MATHEMATICS TEACHING toolkit

ISSUES IN THE TEACHING OF MATHEMATICS

Gender and Mathematics

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THE EDUCATION STATE

VICTORIA State Government | Education and Training

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.

According to the Prinsley, Beavis, and Clifford-Hordacre *(2016, p. 1)*:

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.

Term	Definition	Notes
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.
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.		
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).
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

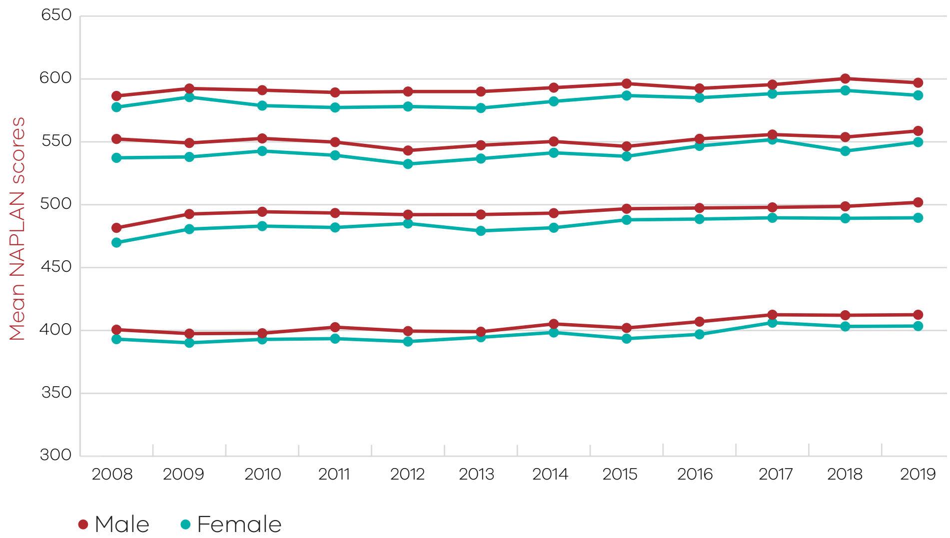
EVIDENCE BASE

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.

NAPLAN results Year 3, 5, 7, and 9 by gender 2008-2019



The consistency of the findings is startling. In each year, and at each grade level, over the past decade boys have, on average, slightly outperformed girls.

But the overall picture is more complicated.

Australia loses female talent at every stage of the STEM pipeline despite no innate cognitive gender differences

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 1. NAPLAN Numeracy data for 2019 by gender (1National Minimum Standard)

	Mean NAPLAN score		**% at or above NMS1**		**% at or above highest band**	
Year	**M**	**F**	**M**	**F**	**M**	**F**
3	412.5	403.5	95.1	96.0	19.1	14.0
5	501.9	489.6	94.8	96.0	12.4	7.5
7	555.7	549.8	93.8	94.9	16.5	12.1
9	597.0	587.0	95.5	96.5	9.5	5.8

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.

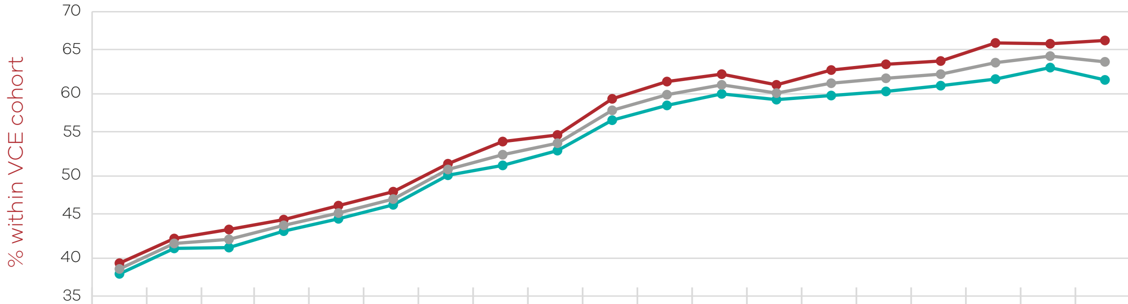
PARTICIPATION

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.

