2021 cohort

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Why are females underrepresented in A level physics? A study in one school

Introduction

The science faculty at this Academy are interested to understand why there is a low uptake of students wanting to study physics at KS5. For both boys and girls, the number of students choosing physics at KS5 has become smaller compared to the other science subjects, but there has existed an underrepresentation of girls at KS5, which is consistent with the national trend. Therefore, for this project I will be looking to collect data across male and female students at KS4 and KS5 at this academy to identify and rank the most relevant factors at this academy that are acting as barriers for girls wanting to study physics at KS5 today. This will then serve as a basis to develop interventions and strategies to change perceptions of physics and motivate girls to consider physics as a viable and practical subject for future careers and jobs.

Literature review

There exists a significant gender imbalance in the number of boys and girls studying physics at A level (key stage 5), which has largely remained stagnant for over 30 years. In the 2021 GCE A level and AS level examination pupil data, the percentage of boys studying physics was 77%, compared to 23 % of girls (Joint Council for Qualifications, 2021). This was despite a comparable number of girls taking physics within GCSE triple science (24%) compared to boys (23.2%) (Cassidy et al., 2018). Comparatively, there are approximately the same number of girls and boys taking A level chemistry (51:49 respectively), while biology is imbalanced towards girls in the most recent statistics (64:36) (Joint Council for Qualifications, 2021). The big picture is that a lack of girls studying physics at a higher level has consequences for the UK economy: a particular emphasis has been placed on developing a throughput of high skilled workers in the sciences, technologies, and engineering sectors, per the governments industrial strategy (Institute of Physics, 2018), and physics-based skills are highly sought in relation to these sectors. To keep the UK economy competitive, thousands of workers, both boys and girls, are needed to be trained each year. If there were as many females as males who studied A level physics, there would be an estimated 15,000 additional young, qualified people to move into medium and high skilled roles across the economy (Institute of Physics, 2018). These statistics do not happen by accident and are a by-product of systemic and in-grained gender issues that still exist within education and industry.

The historically low uptake of females in physics at KS5 has prompted numerous studies over the last 30 years as to understand what factors exist as barriers. Several recurring factors have been identified. Quality of teaching and positive interactions/support from their physics teachers has been found to be significantly influential to pupils' desire to study physics at A level (Mujtaba and Reiss, 2016, 2013a, 2013b). Perception of difficulty has also been a barrier to students, with students put off by an expected step-up in difficulty at A level (Gill and Bell, 2013; Ofqual, 2017; Patall et al., 2018). Self-concept has been found to be a significant factor, with girls much more likely than boys to underestimate their ability in physics and maths (Cassidy et al., 2018; Häussler and Hoffmann, 2002; Hazari et al., 2010; Mujtaba and Reiss, 2016, 2013a, 2013b). This is despite comparable attainment in GCSE grades between triple girls and boys in physics (Institute of Physics, 2018). Unsurprisingly, both boys and girls were significantly more likely to progress to study A level physics if the subject was in their top four GCSE results. This says that if a student does

particularly well in a physics, they are more likely to continue with it at KS5. However, due to a lower self-concept (Mujtaba and Reiss, 2013a, 2013b), girls with high attainment are dissuaded from studying physics, favouring other STEM subjects, such as biology whereby girls are twice as likely to progress to study at A level even if the subject was not in their top four GCSE result, compared to physics (Institute of Physics, 2018). DeWitt et al. (DeWitt et al., 2019) found the primary reason for choosing a subject at A level was found to be the perceived usefulness of the subject in relation to their future job or career. Association of masculinity with physics has also been identified as a demotivator for studying physics, with girls 'failing to belong' within a male-dominated subject and classroom (Francis et al., 2017).

Methodology

A survey was created with questions based on four themes identified from the literature review: self-concept, interest, relevance, and teaching. Questions were selected from within the literature when similar surveys were conducted nationally, as well as relevant questions for designing a course interest survey (Keller, 2010).

