Ondata Research

Physics Mentoring Project/ Prosiect Mentora Ffiseg

Interim Evaluation Report

Prepared by Laura Thomas and Dr Lizzie Rushton July 2019.

Contents

1. Executive Summary

Overview

The physics mentoring project (PMP) has engaged with 87 year 10 and 11 students (52% of which are female) from 9 schools in Wales in the period between January and June 2019. Mentors from five different universities ran sessions in school, with each of the mentors holding a physics A-level and taking a STEM degree.

The main aims of this report were to explore the impact of the programme on the uptake of

1. Physics.
2. Women in STEM subjects.

Main Findings

Following participation in the mentoring programme mentees expressed a more positive attitude to taking A-level physics. This was found to be statistically significant. When the data for the female mentees was examined this also showed an increase in intentions at a statistically significant level.

	I will/I probably will	I am unsure	I probably won't/definitely won't
Mentoring participants	13.6% *(8.8%)*	40% *(47.1%)*	45.5% *(44.1%)*
Not participating	11.2% *(11.5%)*	25.9% *(18.1%)*	62.9% *(70.4%)*

Table 1.1 Intention of taking physics A-level post-participation. Data in brackets indicates response rate pre-participation in the PMP.

An improvement was also seen in the number of female mentees stating an intention of going into a career related to STEM. This can be seen in the table below where the intentions of female respondents are summarised.

	I will/I probably will	I am unsure	I probably won't/definitely won't
Mentoring participants	52.6% *(33.3%)*	42.1% *(42.8%)*	5.2% *(23.8%)*
Not participating	22.2% *(29.6%)*	50% *(26.6%)*	27.8% *(43.8%)*

Table 1.2 Intention of going into a STEM career post-participation as indicated by female respondents. Data in brackets indicates response rate pre-participation in the PMP.

Recommendations

The following recommendations should be seen in the wider context of the universally high regard that the project team were held in. Stakeholders from across the project shared that they experienced high levels of quality communication with project team and found them responsive and adaptable. It is clear to the evaluators that the early success of the PMP is in no small part down to the capability and commitment of the project team.

- Teachers suggest that mentoring could be more effective if undertaken with high achieving Year 9 students during the February of year 9, before they have made GCSE choices (e.g. Triple Science).
- Run the sessions earlier in the school year so that they don't clash with exams.
- Mentors were focused on the process and delivery of the sessions rather than equitable participation. Future iterations of the Mentor Reflection sheets could more explicitly ask them to consider this and training could include the Science Capital Teaching Approach, to give mentors the tools and training required to support young people in this area (see resources at the end of this report).
- Consider including physics-based external trips for mentors and mentees to help develop the mentoring relationship. This would also reduce the perception of the mentor that their role is 'teacher-like' and include a greater variety of contexts in which to work with their mentees.
- Incorporate a final session for mentors where they come back together as a group to reflect upon their experiences and be given guidance about how to take their learning and experiences forward e.g. Initial Teacher Education (ITE) routes, jobs in the Science Communication and/or Widening Participation sectors.
- There were various comments about the activities and there is an opportunity to review these based on the experience of the mentors.

2. Project Rationale

1. Uptake of STEM courses

   The numbers of young people progressing to STEM courses (Science, Technology, Engineering and Mathematics) in further and higher education continue to be low in many countries, including wealthy countries like the UK, USA, France and Australia that invest considerable efforts in advancing STEM careers and promoting equal opportunities (Mutjaba & Reiss, 2013a&b). Female and minority ethnic students are especially underrepresented in STEM subjects and this is most acute in Physics. (CASE, 2014; IoP 2013; OECD, 2015; Royal Society, 2008; SDS, 2018; WISE, 2014).

