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Girls' interest, enjoyment and participation in secondary school mathematics

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Abstract

In recent years, developing Australia's capacity in the Science, Technology, Engineering and Mathematics (STEM) subjects has become a national priority. It is also well known that girls tend to report lower rates of participation, enjoyment and self-belief in these subjects. With the introduction of girls to Barker in Year 7, 2020, it was timely to undertake a study in this area. Therefore, the purpose of the Travelling Fellowship was to identify ways that girls' interest, enjoyment and participation in secondary school mathematics can be increased and to provide key recommendations for coeducational mathematics teachers.

This paper is a brief summary of the full report tabled to the Barker Foundation, to which the author extends his thanks for its generous financial support of this Travelling Fellowship.

Background

Conventional wisdom may say that boys tend to be stronger in numeracy while girls are stronger in literacy. Data on spatial and mathematical reasoning, reading, writing and other related measures is often used to support these claims, though a closer examination shows they are still quite contestable and open to interpretation. Nevertheless, on the back of these claims, there has been a well-established and accepted movement in Australia (and internationally) to increase boys' engagement in reading and writing. Therefore, it would seem just as worthy a cause to look at increasing girls' enjoyment, participation and engagement in mathematics and the STEM fields.

With regard to Australia, research from large-scale international studies such as the Trends in International Mathematics and Science Study (TIMMS) has found that when examining mathematics and science achievement, "there were no gender differences in 22 of the 42 countries that tested at Year 8, *including Australia*" (Thomson et al. 2012, p.20, emphasis added). No gender differences were found within any single state or territory either, including New South Wales (NSW). Therefore, at least with regard to *achievement* in mathematics, the conventional wisdom of gender differences appears to have been overstated.

Instead of concentrating on mathematics achievement, this study focuses on areas where differences are more certain and observable. Consider the following:

- There is a participation difference. Enrolment figures in high school Mathematics Extension courses show consistent under-representation of girls. From 2014-2018, according to NESA, the percentage of Mathematics Extension 1 and 2 candidates who were female was approximately 41% and 36% respectively, while 51% of HSC candidates were female.
- This imbalance in Mathematics Extension courses also occurs at Barker. However, the situation is more complex as the Barker gender ratios from year to year are not weighted evenly and, with girls arriving in Year 10, their formative mathematics experiences and subsequent pathways have often been set by the time they have arrived at Barker.
- There is an interest difference. Watt (2008) has noted that girls in Australia are less likely to follow a mathematics-related career path. There being no achievement gender difference as noted in Thomson et al above, the participation differences in mathematics courses and careers are likely explained by some inherent interest disparity. Watt et al (2012) later confirmed that in the Australian setting, there is some difference in the "intrinsic value" that boys and girls place on mathematics-related careers.
- There is an enjoyment difference. In some international studies, Frenzel et al (2007) reported that although girls and boys received similar grades in mathematics, girls reported significantly less enjoyment and more anxiety than boys. Luo et al (2009) also report statistically significant differences in mathematics anxiety in middle school students (with girls having higher anxiety levels than boys) and with Year 9 being the age of peak anxiety. In non-Australian settings, these studies appear to be relatable to the Australian context given on-the-ground classroom experiences and the other Australian results stated above.

Societal and cultural influences such as gender stereotyping by parents, teachers and peers are often identified as factors underpinning these differences (e.g. Gunderson et al. 2012). Research conducted by Forgasz and Leder (2017) notes that among those with gendered views, the responses are typically in favour of boys. For those who might consider these gender-stereotyped views to be anachronistic and likely self-correcting over time, Forgasz and Leder draw the startling conclusion that "younger adult respondents are more likely to espouse traditionally gender-stereotyped beliefs than older participants" (p. 279). Therefore, it is imperative to be proactive when addressing gender equity issues in mathematics.

All of the challenging gender differences discussed above will be real for Barker's introduction of girls to the Year 7 2020 cohort. However, it is an excellent opportunity to rewrite conventional wisdom and show the world beyond the Mint Gates that girls in a coeducational context can experience real success and engagement with mathematics. It may take time to realise fully, but with some strategic thought (of which this report is but one component), we hope that every learner, girls *and* boys, will be able to thrive in their study of mathematics at Barker.

Study Tour Summary

- Research Conference in San Diego

  The National Council of Teachers of Mathematics (NCTM) is the world's largest association of mathematics educators, drawn from the United states and Canada. Panel discussions included the issue of equity in mathematics education, defined in racial, socioeconomic and gender terms.

- University of Nevada

  Dr Harsha Perera (Assistant Professor of Educational Psychology) is an expert in motivation and engagement for secondary school students with a particular interest in the STEM fields. I was able to consult with him and Dr Rachael Robnett (Associate Professor of Psychology) about recent research on girls' education in STEM fields.

- School Visit 1: The Alexander Dawson School, Las Vegas

  Dawson is an independent school (Pre-Kindergarten to Year 8) with an enrolment of 700 students. I was able to observe several mathematics lessons, including interviews with seven girls in Years 7/8 and a meeting with the mathematics teaching staff. Female students expressed that they needed more time to really understand concepts, whereas boys either "*got it quickly*" or "*didn't care as much*" if they did not. Girls felt they were more likely to take assessment results to heart whereas boys were more likely to shrug off a bad result. The mathematics staff added that boys thrived on competition, placing an emphasis on task completion, whereas girls tended to emphasise conceptual understanding.