To make data collection efficient and complimentary to the students' Google classroom education platform at this Academy; Google forms was used. Most questions were constructed with a 5-point Likert scale used for responses (Thwaites Bee and Murdoch-Eaton, 2016). Some questions were designed to compare and rank the three science subjects, while a single question was designed to gather qualitative data on careers that students' associate with physics. In total, 33 question were devised across the four themes that aimed to quickly survey students and provide a broad and rounded snapshot of students' perceptions and motivations of the three science subjects, but with a focus on physics. An initial question asked the students' if they were male or female, but also included a third input box if the student did not currently identify as binary, so to avoid excluding students from participating. However, due to the nature of the research question, only data from students that identified as male or female was used. Year 11 students on the triple science program were chosen to be surveyed because they are significantly more likely to consider further education and be successful in application for physics, chemistry, and biology at KS5. To increase the number of participants in the survey, the survey was also to be made available to current year 12 and year 13 students, with slight amendments to their questions asking for them to consider their experiences in Y11. It was considered that the current year 12 and year 13 students' experiences of physics could be affected by the disruption caused by Covid-19 pandemic, but that it would still be beneficial to increase the sample size and any anomalies could be reviewed during the data analysis.

Students had to log-in via their Google classroom account, but the survey was made so that all responses were completely anonymised and untraceable. Students could also only complete the survey once, to avoid duplication of data.

The survey was trialled with members of the science faculty at this academy. The feedback provided helped to improve the user experience, correct any mistakes, and improve question design, as well as provide practice on how to disseminate and analyse the data.

The survey was made available for students to complete over an initial 2-week period, with their teachers asking them to complete, but was repeated/extended until at least 50 responses were collected. This was to meet a 95% confidence level, with a 10% margin of error for an estimated population of 100 separate science students in year 11, 12 and 13 (SurveyMonkey, 2023).

Results and discussion

52 respondents were received, although 5 had to be discarded: 2 due to reporting their gender as 'non-binary', and 3 due to spoiled responses. Of the 47 usable sets of data, 28 were male and 19 were female. Considering this, the survey was successful at identifying which factors affect girls more strongly than boys in the four themes of self-concept, interest, relevance, and teaching.

In the self-concept section, boys responded more strongly in their self-concept in all three sciences. A value of 1 represented low ability and 5 represented high ability, and boys tended to rate themselves highly, most so in biology but also quite positively in chemistry and physics. In biology the mean (and standard deviation) and median response was 3.8 ± 0.9 and 4, in chemistry it was 3.3 ± 0.8 and 3, and in physics it was 3.4 ± 0.9 and 3. In comparison, girls also rated themselves very highly in biology, but were much more negative about their ability in chemistry and physics. For girls, the mean and median for biology was 3.9 ± 0.7 and 4, in chemistry it was 2.9 ± 0.8 and 3, and in physics it was 2.5 ± 0.8 and 2. A comparison of the responses for boys and girls in physics is shown in Figure 1. This agrees with the literature that, while triple science male and female students are just as likely to achieve the same grades at GCSE (Cassidy et al., 2018; Institute of Physics, 2018), girls are more likely to rate themselves as inferior with regards to their ability in physics (Mujtaba and Reiss, 2013a). In the survey, boys are girls responded similarly in ranking biology the easiest subject, and chemistry and physics equally ranked as medium or hardest. Boys felt more strongly than girls that physics was not more difficult than the other science subjects, and likely due to their higher self-concept felt more strongly than girls that if they worked harder in physics, they could be successful. However, both boys and girls were indifferent to the question of "you must be good at maths to get good grades in physics". While some of the literature has identified inequalities and difficulties of maths as an issue for girls when studying physics (Institute of Physics, 2018), it appears not to be a significant issue for the boys and girls surveyed at this academy.