2. Aspirations for careers in STEM

   Previous research has investigated factors influencing students' aspirations and their progression towards studies and careers in STEM subjects (DeWitt et al., 2010; DeWitt, Archer & Osbourne, 2014; DeWitt & Archer, 2015; Sheldrake, Mutjaba & Reiss, 2017b). Factors include gender (Archer et al., 2013; Mutjaba & Reiss, 2013a&b), race (Archer & Francis, 2007; DeWitt et al., 2010), STEM careers advice provided at schools (Reiss & Mutjaba, 2017) and general attitudes towards studying science (Archer et al., 2013; Bøe & Henriksen, 2013; DeWitt et al., 2010; DeWitt, Archer & Moote, 2018; Mutjaba & Reiss, 2013a&b; Sheldrake, Mutjaba & Reiss, 2017a). Important constructs in this research describe for example valuing science and scientists; parental attitudes and practices (including attitudes towards science); informal science activities and self-efficacy in science (Archer et al., 2015).

3. Ability in STEM subjects

   Enjoyment of science, interest and students' perceptions of their ability in science increase the likelihood of students choosing science subjects (Palmer et al., 2017). Academic success in science does not necessarily equate to a love of science, or an intention to pursue a career in science (Carlone et al., 2014, Masnick, Valenti, Cox & Osman, 2010). Osborne and Dillon (2008) emphasise the importance of considering the development of identity that is taking place during adolescence when exploring the reasons why students continue with STEM subjects. Carlone et al. (2014) found that stimulating students' social identity in their science learning increased their affiliation to science.

4. Countering negative beliefs about STEM

Research indicates that it is common for adolescent students to develop a model of the scientist identity as ‘geeky’, ‘nerdy’ and socially isolated, and of science careers as difficult, lacking creativity and requiring technical rather than social competence (DeWitt et al., 2018; Hazari, Sonnert, Sadler, & Shanahan 2010; Masnick et al., 2010), even amongst those who are good at science. This identity is unattractive to young people and does not fit with the identity they want to develop for themselves. In order to increase the likelihood of students’ choosing STEM courses at the higher education level, it is necessary to know more about their beliefs about science as a profession (Masnick et al., 2010) and to look at ways of countering the development of negative beliefs.

Having recognised that issues related to identity are likely to be a factor in both students’ engagement with STEM, the question becomes about what factors can influence this and what impact the Physics Mentoring Project (PMP) might have on this process. Previous studies indicate that taking part in STEM projects can encourage groups traditionally underrepresented in science to develop more positive attitudes to science (Bennett et al., 2018). Research highlights the valuable role that mentoring plays in the school STEM context. As well as contributing to the personal and education growth of young people, mentoring can increase interest and engagement in STEM subjects and careers (Jett, Anderson & Yourick, 2005; Tenenbaum, Anderson, Jett & Yourick, 2014).

3. The Physics Mentoring Project

Drawing on the model of Modern Foreign Languages Mentoring Project (Cardiff University, 2017; 2019), the Physics Mentoring Project (Mellors, 2018) uses a model of near-peer, subject-specific mentoring to meeting the following aims:

Aim 1: To explore the impact of the programme on the uptake of Physics

Aim 2: To explore the impact of the programme on the uptake of women in STEM subjects

Sub-aim 1: the impact of the programme on the participating mentors

Sub-aim 2: exploring delivery and framework options for physics mentoring program

The following objectives were identified in late 2018 to meet the above aims:

1. Recruitment of mentors by Jan 2019
2. Training (and re-training) of mentors
3. Development of resources
4. Engagement with 10-12 schools across consortia
5. Mentoring of 240 year 10-11 students
6. Engagement with 3 employers
7. Increase in mentored students intending to take AS level Physics
8. Increase in mentored female students intending to take AS level Physics
9. Gather data on motivation of mentors to continue with teaching

4. Project timeline

January 2019	Undergraduate students are trained as mentors	Completed on weekend of 26/27 January
February – April 2019	Mentors run sessions in school for 6 weeks	Sessions were late in starting or cut short due to various factors and continued well into the summer term.
Easter 2019	Visit to local University for Award and Recognition ceremonies	Deferred into 2019/2020. Two schools held assemblies attended by mentors.

5. Evaluation methods and approach

The evaluation approach for this project is a blended, pragmatic approach that draws on both quantitative and qualitative sources of information to build an understanding of the efficacy of the Physics Mentoring Project. Robson & McCartan (2016) set out the following benefits of a mixed methods approach

> 'Triangulation; completeness; offsetting weaknesses of methods and providing stronger inferences; answering different research questions; ability to deal with complex phenomena and situations; explaining findings; illustration of data; refining research questions (hypothesis development and testing); instrument development and testing; attracting funding for a project.'

