations

The PMP has successfully impacted on mentees in terms of the attitudes and aspirations in relation to physics. Following participation there was an increase of 7.1% in those who “definitely will” or “possibly will” take A-level physics. The PMP has maintained the positive impact on mentees year-on-year through a well-established cycle of reflection and iteration of training and the mentoring model. Mentees are increasing their confidence and resilience in relation to physics and becoming more open to a science-related career.

Schools are benefiting from participating through an improved image of physics within the school, opportunities for professional learning for teachers and deeper relationships with university students and staff. The partner universities are being supported in achieving their civic mission agendas through this relationship development, whilst mentors are able to experience personal and professional development.

The following recommendations are mainly minor enhancements. The overarching recommendation to the project is to consolidate on the significant amount achieved in cycle 4 with the move to online-only mentoring.

Recommendations

1. Provide schools with the option of in-person or online-only sessions. Having online-only sessions has worked well in cycle 4. Whilst there will be some schools who will prefer a return to in-person delivery, there may be those who for a variety of reasons would like to continue to engage online. This has the benefit of allowing schools from all across Wales, regardless of their location, engage with the PMP. This will also provide the project with flexibility in case of the return of restrictions.
2. Mentors would like an informal space to discuss issues arising with each other without the oversight of the project. For example, they are keen to get quick, informal guidance on aspects such as technical advice, feedback on planned activities and sharing experiences working with schools.
3. Revisit the information and guidance provided to mentors before and at the training sessions in order to ensure they have a clear understanding about the time commitment and personal commitment to completing the training and participating in the mentoring sessions.
4. Compared with previous years, mentors did not get the same level of information from teachers about the mentees before starting the sessions. In future cycles it would be useful to agree a description of the types of information mentors should be asking teachers for before they go into the first session.
5. Where possible, organise a visit to the mentors’ university to link with them and see the facilities and take part in some physics-related activities. Mentors, mentees and teachers are keen to return to in-person visits to universities. The mentees are able to relate well to the mentors in the sessions but for some this experience of seeing the

university facilities could make a further contribution to them considering further study at university.

6. In addition to the project-related recommendations, a review of the evaluation methodology and considerations of approaches to longer-term tracking of impact will be pursued by the evaluators and the PMP project team.

Appendix A: Pre-participation survey questions

1. What is your name?
2. What is your gender? One of the aims of the PMP is to increase the uptake of physics with female students. We are collecting this information to understand whether we are successful in achieving this.
    a. Female
    b. Male
    c. Please state
    d. Prefer not to say
3. What is the name of your school?
4. Which year group are you in?
    a. Year 8
    b. Year 9
    c. Year 10
    d. Year 11
    e. Other
5. Which science course are you taking?
    a. Double Award Science
    b. Double Applied Science
    c. Triple Award Science/Separate Science
    d. Single Applied Science
    e. BTEC Science
6. How likely are you to choose Physics at A-level?
    a. I definitely will
    b. I probably will
    c. I am unsure at this stage
    d. I probably won't
    e. I definitely won't
7. Which subjects are you considering studying post-16? This could be at A-level or BTEC. If you are going onto another form of study, e.g. apprenticeship, or the subject isn't listed then please select "other" and tell us what you are doing.
    a. Art
    b. Biology
    c. Business
    d. Chemistry
    e. Computer Science
    f. Drama
    g. English (including English literature)
    h. Geography
    i. Health and Social Care
    j. History
    k. Law
    l. Maths
    m. Media Studies
    n. Music
    o. Performing Arts
    p. Physical Education
    q. Physics
    r. Psychology

s. Religious Education
t. Welsh

8. How likely are you to choose a career that involves science?
    a. I definitely will
    b. I probably will
    c. I am unsure at this stage
    d. I probably won't
    e. I definitely won't

The Physics Mentoring Project evaluation was undertaken by Laura Thomas of Ondata Research. Ondata Research collaborates with clients to help them understand project impact, whilst also providing mentoring and support through the phases of project development and delivery.

Laura has extensive experience with a range of education projects across formal and informal education. In addition to evaluation she is experienced with project and resource development, delivery and training for a variety of organisations such as schools, museums, education charities, universities and professional bodies. She is undertaking research relating to professional development of teachers after having recently completed an MRes in Educational Research with the University of Stirling.

Ondata Research

Ondata Research LTD 10 Douglas Terrace, Stirling, FK7 9LL
info@ondata.org.uk www.ondata.org.uk 07887920426

Company number: SC621169 (Registered in Scotland)