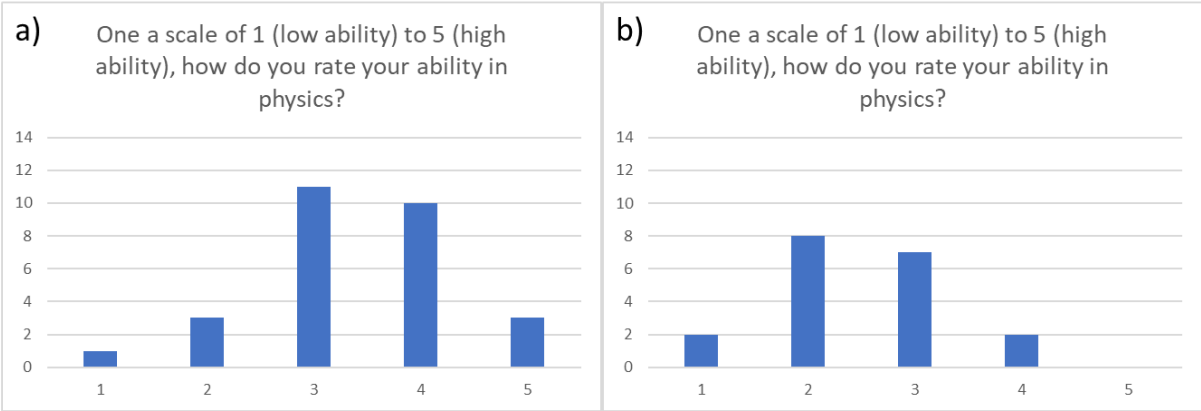

Figure 1 – Responses from a) boys and b) girls with respect to their ability in physics

There was less divergence between boys' and girls' responses to questions in the theme of 'interest'. Boys and girls both ranked biology as the most enjoyed and interesting subject, with chemistry and physics ranked almost equally as middle or least interesting. Where there was any notable divergence was that some boys ranked physics as most interesting, while no girls in the survey thought physics (or chemistry) as the most interesting subject. Coinciding with the national picture, boys were more likely to say they planned to study physics (11 yes to 17 no) compared to biology (9 to 19) or chemistry (7 to 21) after GCSE, while girls were more likely to plan on studying biology (9 to 10). Only 1 girl responded saying they planned to study physics after GCSE.

The 'relevance' theme of questions provided an interesting insight into students' perception of the three science disciplines. Most boys and girls did not associate biology, chemistry, or physics with gender. However, when they did; both boys and girls associated biology as feminine and physics as masculine. The strongest response across the three science disciplines was associating physics as masculine, which for boys the responses were 12 masculine, 1 feminine, 15 neither, and for girls the responses were 9 feminine, 0 feminine, and 10 neither. Again, this agrees with the literature in which girls tend not feel a sense of belonging in physics due to a strong perception of masculinity associated with the subject (Francis et al., 2017; Mujtaba and Reiss, 2013a, 2013b). Boys reported most strongly on what they learned in physics as being relevant to their future careers but were mostly indifferent to the importance of what was studied to their daily lives. Girls on the other hand

felt quite strongly that what was learned in physics was not important to their future career or goals. In terms of careers that they associate with physics, 25% (7/28) of males responded with something related to 'teacher', compared to 37% (7/19) responses from girls. 54% of boys suggested something related to 'engineering', compared to 32% of girls. 35% of boys suggested a career related to 'physicist', compared to 47% of girls. 7% of boys suggested a career relating to 'medical/NHS', compared to 16% of girls. This suggests more awareness of female role models and breaking gender stereotypes is needed to break the association of masculinity within physics (DeWitt et al., 2019; Francis et al., 2017), as well as exposure to more careers that use physics (and related skills developed), beyond the immediately obvious 'teacher' or 'physicist' (Borg and Sui, 2013; Hoffmann, 2002; Murphy and Whitelegg, 2006).