Data collection tools include survey, interviews, focus groups and case studies.

Census survey

- Pupil survey developed by the evaluation team that collects data on student intentions, attitudes and aspiration from all students in the schools. This captured a significant baseline dataset (upwards of 1000 individual responses) and enabled the identification of students who will most benefit from the mentoring scheme. The census survey was run pre- and post-intervention to explore any changes in student responses.
- Census survey data is also collected for all mentors as part of their application process.

Mentor and mentee reflections

- Reflection sheets that provide guidance and a framework for mentors and mentees was developed for each of the six sessions. This enabled mentors to reflect on their engagement in schools and plan for future sessions, as well as capturing a useful source of contemporaneous information. Reflection is a useful tool for mentees to learn and their immediate responses provide insight into their experiences as mentees.

Case studies

- A case-study approach will complement the large-scale census survey data, following in detail the activities of a small sample of the participating students, teachers and mentors. The focus of this strand is to identify what it is about the mentoring experience that makes a difference (or not) to young people; what makes a high-quality mentor and mentoring session; which activities add most value in terms of influencing decisions and behaviours, and how pupils engaged (or not) with the scheme. This detailed approach will be taken with two schools that are highly engaged and two schools that been less engaged to ensure that as many of the challenges and barriers are identified for future iterations of the scheme. Data collection methods include interviews and focus groups with mentors, mentees and teachers (in person, phone and skype), school visits, engagement with mentor training and surveys.

Drawing on qualitative methods such as interviews, focus groups and case studies, it is possible to identify factors which answer the questions about the ‘where’, ‘for whom’ and ‘under what conditions’ participation in the Physics Mentoring Project increases the likelihood of young people, particularly young women, choosing to continue with physics.

Below is the outline of the activities to date in relation to the evaluation of the Physics mentoring programme.

November 2018	• Questionnaires for baseline/follow up for students developed and agreed.
December 2018	• Evaluators visit the team in Cardiff. • Mentor application form reviewed. • Self-reflection forms and guidance developed for mentors and mentees.
January 2019	• Questionnaires to students. • Evaluators to attend mentor training to meet mentor trainer and mentors.
May 2019	• Develop and test the end of intervention interview. • Follow up questionnaire. • Post-intervention interviews with teachers, mentors and other stakeholders.
June 2019	Data compilation and clean up, analysis and report writing.
September 2019	Initial questionnaire to be distributed in conjunction with coordinators.
January 2020	Case study completion.

6. Participant Profile

Overview of Mentees

School	Mentees	Percentage Female mentees
Hawthorn High School	9	44%
Cantonian High School	7	29%
Pencoedtre High School	7	29%
Islwyn High School	12	58%
Friars High School	7	57%
Llangefni	7	57%
Ysgol Gyfun Cymraeg Bryntawe	12	42%
Cefn Saeson	12	58%
Ysgol Bro Hyddgen	14	71%
	87	52%

Table 6.1 Summary of participating schools

The majority of mentees were Year 10 with a small number of Year 11s. Mentees responded to two surveys to indicate their intentions for the study of physics A-level before and after their participation in the programme.

	I will/I probably will	I am unsure	I probably won't/definitely won't
Mentoring participants	8.8%	47.1%	44.1%
Not participating	11.5%	18.1%	70.4%

Table 6.2 Intention for taking physics A-level pre-participation

Overview of Mentors

In total twenty-one mentors were recruited from across the universities, 29% were female. Fifty two percent of the mentors were placed in schools, in some cases they worked with more than one mentor group and school.

In general, mentors were motivated to apply to the programme because they were interested in becoming a teacher and this would provide them with some direct experience of working with school students. Over seventy per cent of mentors were considering a career in teaching. Other reasons included communicating about a subject they are passionate about and broadening their experience of physics beyond that which they get as part of teaching on their degree. With regards to skills development, mentors felt that they would develop their time management, confidence, teaching, mentoring, problem solving, knowledge, and communication skills through participation in the project.