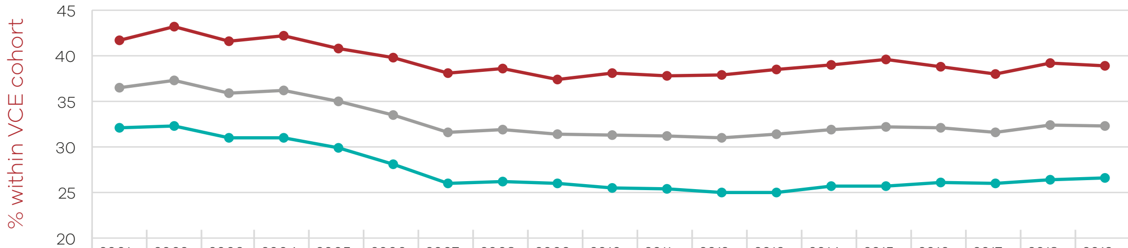
> **...proportionally more boys than girls have been enrolled in the three VCE mathematics subjects**

VCE Further Mathematics Enrolments (2001-2019)



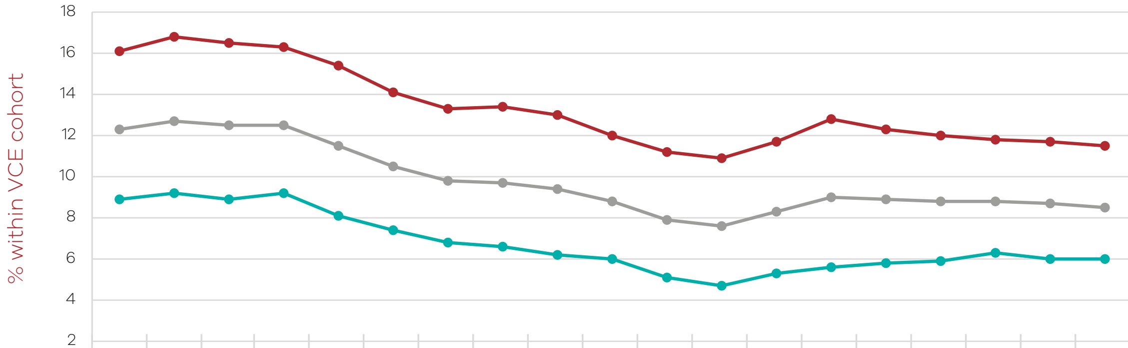
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
All	38.7	41.8	42.3	44	45.5	47.2	50.8	52.6	54	58	59.9	61.1	60.1	61.3	61.9	62.4	63.8	64.6	63.9
M	39.4	42.4	43.5	44.7	46.4	48.1	51.5	54.2	55	59.4	61.5	62.4	61.1	62.9	63.6	64	66.2	66.1	66.5
F	38.1	41.2	41.3	43.3	44.8	46.5	50.1	51.3	53.1	56.8	58.6	60	59.3	59.8	60.3	61	61.8	63.2	61.7

VCE Mathematical Methods Enrolments (2001-2019)



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
All	36.5	37.3	35.9	36.2	35	33.5	31.6	31.9	31.4	31.3	31.2	31	31.4	31.9	32.2	32.1	31.6	32.4	32.3
M	41.7	43.2	41.6	42.2	40.8	39.8	38.1	38.6	37.4	38.1	37.8	37.9	38.5	39	39.6	38.8	38	39.2	38.9
F	32.1	32.3	31	31	29.9	28.1	26	26.2	26	25.5	25.4	25	25	25.7	25.7	26.1	26	26.4	26.6

VCE Specialist Mathematics Enrolments (2001-2019)



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
All	12.3	12.7	12.5	12.5	11.5	10.5	9.8	9.7	9.4	8.8	7.9	7.6	8.3	9	8.9	8.8	8.8	8.7	8.5
M	16.1	16.8	16.5	16.3	15.4	14.1	13.3	13.4	13	12	11.2	10.9	11.7	12.8	12.3	12	11.8	11.7	11.5
F	8.9	9.2	8.9	9.2	8.1	7.4	6.8	6.6	6.2	6	5.1	4.7	5.3	5.6	5.8	5.9	6.3	6	6

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, Pedro, Wolleat, & 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?

