Gender, self-perception, and mathematics: The 2020 England, Wales, and Northern Ireland PISA Field Trial

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Concerns around discrepancies in mathematics participation by gender are longstanding in many jurisdictions. Normatively, those are a question of social justice: if girls are being disproportionately excluded for conscious or unconscious reasons at any level of the curriculum 'system', those should be addressed. Economically, disincentives for girls' engagement might also impinge on both personal and national thriving. While more girls than boys took pre-university STEM 'A Levels' in recent years in England, Wales and Northern Ireland, issues remain specifically with mathematics.

This paper draws on the 2020 PISA Field Trial data to outline some areas of concern as perceived by 15-year-olds in England, Wales, and Northern Ireland in early 2020. We first identify key issues recognised in previous literature, and then locate those within the 2020 dataset. By exposing the continuation and extent of these challenges in mathematics, the paper has potential also to identify opportunities to address them.

Keywords: PISA; mathematics; gender; self-perception

Introduction

PISA (on a three-year cycle) is a large-scale international assessment measuring 15-year olds' performance and attitudes in relation to literacy, and mathematical and scientific literacies, with a particular focus on one area each time (mathematical literacy for PISA 2021/2). PISA results enable governments to benchmark some aspects of education policy and performance, offer data that can contribute to related evidence-based decisions and support cross-jurisdiction learning. Nearly 80 jurisdictions participated in PISA 2018, including all members of the OECD and all four countries within the United Kingdom. The 2020 PISA Field Trial (FT) in England, Wales and Northern Ireland in which we are involved precedes the main study in 2021/2, which has been delayed because of the coronavirus pandemic. Assessments/questionnaires for both will be delivered by Pearson UK. Here, we analyse the 2020 FT mathematics-related data pertaining to self-reported gender: 'male/female/other' in PISA 2021. All sample students reported themselves male or female, and we here follow common practice of referring to them as 'boys' or 'girls' respectively. We draw on data from the mathematics assessment, and student, school and ICT questionnaires.

In the focus jurisdictions there has been an increase in % participation of girls in STEM (pre-university) A Levels in recent years, though in all three, gender-differential participation in mathematics A Levels remains stubbornly persistent (JCQ, 2020), despite investment made in addressing this (via e.g. AMSP and FMSPW Further Maths). This is an issue of both social justice and of economic thriving, especially in a context of unusually low upper secondary participation in mathematics

(Hodgen et al., 2010 but persisting since), although participation in 'Core Maths', if as yet low, seems encouragingly gender-neutral (JCQ, 2020).

The study

For the 2020 PISA FT, students from 19 schools completed both the assessment and student questionnaire. 20 schools returned the school questionnaire with enough data to analyse. 742 students (313 girls, 429 boys) took part. Of these, 22% of boys and 11% of girls were in single-sex schools. All students were born in 2004 (year 10 or 11 in England and Wales, year 11 or 12 in Northern Ireland).

Because Covid-19 reduced the intended sample from 40 to 20 schools, it was important to establish the representativeness of the achieved sample. PISA is not intended to be entirely representative in all relevant characteristics, but with a low response rate representation is a good metric to judge the usefulness of the data. Analysis established that representativeness by country, type of local community, institution and pupil level school governance, and student first language, special educational need, and socio-economic status, while not perfect, is good. Additionally, responses to identical questions asked in 2018 and 2020 were compared, with just four of 25 sets of responses showing a statistically significant difference. What follows, then, is likely to be indicative of patterns in the wider population.

Smith (2014) identifies five gender-differentiated factors, widely impacting students' intentions to study mathematics at A-level, and that might be influenced by school practices; Table 1 shows how we harnessed those to focus research questions:

Table 1: Rationale for research questions

Factor	Why is this important?	Related research question
Prior attainment*	Prior attainment and self-assessment limit one's perceived options for future study (Matthews & Pepper, 2007; Noyes, 2009).	Are girls, despite actual assessments, under-estimating their ability?
Enjoyment	Students are more likely to continue studying mathematics if they have positive emotional responses to it (Mutjaba & Reiss, 2013).	Are girls enjoying maths less?
Interest	Interest is prerequisite for girls choosing to study it when optional (Brown et al., 2008).	Are girls less interested in maths?
Perceived utility	Girls perceive less utility in mathematics than boys (Halpern et al., 2007; Hodgen et al., 2013), and it has been the second most common reason given for avoiding mathematics (Brown et al, 2008).	Is there evidence that students (of either gender) fail to see/be shown the utility of maths?
Perceived competence	Perceived (incl. relative) competence is inherent in choices made at 16 (Noyes et al., 2009; Sheldrake et al., 2015).	Do girls report being less competent than boys?

*we analysed self-assessment in relation to performance, since prior attainment was not available.

Findings

FT outcomes showed no statistical difference in average mathematics performance at gender level. There was insufficient data in the FT to probe profiles of attainment by gender in reliable ways. However, the data indicated clear answers to most of the research questions, *on average*: it is important to note that there was also considerable overlap of responses by gender. Graphical illustrations of findings, with some specifics of the contributing questions, are in Figure 1.