University	Gender	Course	Placed? Y/N
Aberystwyth University	M	Physics	N
Aberystwyth University	F	Astrophysics	Y
Aberystwyth University	F	Astrophysics	N
Bangor University	M	Electronic Engineering	Y
Cardiff University	M	Astrophysics	Y
Cardiff University	M	Physics	Y
Cardiff University	F	Astrophysics	N
Cardiff University	M	Physics (PG)	N
Cardiff University	M	Mechanical Engineering	Y
Cardiff University	M	Physics	Y
Cardiff University	F	Mechanical Engineering	Y
Cardiff University	M	Physics with Astronomy	N
Cardiff University	M	Physics	N
Cardiff University	F	Physics	Y

Cardiff University	M	Mechanical Engineering	N
Swansea University	M	Physics	Y
Swansea University	M	Physics	N
Swansea University	M	Physics	Y
Swansea University	F	Physics	N
University of South Wales	M	Aeronautical Engineering	N
University of South Wales	M	Computer Games Development	Y

Table 6.3 Overview of mentor information.

7. Main Findings

Aim 1: To explore the impact of the programme on the uptake of Physics

Data sources

1. Survey responses
2. Teacher interviews
3. Mentee reflection sheets

Outcomes

- Teachers suggested that the PMP had ‘huge potential’ to encourage young people to continue with Physics post-16.
- Teachers particularly valued that the mentoring delivered by the university student mentors, they saw this as an important opportunity for young people to engage with physics beyond school, including information about careers in physics.
- Mentees (who completed and returned the reflection journals) were very positive about the experience. They regularly reported that the sessions were engaging, the mentors encouraging and supportive and that they learnt more about physics in terms of subject knowledge, careers and the relatedness of Physics to other science subjects and the wider world.
- In order to understand motivations for study, the schools participating in the PMP were asked to disseminate a survey to all of their Year 10 students. The project team identified potential mentees using their response to the question about intentions for studying physics A-level. Over one thousand survey responses from the schools participating were recorded. Schools were then asked to complete the survey again following the completion of the PMP in their school. This allowed for a comparison of intentions to study physics, and other aspects, before and after participation.
- Following participation in the mentoring programme mentees expressed a more positive attitude to taking A-level physics. This was found to be statistically significant. When the data for the female mentees was examined this also showed an increase in intentions at a statistically significant level.
- Participation in PMP seems to have supported informed decision making for students. As can be seen in the table below, those participating in the project became surer about their decisions, whilst those not participating seemed to become more unsure.

	I will/I probably will	I am unsure	I probably won't/definitely won't
Mentoring participants	13.6% *(8.8%)*	40% *(47.1%)*	45.5% *(44.1%)*
Not participating	11.2% *(11.5%)*	25.9% *(18.1%)*	62.9% *(70.4%)*

Table 7.1 Intention of taking physics A-level post-participation. Data in brackets indicates response rate pre-participation in the PMP.

Challenges

- Recognition from project team and partners that the timing of the sessions was problematic both in terms of the Year groups chosen (some suggested that Year 10 and 11 was too late to make an impact on young people's subject choices) and the implementation of the PMP late in the academic year.
- Project team and partners recognised the logistical challenges that mentors faced in schools e.g. variable attendance of students due to other school commitments, changing location and timing of sessions.

Learning for Phase 2

- Teachers suggest that mentoring could be more effective if undertaken with high achieving Year 9 students during the February of year 9, before they have made GCSE choices (e.g. Triple Science)

Aim 2: To explore the impact of the programme on the uptake of women in STEM subjects

Data Sources

1. Survey responses
2. Teacher interviews
3. Mentee reflection sheets
4. Mentor reflection sheets

Outcomes

- Girls more frequently and comprehensively completed the mentee reflection sheets and for some this activity seemed to support their reflections on subject and career choices – e.g. 'Have enjoyed the project and it has helped me think about my career'; 'Has made me think about how all the sciences are related, and made me think about taking physics, but have decided to take Bio.'; and 'I would like to take A level Physics and Maths' (three female students from Caefn Saeson).
- Following participation in the mentoring programme the survey results show an improvement in the number of female mentees stating an intention of going into a career related to STEM. This can be seen in the table below where the intentions of female respondents are summarised.

