Gender and Mathematics

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THE BIG PICTURE: INTRODUCTION

“What if we lived in a world without mathematics?” Australia’s Chief Scientist (Finkel, 2017, p. 3) asked rhetorically. “…take away numbers, and you take away commerce, farming, medicine, music, architecture, cartography, cooking, sport… and every other activity we’ve invented since 3000 B.C.”

Historically, mathematics (and science) and related careers have been viewed as fields more suitable for boys and men than for girls and women. While there have been some advances made over time, gender remains a factor impacting on:

- Achievement in mathematics.
- Attitudes about mathematics and towards oneself as a learner of mathematics, and
- In participation rates in mathematics once it is no longer compulsory.

The latter impacts on future career options and opportunities.


Girls and women represent untapped talent. Enabling them to realise their potential is about both economic growth and social justice.

In order to address the gender differences in mathematics learning outcomes that are found, most often favouring boys and men, it is important to understand the underlying reasons.

Following a summary of the definitions of key terms, we:

- Present research-based evidence supporting our claims of gender differences in mathematics learning outcomes.
- Describe the challenges and barriers that teachers may face when addressing gender inequities in mathematics learning.
- Provide resources and activities to assist teachers in this area.
### KEY TERMS AND DEFINITIONS

It is important to know how gender is defined and used in this monograph, and how sex and gender differ. In the table below, we provide definitions of these terms.

Below the table you will find a list of words and terms associated with gender and mathematics learning. These words and terms are hyperlinked to a glossary that is found towards the end of the monograph.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Notes</th>
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</table>
| **Gender**         | Part of a person’s personal and social identity. It refers to the way a person feels, presents, and is recognised within the community. A person’s gender may be reflected in outward social markers, including their name, outward appearance, mannerisms and dress.                                                        | Definition drawn from Australian Government (2015): “The preferred Australian Government approach is to collect and use gender information” (p. 4).    The categories of ‘gender’ to be used for government data gathering are: M (male), F (female) or X (indeterminate/Intersex/Unspecified).
 |
| **Gender categories** | A mixture of categories for gender self-identification has been used. Historically (traditionally), the binary categorisations of: M (male) and F (female), or boys and girls, or men and women have been used. A third category, for those who identify as non-binary (or “X”), consistent with Australian Government (2015) guidelines, is being added. Another term commonly used for non-binary is gender diverse. | While some researchers are adamant that the binary categories of ‘male’ and ‘female’ as gender identifiers are inappropriate, many researchers continue to use these terms. |
| **Sex**            | The chromosomal, gonadal, and anatomical characteristics associated with biological sex. The categories of ‘sex’ to be used for government data gathering are: M (male), F (female) or X (indeterminate/intersex/unspecified).                                                                                   | This definition is drawn from Australian government (2015). Mathematics education researchers generally do not gather data on biological sex. |
| **Intersex**       | People who are born with genetic, hormonal, or physical sex characteristics that are not typically ‘male’ or ‘female’. Intersex people have a diversity of bodies and gender identities, and may identify as male or female or neither.                                                                                              | This definition is drawn from Australian government (2015).                                                                                                                                                                    |

Since the study of “gender differences” with respect to mathematics learning has generally focussed on the binary categories of Males/Boys/Men and Females/Girls/Women, in this monograph we focus on these two categories. At the same time, we wish to emphasize that we recognise that there are a number of individuals who self-identify as non-binary; we do not discuss findings for this third category here.

Although sex and gender are conceptually distinct, these terms are commonly used interchangeably, including in legislation (Australian Government, 2015, p. 4). Although usage in research has changed over time, regrettably some mathematics education researchers still use the terms loosely.
WORDS AND TERMS USED IN RESEARCH ON GENDER AND MATHEMATICS

The following words and terms used in research on gender and mathematics are explored in a glossary in the supplementary materials.

- Attitudes and beliefs
- Attributions for success/failure in mathematics
- Confidence as a learner of mathematics
- Female domain
- Gender difference
- Gender equity
- Gender equity model (explaining gender differences in mathematics)
- Gender stereotype
- Gender stereotyped beliefs
- Male domain
- Mathematics anxiety
- School factors
- Self-rating of mathematics capabilities/achievements
- Significant others
**EVIDENCE BASE**

For many years we have been reading about gender differences in mathematics learning. And for many years, too, we have asked what we, teachers, parents, and educational bodies, can do to ensure that girls are not left behind. Sadly, we have to accept that after at least five decades of serious research, hard work, and good intentions, subtle but persistent gender differences continue to be observed and described. Further research and actions are clearly needed.