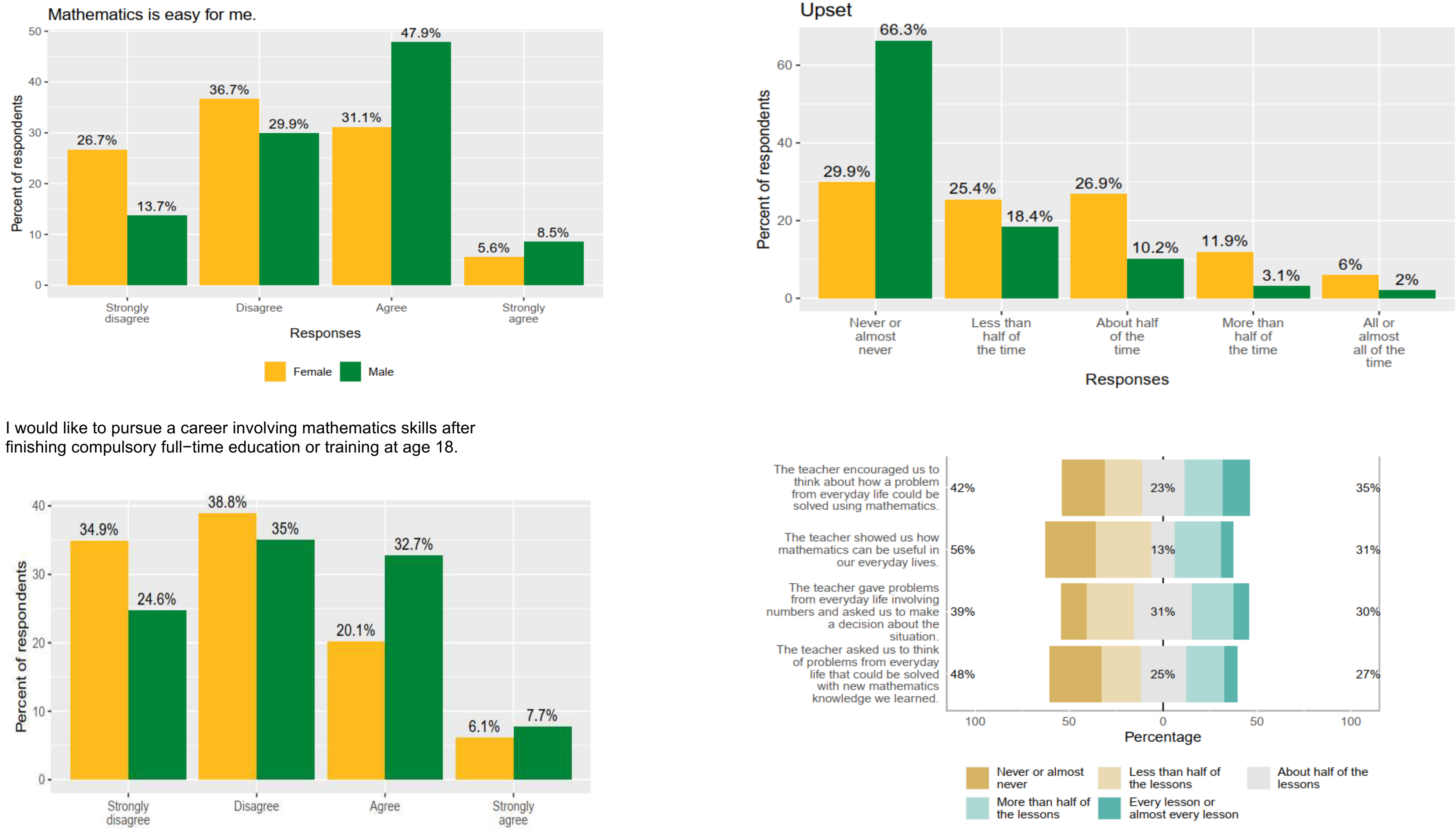


Figure 1: PISA 2020 FT data by gender

Self-assessment in relation to performance

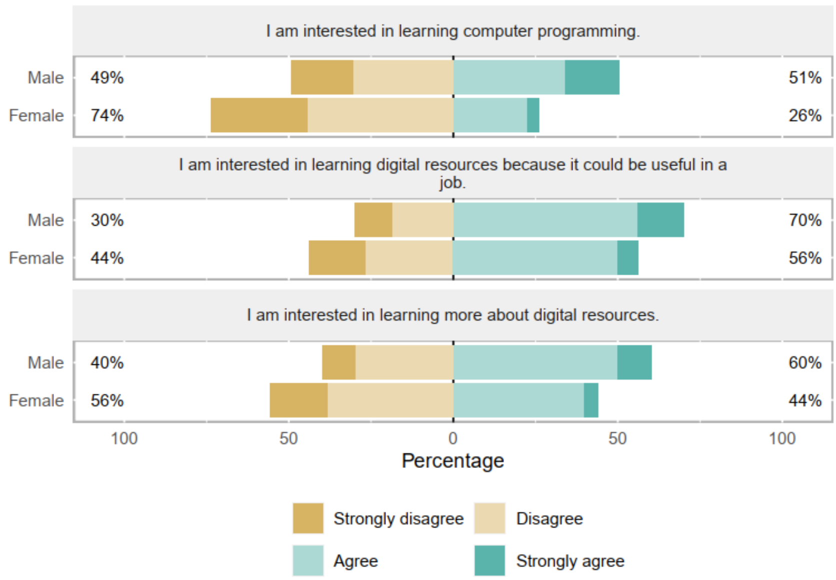
Overall, girls reported finding mathematics harder than boys: 56% of boys report that "Mathematics is easy for me" compared to 37% of girls ($p < 0.05$). There was no comparable statistical relationship for Science or English. Boys, but not girls, who attained highly were more likely to self-assess mathematics as easy.