	I will/I probably will	I am unsure	I probably won't/definitely won't
Mentoring participants	52.6% *(33.3%)*	42.1% *(42.8%)*	5.2% *(23.8%)*
Not participating	22.2% *(29.6%)*	50% *(26.6%)*	27.8% *(43.8%)*

Table 7.2 Intention of going into a STEM career post-participation as indicated by female respondents. Data in brackets indicates response rate pre-participation in the PMP.

Challenges

- Girls particularly wanted to know more about what they would study in Physics A level in order to make an informed subject choice however, this was not the focus of the PMP and it is perhaps unwise for PMP mentors to give A-level curricular advice as they are not best placed to do this.

Learning for Phase 2

- Mentors were focused on the process and delivery of the sessions rather than equitable participation. Future iterations of the Mentor Reflection sheets could more explicitly ask them to consider this and training could include the Science Capital Teaching Approach, to give mentors the tools and training required to support young people in this area (see resources at the end of this report).

Sub-aim 1: the impact of the programme on the participating mentors

Data Sources

1. Mentor reflection sheets
2. Mentor interviews
3. Stakeholder interviews
4. Mentor application forms

Outcomes

- This was challenging for the evaluators to accurately assess. The application forms and observations made during the training weekend provided useful insights as to mentors' motivations for participating.
- Mentors who fully completed reflective journals were very positive about the experience and said that they would like to participate again in the future, that it was a nice way to engage teenagers, who the mentors had previously perceived to be a challenging age group.
- Mentors enjoyed being able to share their own personal experience to the benefit of others to help them have a better understanding of what studying physics is like.
- There is some suggestion that participation in the PMP is a potential pathway to ITE and the mentor application forms suggest that a significant proportion of mentors are considering careers in teaching however, this needs to be explored in the second phase of project.

Challenges

- Not all mentors who attended the training participated in the programme. Some dropped out prior to working with schools due to timing/appropriateness for role.
- Mentors described logistical challenges with variable student attendance/participation/engagement that limited the impact they felt they could make as mentors.

Learning for Phase 2

- Build in an icebreaker activity that provides the mentors with some structure to facilitate discussion about the mentees' aspirations. The mentors who engaged in a discussion with mentees felt more able to tailor sessions and respond to queries when they understood more about their interests and motivations.

- Incorporate a final session for mentors where they come back together as a group to reflect upon their experiences and be given guidance about how to take their learning and experiences forward e.g. ITE routes, jobs in the Science Communication and/or Widening Participation sectors.
- Possibly frame participation in PMP as getting valuable experience for future ITE applications. If this is taken forward, work with Education researchers to explore alternative training content e.g. make the focus Science Capital training as opposed to science communication training.

Sub-aim 2: exploring delivery and framework options for physics mentoring program

Data Sources

1. Stakeholder interviews
2. Teacher interviews
3. Evaluator observations
4. Mentee reflection sheets
5. Mentor training evaluation

Outcomes

- Mentors were positive about the reflective journals both for themselves and their mentees. Mentors suggested that the reflective journal activity was a good way to bring a session to a close and completing them each week allowed the students to see their development across the weeks.
- Mentors were positive about the training and most felt that they were better prepared to take on the mentoring role and that they understood what was required of them. Mentors valued the practical, interactive and varied training programme and appreciated the friendly and supportive atmosphere.
- There was some consistency across the mentee responses as recorded in the reflection journals as to the activities that they most engaged with. These included:
    - ‘What is in the box?’
    - Recruitment agency and science careers
    - Electromagnetic Spectrum
- The mentee reflections show that mentees were able to recall physics subject knowledge delivered in the session (even though they were not asked to recall or record this information) and regularly made links between the sessions and future career options.

Challenges

- The project team were highly regarded by all stakeholders and particularly in the early phases of the project they had to take on a number of unexpected roles. This included resource production and development, which was protracted and relied upon the capacity and capability of the project team working to a tight timescale. Future phases of the project will benefit from these resources.

- Many mentors felt that the Saturday of the training was too long, although they recognised that all the content covered was necessary and important and some felt they would have liked some more safeguarding content covered and compared the more extensive safeguarding training they had received in other roles.
- Mentors described the varying relevance and appropriateness of the learning resources; some were much easier than others to engage students with (e.g. Pendulum activity was ‘a bit of a faff’) and some content beyond some students (e.g. wave length activity).
- Mentors were focused on their role as subject-specialists who could delivered taught physics content in a more informal and engaging way and sometimes lost sight of their role in widening participation and providing positive role models in science/physics.