**PERFORMANCE**

It is often reported in the literature that, on average, boys outperform girls in mathematics. Is this true in Australia? Let’s look at the Numeracy component of the nationally mandated NAPLAN tests.

Consider further results from the NAPLAN Numeracy test – see the entries for 2019 in Table 1. It can be seen that:

- A slightly higher proportion of girls than boys met the National Minimum Standard.
- A higher proportion of boys than girls scored in the highest band.

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean NAPLAN score</th>
<th>% at or above NMS1</th>
<th>% at or above highest band</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>M: 412.5  F: 403.5</td>
<td>M: 95.1  F: 98.0</td>
<td>M: 19.1  F: 7.5</td>
</tr>
<tr>
<td>5</td>
<td>M: 501.9  F: 489.6</td>
<td>M: 94.8  F: 96.0</td>
<td>M: 12.4  F: 8.0</td>
</tr>
<tr>
<td>7</td>
<td>M: 555.7  F: 549.8</td>
<td>M: 93.8  F: 94.9</td>
<td>M: 16.5  F: 12.1</td>
</tr>
<tr>
<td>9</td>
<td>M: 597.0  F: 587.0</td>
<td>M: 95.5  F: 96.5</td>
<td>M: 9.5   F: 5.8</td>
</tr>
</tbody>
</table>

Importantly, for high achieving students, similar findings have been reported on this test in previous years and also for test data gathered in other countries.
What about participation in mathematics subjects beyond the compulsory years of mathematics? For this it is useful to look at Victorian data for the three VCE mathematics subjects. Findings for almost two decades, from 2001 to 2019, are summarised in the graphs below. Although in 2018 and 2019 the category X was included among the self-identification categories, the small number of students who so identified are not included in the graphs.

For each year (2001–2019), and for each of the subjects, proportionally more boys than girls have been enrolled in the three VCE mathematics subjects. Similar findings for enrolments in post compulsory mathematics subjects are reported in many other countries.

...proportionally more boys than girls have been enrolled in the three VCE mathematics subjects
EXPLANATIONS

Why have these gender differences in performance and participation in mathematics not disappeared, despite widespread agreement that we wish the best educational outcomes for all our students, both girls and boys? What do students themselves think about mathematics?

Students’ beliefs and attitudes are difficult to measure. They are typically inferred from answers to survey items and from observations of students’ behaviours. Pooling results from many different studies, on average:

• More boys than girls say they like doing mathematics (though for both groups, liking of mathematics decreases as students move into higher grades).
• More boys than girls are confident they can do well in mathematics.
• More boys than girls indicate that their parents and teachers expect them to do well in mathematics, though in some recent surveys many girls also say that they believe girls are as good as boys at mathematics.
• When shown a mathematics question, more boys than girls state that they can solve it correctly.
• More boys than girls expect to use mathematics in their work.
• More boys than girls volunteer to answer or ask a question in class.
• More girls than boys say they like to work with others when doing mathematics.

There is research evidence that, individually or collectively, these gender differences in beliefs and attitudes subtly affect students’ performance and motivation in mathematics. What strategies can teachers constructively implement in their classroom? Examples are provided later.

What about teachers?

Engaging and motivating students requires skill, ingenuity, craft, reflection, and self-awareness. We know that some in our society still think that boys are better than girls at mathematics and girls better at English than boys (Leder, Forgasz, & Jackson, 2014). Might this also be true for some teachers, who themselves are part of the general public? Might they, unintentionally, convey this to their students?

• In a recent study (Li & Koch, 2017), teachers were asked to specify whether year 10 or year 12 mathematics was required for a range of occupations. A higher proportion of women than men selected the higher level of mathematics for all of the occupations listed, apart from chef and fashion designer. Might this indicate, the researchers asked, that female teachers value the need for mathematics in different careers more highly than male teachers? Might this influence discussions about the usefulness of mathematics and subsequent career choices?
• In an influential article (Fennema, Pedra, Walleat, & Becker, 1981, p. 4) about the impact of different teacher strategies the following teacher-student dialogue was recorded:

Teacher: Have you figured out the answer, Marcia?
Marcia: Uh, no. Not yet.
Teacher: Eric, how about you?
Eric: I can't get it!
Teacher: Come on, Eric. You can do it.
What's the exponent?
Eric: Oh Yeah, x to the fifth. get it now.