Schools, parents, and society

A school's culture might influence students' beliefs and teachers' behaviours. For example:

- School based assessment practices. Are timed tests, on which boys often perform better than girls, the exception or the norm?
- How students are grouped for learning across and within schools and classrooms (e.g., single-sex/co-education, mixed ability/ability grouping). What beliefs may be reinforced by the different grouping practices?
- Why might opportunities for collaborative activities in and beyond the classroom be important?
- Timetabling of subjects and the resulting subject choices that need to be made. What may be implied by particular subjects being blocked together?

Beyond school

Does the content of the print media, films, and TV portrayals of women and men in STEM activities reinforce or challenge stereotypes?

Do the figures in the table below reflect parents', friends', and broader society's attitudes and expectations towards STEM and STEM-related occupations for boys and girls?

% of STEM graduates in sector who are female		
Bottom 2 sectors	Construction	12%
	Transport	15%
Top 2 sectors	Education	41%
	Healthcare	60%

ISSUES AND CHALLENGES

THE GOAL

Achieving gender equity in mathematics learning at your school.

CALL TO ACTION

The Chief Scientist's Office suggests the following strategies for achieving equity in STEM . Focussing on mathematics, these steps can be applied in your school.

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.

Gender and Mathematics

SUPPLEMENTARY MATERIALS

Activities and reference material

ACTIVITIES

Within this section of this monograph, we provide a range of activities that can be used with mathematics teachers, students, and/or with other members of the school community.

The instruments associated with the activities should be used to examine and explore provocations about gender issues as they relate to the teaching and learning of mathematics. For each activity, we suggest with whom to use the instrument and the setting in which it might work best, and provide instructions on how to prepare and administer the instrument, and how to analyse any gathered data.

The activities should be seen as relevant in the planning of a road map to attaining gender equity in your school. Pertinent activities can be selected to be used in professional learning settings (in-house or invited facilitators). Findings from the activities can be shared with other school community groups (school leadership team, teachers of other subjects, professional support staff, school council, and parents).

As a result of the activities with mathematics teachers, an action plan for change to address identified gender inequities can be developed. Students should be provided with feedback on the data gathered from them.

To support students, the school community might consider:

- Exposing and challenging stereotyped views.
- Encouraging students to examine why they feel as they do, and who influenced and shaped their views.
- Discuss their views on what might improve/change their beliefs and expectations, and how they might challenge the views of those who influence them.

The outcomes of all actions aimed at achieving gender equity in mathematics in your school should be evaluated.

ACTIVITY 1:

Raising awareness of gender and mathematics issues in society and in your school

Before change can be embarked upon, members of the school community (the school leadership team, school council members, teachers, professional support staff, and students) need to be aware of the pertinent issues and why they are important.

Raising awareness is a good way to begin the quest of meeting your school goal of gender equity in mathematics.

Before calling various meetings, the mathematics teaching team, with the support of the school administration should:

Gather and analyse your school's data by gender on:

- NAPLAN numeracy results.
- VCE subject enrolments and past results.
- Representation of girls and boys in mathematics groupings (e.g., if your school has streamed mathematics classes, mathematics clubs, extra-curricular programs; if your students participate in mathematics competitions; etc.) .