Learning for Phase 2

- Mentors would like more training to be focused on the delivery of the content, rather than the role of the mentor. The mentors suggested that the content delivery was the core to their work as mentors and if this was not effective, they were not able to develop the mentoring role. Our evaluation would recommend that training included more content about the role of the mentor using Science Capital Teaching Approach which delivers science rich content in equitable and socially just ways (see resources section).
- Mentor training could be spread across three days so that days could be shorter but with greater time given to safeguarding and perhaps rename the assessment aspect so that it reduces anxiety mentors may feel about ‘failing’ this element of the training. Mentors would also have appreciated the opportunity to meet with a mentor from a similar project so they could learn from their experiences and ask questions they may have.
- Teachers suggest that mentoring could be more effective if undertaken with high achieving Year 9 students during the February of year 9, before they have made GCSE choices (e.g. Triple Science).
- Greater guidance could be given to mentees as to the purpose of the mentee reflection sheets, that these are opportunities for young people to reflect on what they have experienced rather than recall what they have learnt.
- Consider including physics-based external trips for mentors and mentees to help develop the mentoring relationship. This would also reduce the perception of the mentor that their role is ‘teacher-like’ and include a greater variety of contexts in which to work with their mentees.
- Consider including a session where the mentor talks about their physics story, how they came to study physics, what they are most interested in and where they hope physics will take them in the future. This could be explicitly linked to the importance of reflection and how to use a reflective journal as a learning tool.
- Consider including training for mentors (and teachers) on the Science Capital Teaching Approach (see Recommendations section and also Resources section).

8. Recommendations

The following recommendations should be seen in the wider context of the universally high regard that the project team were held in. Stakeholders from across the project shared that they experienced high levels of quality communication with project team and found them responsive and adaptable. It is clear to the evaluators that the early success of the PMP is in no small part down to the capability and commitment of the project team.

Targeting

1. Teachers suggest that mentoring could be more effective if undertaken with high achieving Year 9 students during the February of year 9, before they have made GCSE choices (e.g. Triple Science).

Logistics

2. In some cases, mentors seemed to only have 30 minutes (Cefn Saeson), this should be reviewed and a longer slot negotiated where possible.
3. Run the sessions earlier in the school year so that they don't clash with exams.

Training/Delivery

4. Mentors were focused on the process and delivery of the sessions rather than equitable participation. Future iterations of the Mentor Reflection sheets could more explicitly ask them to consider this and training could include the Science Capital Teaching Approach, to give mentors the tools and training required to support young people in this area (see resources at the end of this report).
5. Greater guidance could be given to mentees as to the purpose of the mentee reflection sheets, that these are opportunities for young people to reflect on what they have experienced rather than recall what they have learnt.
6. Mentor training could be spread across three days so that days could be shorter but with greater time given to safeguarding and perhaps rename the assessment aspect so that it reduces anxiety mentors may feel about 'failing' this element of the training. Mentors would also have appreciated the opportunity to meet with a mentor from a similar project so they could learn from their experiences and ask questions they may have.
7. Possibly frame participation in PMP as getting valuable experience for future ITE applications. If this is taken forward, work with Education researchers to explore

alternative training content e.g. make the focus Science Capital training as opposed to science communication training.

8. Consider including physics-based external trips for mentors and mentees to help develop the mentoring relationship. This would also reduce the perception of the mentor that their role is 'teacher-like' and include a greater variety of contexts in which to work with their mentees.
9. Incorporate a final session for mentors where they come back together as a group to reflect upon their experiences and be given guidance about how to take their learning and experiences forward e.g. ITE routes, jobs in the Science Communication and/or Widening Participation sectors.

Activities

10. Build in an icebreaker activity that provides the mentors with some structure to facilitate discussion about the mentees' aspirations. The mentors who engaged in a discussion with mentees felt more able to tailor sessions and respond to queries when they understood more about their interests and motivations.
11. Consider including a session where the mentor talks about their physics story, how they came to study physics, what they are most interested in and where they hope physics will take them in the future. This could be explicitly linked to the importance of reflection and how to use a reflective journal as a learning tool.