- School Visit 2: All Saints' Episcopal School, Fort Worth

  At All Saints School, similar to Barker, but smaller in size, I was able to observe several Middle School mathematics lessons, including an excellent one involving grouped seating and group work, where the groups had been engineered to be of mixed genders. With careful guidance from the teacher, students were able to work well together and achieve high standards of learning outcomes.

- School Visit 3: Good Shepherd Episcopal School, Dallas

  Good Shepherd is a K-8 school and their mathematics staff were particularly effusive about the work of Jo Boaler, a well-known mathematics educator and researcher who emphasises the importance of mathematical growth mindsets, having conducted research with Carol Dweck in this area. Staff advised of the good potential of group work and team discussion and the necessity of strong behaviour management.

- School Visit 4: Parish Episcopal School, Dallas

  Parish is a K-12 school with a hard-driving and innovative flavour. The school's campus is a repurposed ExxonMobil Research and Development centre. Educationally progressive, Parish had many pioneering programs, particularly in STEM fields and it had systems of project-based learning. An experienced female member of the mathematics staff advised of the "speed advantage" that boys had compared to girls, not due to intelligence or affinity, but because of boys' tendency to "do first, think later," whereas girls tended not to put pen to paper until they had thought through the issues first and were confident.

Conclusions

Mathematics staff should be passionate about the subject, form positive relationships, have strong classroom management and use alternative assessment practices

In my discussions with Dr Robnett about the best type of teacher for an incoming Year 7 coeducational cohort, she was careful to point out that having a female teacher does not automatically result in better outcomes for female students. Indeed, the majority of mathematics teachers in the USA are female and yet girls still face challenges in engaging with mathematics. The quality of the teacher is most important, regardless of their gender, including:

- Dynamic passion for the subject
- Ability to form positive, warm relationships with students. The teacher-student relationship is crucial for any student, but particularly for girls and for Year 7 (the first year of high school).
- Strong and equitable behaviour management, while being carefully attuned to gender dynamics in the classroom such as using inclusive language, speaking sensitively about marks, proactively managing poor behaviour.
- Good assessment practices, being able to assess achievement and provide feedback in many different ways, not just pen and paper tests. Traditional tests tend to advantage boys in terms of their competitiveness, emphasis on speed and higher outward confidence.

Mathematics staff should encourage more group discussion and make physical spaces more engaging

At all four schools I visited, I was struck by the constant presence of group work and group discussion. As Year 7 and 8 are considered part of the Middle School (Years 5-8) in the United States, it was common to see classrooms that were similar to the Barker Junior School; that is, they were colourful and engaging spaces, filled with technology, with grouped seating (not rows) and sometimes alternative furniture.

Girls seemed to thrive in this environment, especially when given the chance to explain something to another student or work together. Mixing boys and girls in groups may be challenging at first, but ultimately beneficial, rather than having students gravitate to different halves of the classroom, creating group mentalities based on gender.

Mathematics staff should recognise and encourage examples of female role models in mathematics

While some might consider this recommendation tokenistic, the conversations I had with female students indicated that they took notice of such things and were often encouraged by having female role models in mathematics and other STEM fields. Both Dr Robnett as well as female teachers from the schools I visited were keen to stress this. Role models need not be limited to having female teachers in the classroom.

I was directed to the research work of Walton, Murphy and Ryan (2015) who spoke about female "belongingness" in STEM fields and the "stereotype threat" that undermines confidence and performance for people who are in settings where their group is negatively stereotyped (such as girls in mathematics). I am familiar with the research myself, having

published a paper (Lee & Anderson 2014) based on my interviews with male and female students across a number of schools that showed a strong bias (44 to 17) towards male figures when asked to name someone "who is really interested in mathematics", with fathers and male peers the dominant figures named.

The "stereotype threat" can be mitigated by recognising examples of female representation and providing female role models in these areas. In the schools I visited, practical measures included "fixed" features (including alumni posters and advertisements) and more personal interactions (such as guest speakers and female mentors for girls). To be clear, this does not suggest that we focus solely on female role models, only that we ensure that they are included equitably alongside any male role models.

Schools should educate parents about stereotypes and growth mindsets

At each school that I visited, staff commented on the parental effect on gendered expectations in mathematics. In particular, mothers often comforted their daughters after a bad result by saying that they were not good at mathematics and this "problematic comforting" often led to reduced expectations. It can sometimes be a similar story at Barker, where parents may be, sometimes understandably, very quick to comfort their children by talking down their own mathematical experiences.

In public settings, Barker staff need to continue to combat negative stereotyping and problematic comforting in mathematics. We ought to replace such thinking with Jo Boaler's "mathematical growth mindset" — it is a peculiarity that most people believe that proficiency in mathematics is a fixed trait which you are born with (or not, as the case may be!) whereas in many other areas and fields we recognise and champion the value of hard work and training. Jo Boaler's (and Carol Dweck's) research shows that this is not the case, and that anyone can attain proficiency at mathematics.

Moving from a fixed mindset to a growth mindset is a message that we need to be repeating time and time again, to parents, students and even our own staff; that we have high expectations of all students, male and female; that we will encourage and support all students to achieve their best and that all students can thrive in their study of Mathematics at Barker.

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