In the final theme 'teaching' theme of questions, both boys and girls rated the teaching and support in biology as 'highest', with chemistry and physics comparably labelled as either 'middle' or 'least'. There was some disparity in the level of support provided, with boys responding that they felt they got the most support in physics, while girls feel they get the least amount of support in physics. This correlates with some of the literature, where girls with lower aspirations being less likely to report positively on their experiences and support within physics, and that even for girls with high aspirations experienced teacher support less positively than that for boys with high aspirations (Mujtaba and Reiss, 2016). Boys responded more favourably that they felt involved in their physics lessons (mean = 3.4 ± 1.1, median = 4), while girls responded lightly more strongly with indifference (mean = 3.0 ± 1.0, median = 3), which is shown graphically in Figure 2.

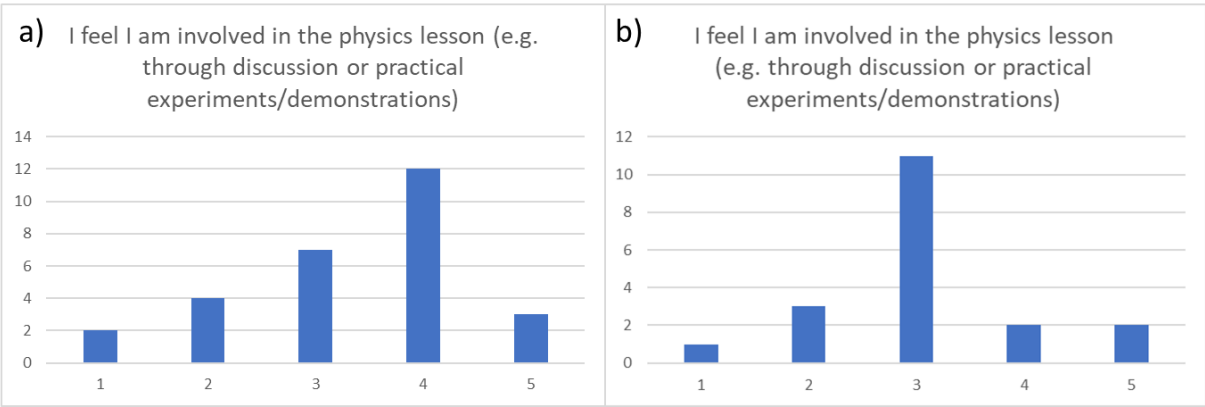

Figure 2 – Responses from a) boys and b) girls as to whether they feel involved within the physics lesson

Conclusion

The survey has achieved its goal in identifying what factors relating to physics are affecting girls more strongly than boys at this Academy. Girls have responded showing they had a lower self-concept in physics, associated physics as a masculine subject (as well as boys) and were less likely to feel strongly about the support they receive or their involvement in physics lessons.

The survey had limitations due to a lower uptake of female respondents than desired, with a greater number of males completing the survey. Overall, this will have impacted the robustness of the conclusions derived, however the research has signposted to where the science faculty at this academy can act to break down some of the barriers to girls belonging in the physics classroom.

Some initiatives worth pursuing off the back of this research project are additional careers resources and making students more aware of how physics, and the skills developed within lessons, impacts their daily lives. This will be impactful for both boys and girls, but this should provide girls with a more rounded awareness of the reach physics has to different careers. The Institute of Physics Limit Less strategy provides resources for this, as well as strategies to tackle the stereotypes and prejudice in physics. Efforts will need to be made as to what can make physics more interesting to girls. Support from the science faculty, as well as interviewing some students,

could help to identify why girls enjoy biology lessons, and consideration of what could be carried over into the physics classroom. It may be worth exploring the impact interventions have for female students in KS4, as to whether this would help to improve the issue of lower self-concept within physics.

The survey will be used again, possibly annually, to track how attitudes could be changed with time and with forthcoming strategies implanted at KS3 and KS4 to improve aspirations, interest, and motivations to study physics at KS5 and pursue careers in the associated fields. Improvements would be providing a longer window to collect data, promoting the survey to the different year 11 classes, and changing the gender question to include responses from non-binary students and so that students cannot spoil their responses. The survey could also be implemented at other schools within the trust to compare how students perceive physics in those schools, while accounting for different demographics and student backgrounds.

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