Additional recommendations based on mentor feedback include:

12. The EM spectrum activity should be reviewed. The image matching could be shortened as it seems to have been too long to fit in to the time allocated.
13. For some of the activities perhaps indicate whether they would be good near the start of the block or the end. E.g. mystery box is a good ice breaker, connecting wall better more into the block.
14. Set of recommended extension activities that can easily fill up 5-10 minutes at the end of the session.
15. Include some specific guidance on how to adapt sessions to fit different time constraints and other circumstances as part of the training.
16. For the mentors who were not educated in Wales, perhaps a short crib sheet on A-level content would be helpful.

Revisiting the Project Objectives

In this final section we revisit the project objectives and comment on the progress being made.

Objective	Comment
Recruitment of mentors by Jan 2019	Complete for phase 1 (January – June 2019)
Training (and re-training) of mentors	Complete for phase 1 (January – June 2019)
Development of resources	Complete for phase 1 (January – June 2019)
Engagement with 10-12 schools across consortia	9 schools worked with in phase 1 (January – June 2019)
Mentoring of 240 year 10-11 students	87 students engaged with (52% female) in phase 1 (January – June 2019)
Engagement with 3 employers	Ongoing. Information on employers has been incorporated into the recruitment agency activity.
Increase in mentored students intending to take AS level Physics	Survey responses show an increase in the numbers intending to take Physics and the number of females intending to go into a STEM career.
Increase in mentored female students intending to take AS level Physics	
Gather data on motivation of mentors to continue with teaching	Further information needed.

Future questions for evaluators

There are various aspects that have arisen for further investigation, this can include:

- What factors influence mentee attendance?
- Does the size of the mentoring group affect the outcome?

9. References

Archer, L., & Francis, B. (2007). *Understanding minority ethnic achievement*. London: Routledge

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2013). 'Not girly, not sexy, not glamorous': Primary school girls' and parents' constructions of science aspirations. *Pedagogy, Culture & Society*, *21*(1), 171-194. doi: 10.1080/14681366.2012.748676

Archer, L., Dewitt, J., & Willis, B. (2014). Adolescent boys' science aspirations: Masculinity, capital and power. *Journal of Research in Science Teaching*, *51*(1), 1–30.

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.

Bennett, J., Dunlop, L., Knox, K. J., Reiss, M. J. & Torrance Jenkins, R. (2018). Practical independent research projects in science: a synthesis and evaluation of the evidence of impact on high school students. *International Journal of Science Education*, *40*(14), 1755-1773.

Carlone, H. B., Scott, C. M. & Lowder, C. (2014). Becoming (less) scientific: A longitudinal study of students' identity work from elementary to middle school science. *Journal of Research in Science Teaching, 51*(7), 836-869.

Cardiff University (2017) *Languages in schools scheme honoured*. Cardiff University News 8.11.2017. Available at: https://www.cardiff.ac.uk/news/view/997055-threlford-cup

Cardiff University (2019) *Inspiring a love of languages*. Cardiff University News 9.10.2019. Available at: https://www.cardiff.ac.uk/news/view/1411880-inspiring-a-love-of-languages

CASE [Campaign for Science and Engineering] (2014). *Improving diversity in STEM*. London: Campaign for Science and Engineering.

DeWitt, J., Archer, L., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2010). High aspirations but low progression: The science aspirations–careers paradox amongst minority ethnic students. *International Journal of Science and Mathematics Education*, *9*(2), 243-271.

DeWitt, J., Archer, L., & Osborne, J. (2014). Science-related aspirations across the primary–secondary divide: Evidence from two surveys in England. *International Journal of Science Education*, *36*(10), 1609-1629. doi: 10.1080/09500693.2013.871659

DeWitt, J., & Archer, L. (2015). Who aspires to a science career? A comparison of survey responses from primary and secondary school students. *International Journal of Science Education*, *37*(13), 2170-2192. doi: 10.1080/09500693.2015.1071899

DeWitt, J., Archer, L., & Moote, J. (2018). 15/16-Year-Old Students' Reasons for Choosing and Not Choosing Physics at a Level. *International Journal of Science and Mathematics Education*, 1-17.