Through appropriate channels, share the school's data on gender and mathematics learning with the school community (e.g., staff, school council, parent meetings; assemblies; newsletters, website, etc.). The following should be considered for inclusion:

Compare the school's data to Australian and international data (see the Stem Equity website, https://www.industry.gov.au/data-and-publications/stem-equity-monitor/primary-and-secondary-school); some Victorian data are included in the Evidence Base section of this monograph. State NAPLAN are found on ACARA's NAP website (https://www.nap.edu.au/results-and-reports/national-reports) and PISA data can be extracted from the PISA reports that are downloadable from the ACER PISA website (https://www.acer.org/au/pisa/publications-and-data)

- Use research findings to highlight potential contributing factors – see the Glossary of key terms used in research and Evidence Base in this monograph for guidance.
- Invite comments/thoughts on the data presented .
- Highlight why attaining gender equity in mathematics in your school is important.
- Present ideas on the steps that can be taken towards achieving the goal.

ACTIVITY 2:

Views of mathematics

This activity serves as a simple method for exploring your students' thoughts and feelings about mathematics.
It could also be used with teachers of subjects other than mathematics.

INSTRUCTIONS

Make multiple copies of the Views on mathematics sheet found on page 25.

Give a copy of the sheet to each student in your class.

Ask students to write one or more words against each spoke to indicate what they think about, and how they feel, when they hear the word, **"mathematics"**.

Be sure to tell them that there are no right or wrong answers – you are just interested what **THEY** think and feel. If necessary give them a few examples to start: for example: fun, interesting, geometry etc.

DATA ANALYSES

Analyse the data separately for girls and for boys.
Look at the words they have used to describe:

- Their thoughts about mathematics.
- Their feelings about mathematics.

Sort the words into **POSITIVE** thoughts/feelings and **NEGATIVE** thoughts/feelings.

PROVOCATIONS

Over all, were students' thoughts and feelings about mathematics more likely to be positive or negative? Why might that be?

Were the patterns of positive and negative thoughts and feelings similar or different for girls and boys? Why might that be?

If you used the activity with students at different grade levels, were there any differences, by grade level, in the thoughts and feelings tapped? As a group, were older or younger students more positive? Were the patterns different for girls and boys? Why might that be?

How might you address students' negative thoughts and feelings about mathematics?

ACTIVITY 3:

(Sub-conscious) gender-stereotyped views

This activity is suitable for students.
(It can also be completed by teachers.)

[Click for definitions of male domain, gender stereotype]

DRAW A MATHEMATICIAN

The activity offers a simple opportunity to determine how and what students think about mathematicians.

INSTRUCTIONS:

Give students a piece of paper. The students should indicate their own gender on the sheet – girl/boy/non-binary.

Ask the students to **"Draw a mathematician"**. Also ask them to add a sentence or two to explain who or what they have drawn, and their reasons for the particular depiction of a mathematician.

ANALYSING THE DRAWINGS

Collect the drawings and analyse them.
(You could also analyse the drawings separately for girls and for boys.)

Use the following characteristics for guidance in your analysis:

- Gender
- Ethnicity
- Hair
- Glasses
- Where located
- What doing

Compare your findings with those of researchers. Many of the characteristics of the drawings of mathematicians are aptly summarised in the following quotation from *Berry and Picker (2000, p. 25):*

In the 306 surveys returned from schools in England and the USA, the images of mathematicians were primarily male, all were white, the majority with glasses and/or a beard, balding or with weird hair, invariably at a blackboard or computer. When the drawing included a blackboard, one of two types of writings was generally on it: trivial arithmetic, such as 1+1=2; or a meaningless gibberish of mathematical symbols and formulas. Often among these symbols could be discerned Einstein's 'E=mc2.

Others have also found that if a woman is drawn, she is most often depicted as a teacher, and that in several drawings, gender-neutral people are portrayed.

It is often noted that very few males or females perceive woman as mathematicians, despite advances in gender equity in society. It is considered important to expose girls (and boys) to female role models in mathematics and to explore the challenges women faced being recognised as mathematicians in the past. The film, "Hidden Figures", and other resources (see lists of suggested Resources: Readings and YouTube videos) are available as conversation starters with students.