Enjoyment

Girls reported enjoying mathematics less. It was their least favourite subject, including amongst those reporting it "easy." Being anxious and upset were both statistically more common amongst girls ($p < 0.001$); girls more frequently reported anger, boredom, tiredness, or being upset, and were up to ten times more likely to report anxiety "all or almost all of the time" while in class. However, anxiety was more frequently related to "doing well" rather than the act of doing specific mathematics, among both genders. Those who feel less anxious were statistically more likely to do well; the more anxious less well, in an apparent vicious cycle.

Interest

Girls were rarely interested in their mathematics lessons, and much less so than boys; they were less interested in careers using mathematics ($p < 0.005$). However, their interest increased when the question was posed through a lens of career utility, when the majority claimed interest. Awareness of career utility is therefore important, since Brown (2008) suggests for optional mathematics study, interest is a prerequisite for girls choosing it. Similar patterns can be found from the FT ICT questionnaire, where girls showed much less interest except when job utility was involved:



Perceived utility

A majority of both genders reported their mathematics lessons fail to make the relationship between mathematics and the real world obvious. Most students reported they are rarely or never encouraged "to think about how a problem from everyday life could be solved using mathematics" and are rarely exposed to questions making use of real-life examples. However, girls were statistically more likely to report that this relationship is not made in their lessons ($p < 0.05$). It is also striking that boys were more likely to report wanting to pursue a career involving mathematics (40% to 26%). They were also more likely to report being encouraged to do so by family (46% to 36%) and teachers (42% to 34%).

Perceived competence: a complex picture

The picture in relation to perceived competence is complex: girls' responses suggested they were less confident and feel less encouraged by teachers than boys ($p < 0.05$). Girls are also less likely to believe mathematics performance can be improved through effort ($p < 0.005$). There are, however, two issues with this at a gender level: such responses have historically been shown to have a gender bias built in, as boys overestimate their ability (e.g. Shure et al., 2019). Questionnaire data also shows that when mathematical situations are explicit (for example, solving equations such as $3x + 5 = 17$, $6x^2 + 5 = 29$, $2(x + 3) = (x + 3)(x - 3)$), girls were equally confident, but were significantly less confident in relation to more generally described tasks (e.g. "interpreting mathematical solutions in the context of a real−life challenge", "extracting mathematical information from diagrams, graphs, or simulations", "using the concept of statistical variation to make a decision").

Discussion and conclusion

The FT shows that numerous challenges (likely for both policy and practice) persist if girls' participation in mathematics in England, Northern Ireland and Wales is to significantly increase. By re-focusing on identifying specific continuing challenges, there is potential to support identification of opportunities to address them, as well as to inform international efforts and initiatives.

Responses to some questions are challenging to interpret: for example, "maths is easy for me" might reflect a conviction that the student considers they find given mathematical tasks more accessible than many of their peers do – or might instead reflect limitations to the mathematical challenges and expectations made during lessons. However, the findings above broadly support a disappointing continuation of established gender differentials in relation to each of self-assessed difficulty with mathematics, enjoyment of, interest in, and perceived utility of mathematics – on average. Similar patterns in relation to ICT-focused questions also suggest that enhanced use of ICT in mathematics lessons – at least as currently harnessed – is not likely to offer a 'quick fix' to girls' relatively low interest, confidence and participation in mathematics.

However, this work suggests/confirms some possible areas for improvement:

- Address feelings of lack of encouragement/explicitly reinforce everyday successes of all sizes;
- Address the vicious cycle of anxiety and poor results;
- Focus on student engagement, meaning-making and success with particular mathematics, rather than their overall 'performance';
- Further build links between real-world utility and mathematics (perhaps with a focus on employment, but also of application of mathematics to 'real world', especially people-focused, issues such as climate change, over-population, infant mortality, spread of disease…)

- Address issues of different levels of self-assessment between genders, e.g. through frequent explicit teacher feedback, to further understand the above data.

Taken with other evidence (e.g. Tripney et al., 2010), such approaches are likely to benefit all students, but result in a proportionately greater impact on the mathematical participation and dispositions of girls. Fuller analysis will be conducted with the much more extensive Main Study data, which will also offer the opportunity to track any pre-/post-pandemic changes.

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