Hazari, Z., Sonnert, G., Sadler, P. M. & Shanahan, M. C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching, 47(*8), 978-1003.

IOP (2013). *Closing Doors. Exploring Gender and subject choice in schools*. London: Institute of Physics Report. Available at: http://www.iop.org/publications/iop/2013/closingdoors/

Jett, M., Anderson, M. & Yourick, D.L. (2005). Near peer mentoring: A step-wise means of engaging young students in science. *Federation of American Societies for Experimental Biology Journal 19*, 1396.

Masnick, A. M., Valenti, S. S., Cox, B. D. & Osman, C. J. (2010). A multidimensional scaling analysis of students' attitudes about science careers. *International Journal of Science Education, 32*(5), 653-667.

Mellors, R. (2018) *Physics Mentoring Project*. Cardiff University Physics and Astronomy Blog. Available at: https://blogs.cardiff.ac.uk/physicsoutreach/physics-mentoring-project/

Mujtaba, T., & Reiss, M. J. (2013a). Inequality in Experiences of Physics Education: Secondary School Girls' and Boys' Perceptions of their Physics Education and Intentions to Continue with Physics After the Age of 16. *International Journal of Science Education*, *35*(11), 1824-1845.

Mujtaba, T., & Reiss, M. J. (2013b). What sort of girl wants to study physics after the age of 16? Findings from a large-scale UK survey. *International Journal of Science Education*, *35*(17), 2979-2998.

Reiss, M. J., & Mujtaba, T. (2017). Should we embed careers education in STEM lessons?. The Curriculum Journal, 28(1), 137-150.

OECD (2015). *Universal basic skills: What countries stand to gain*. Paris: OECD Publishing doi: 10.1787/9789264234833-en

Osborne, J., & Dillon, J. (2008). *Science Education in Europe*: Critical reflections (Vol. 13). London: The Nuffield Foundation.

Palmer, T. A., Burke, P. F., & Aubusson, P. (2017). Why school students choose and reject science: a study of the factors that students consider when selecting subjects. *International Journal of Science Education, 39*(6), 645-662.

Reiss, M. J., & Mujtaba, T. (2017). Should we embed careers education in STEM lessons?. *The Curriculum Journal*, *28*(1), 137-150.

Royal Society (2008). *A higher degree of concern*. London: The Royal Society.

Sheldrake, R., Mujtaba, T., & Reiss, M. J. (2017). Science teaching and students' attitudes and aspirations: The importance of conveying the applications and relevance of science. *International Journal of Educational Research*, *85*, 167-183.

Sheldrake, R., Mujtaba, T., & Reiss, M. J. (2017b). Students' Changing Attitudes and Aspirations Towards Physics During Secondary School. *Research in Science Education*, 1-26.

SDS (2018) *Review of Improving Gender Balance Scotland*. Scotland: SDS Evaluation and Research Team. Available at: https://www.skillsdevelopmentscotland.co.uk/media/44705/review-of-improving-gender-balance-2018.pdf

Tenebaum, L.S., Anderson, M.K. & Yourick, D.L. (2014). An innovative near-peer mentoring model for undergraduate and secondary students: STEM Focus. *Innovative Higher Education 39*(5), 375. doi: 10.1007/s10755-014-9286-3

WISE (2014). *Not for people like me? Under-represented groups in science, technology and engineering*. Bradford: WISE

10. Resources

Science Capital Resources

- Science Capital Teaching Approach manual, films and infographic: http://www.ucl.ac.uk/ioe/departments-centres/departments/education-practice-and-society/science-capital-research/science-capital-teaching-approach-pack
- 2 minute animations:
  What is science capital? buff.ly/1FmfXsi
- A science capital approach to building engagement: https://www.youtube.com/watch?v=NDuEZFRt59M
- The science capital teaching approach: www.ucl.ac.uk/ioe-sciencecapital
- Science capital teaching approach film: https://www.youtube.com/watch?v=XDCekYVTkws
- Science capital teaching approach trailer: https://www.youtube.com/embed/AxJP789Zu8U