Exchanges such as these, the authors argued, could be interpreted by students as a subtle message that, for their teacher, problem solving is more important for boys than girls. Marcia’s experience this time was one of failure. By staying with Eric, the teacher encouraged him to persevere and helped him achieve success. What might be the cumulative impact of such interactions?

• Previous studies of interactions in mathematics classes have revealed that teachers, on average, spend more time with boys than with girls, interact more frequently with boys than with girls, more often ask boys more challenging questions and girls simpler questions, and offer boys longer wait times (time to provide answers) than girls (Jones & Dindia, 2004; Leder, 1995; Peterson & Fennema, 1985). What subtle message might be inferred from these practices?
ISSUES IN THE TEACHING OF MATHEMATICS: GENDER AND MATHEMATICS

Key steps towards gender equality in STEM:

**ELIMINATE** stereotypes and bias

**EMPHASISE** real-life STEM applications in teaching

**REWARD** hard work and build confidence – it’s okay if you don’t understand straight away

**ENCOURAGE** organisations to create supportive and inclusive workplaces, and monitor progress towards equality

HOW WILL THE SCHOOL KNOW IF EQUITY IN MATHEMATICS HAS BEEN ACHIEVED?

Evidence of gender equity in mathematics learning outcomes in your school would include:

- Near equal proportions of girls and boys studying each VCE mathematics subject.
- At all grade levels, no gender difference in the mean mathematics scores/grades of girls and boys in classwork, NAPLAN numeracy, VCE results.
- Girls and boys exhibit equal interest and enjoyment in mathematics, believe that mathematics is useful in their lives, and recognise that good mathematical skills will enhance their lives and future job/career options.
HOW CAN THESE OUTCOMES BE ATTAINED?

A whole school approach is preferable. That is, the whole school community (leadership team, school council, all teachers, all professional support staff, parents, and students) needs to:

- Know the current status of gender differences in mathematics learning in the school and across Australia.
- Appreciate the range of factors contributing to the inequities.
- Recognise the benefits of achieving gender equity.
- Be supportive of the need for school-wide strategies to address the known gender inequities in mathematics.

A ROADMAP TO ATTAINING GENDER EQUITY IN MATHEMATICS IN YOUR SCHOOL

Members of the entire school community should be included in the various stages of the roadmap to attaining gender equity in your school: mathematics teachers; teachers of other subjects; professional support staff; school leadership team members; school council members; parents; and students.

HOW WILL YOU KNOW IF THE ROADMAP HAS LED TO THE DESIRED OUTCOME OF GENDER EQUITY IN MATHEMATICS?

Consider the case of the media campaign, Maths multiplies your choices, conducted by the Department of Labour, Victoria, in the early 1990s. Parents were targeted. The goal was to increase girls’ enrolments in Year 11 (non-compulsory) mathematics subjects in order to keep flexible their future job/career options. Some may remember the campaign slogan, “Don’t pigeon-hole your daughters”. In the year following the media campaign, girls’ enrolments in Year 11 mathematics soared. The campaign was deemed successful and, regrettably, funding for the next year was withdrawn. It was not long before girls’ enrolments fell back to what they had been prior to the campaign.

In an earlier section of this monograph, the evidence for the attainment of gender equity in mathematics in your school was listed. As the roadmap is being implemented in the school, it is important to constantly monitor and evaluate progress. The findings should also be shared with the school community to avoid the possibility that the purposes of the program are forgotten over time.

What are some of the potential obstacles to attaining the school’s goals?

- People holding entrenched, stereotyped beliefs, that are claimed to be “the natural order”.
- Other school-related issues being considered more pressing.
- Fear of change and/or the reluctance to embrace change.
- Lack of support from one or more school community groups.
- Financial implications of change.

ELEMENTS OF A ROADMAP TO ATTAINING GENDER EQUITY IN MATHEMATICS IN YOUR SCHOOL

In the supplementary materials of the monograph you will find a number of activities that can also be used. We provide lists of readings and YouTube videos that can be used to extend personal understandings of gender issues and mathematics. Selected readings and videos can also be incorporated within the gender equity roadmap.

We provide instructions on how to prepare and administer the instruments accompanying the activities, how to analyse any data gathered, as well as suggested provocations for discussion of the findings.

The readings, YouTube videos, and activities can be used separately, or in combination, to:

- Raise awareness of pertinent issues.
- Serve as professional learning activities.
- Adopt with students.