PROVOCATIONS

- Were gender stereotypes evident in the students' drawings?
- What factors may have contributed to the views of mathematicians that your students hold?

AN ALTERNATIVE APPROACH

Many instruments have been used in research studies to explore students', pre-service teachers', and the general public's views on mathematics. Personal views have been found to reflect gender differences, and people's views about boys and girls and their aptitude for mathematics have also been found to differ.

The two instruments found in the Leder and Forgasz *(2002)* article (reference below) have been used, often modified or adapted, in a variety of studies both in Australia and internationally. They are not achievement tests and are best thought of as attitude inventories, with a focus on the extent of gender stereotyping of mathematics. They offer an alternative way to understand better your students' attitudes and feeling.

Leder, G. C., & Forgasz, H. J. (2002). *Two new instruments to probe attitudes about gender and mathematics?* Retrieved from https://eric.ed.gov/?id=ED463312.

ACTIVITY 4:

Attitudes towards mathematics

This activity involves exploring students' feelings (attitudes and beliefs) towards mathematics and themselves as learners of the subject, as well as their attributions for success and failure in mathematics.

The instrument includes items that tap their views on the importance of mathematics, the learning settings they like (individual/co-operative), their peer's reactions to their efforts, and their beliefs about their teachers, as well as whether they are anxious about mathematics.

(see Key Terms for definitions of attitudes and beliefs, attributions for success/failure, significant others, mathematics anxiety)

INSTRUCTIONS

Make copies of the Attitudes to mathematics instrument found on page 18.

Distribute copies of the instrument. It should not take more than 15 minutes for the students to complete.

ANALYSIS

Analyse the responses separately for girls and for boys, noting how many boys and how many girls completed the instrument.

For each of the items 1–19, tally the numbers of Yes/No/Neutral responses.

For each of the items 20–21, tally the numbers of responses in each category.

For item 21, categorise the responses and find totals for each category. The following are some common responses: mother, father, sister, brother, tutor, friend, other.

Compare the responses of girls and of boys on the 21 items.

NB. If approximately equal numbers of boys and of girls completed the instrument, then trends can be identified by simply comparing the numbers. If, however, there were clearly a different number of girls and of boys who completed the instrument, you should use percentages (within gender) to make comparisons.

PROVOCATIONS

What can you deduce from the patterns of responses to the first 19 items? Do girls and boys hold similar views on some items but not on others? What factors may have contributed to any differences you find?

(For previous research findings, re-visit the Evidence Base and the Key Terms attitudes and beliefs, significant others, and mathematics anxiety)

Are the results for questions 20 and 21 similar to, or different from, the findings from research in the past?

(For previous research findings, re-visit the Evidence Base and the Key Term attributions for success/failure).

For question 22, were the people boys and girls turned to for assistance with homework similar or different? Who were the most likely people help was sought from? What factors may have contributed to the patterns you found?

ACTIVITY 5:

Gender bias and mathematics: evaluating students' capabilities and potential

This activity is suitable for mathematics teachers; it is also appropriate for teachers of other subjects.[2]

INSTRUCTIONS

The instrument to use for this activity is provided on page 19.

Prepare several copies of each of the two case studies (Denis and Denise).

Groups of 3 or 4 teachers work best for this activity.

Give a copy of only ONE of the case studies to each group. No group should be aware of what any other group is doing. Each case study should be considered by at least one of the groups.

The group should reach an agreed consensus on:

i. What subjects the student would be recommended to study in Year 12.

ii. What the student is likely to be doing one year after leaving school.

iii. What the student is likely to be doing when 30 years of age.

After about 15 minutes, open a discussion to compare what the groups have to say about Denis and Denise.

PROVOCATIONS

The profiles of Denis and Denise were identical. From the perspective of gender equity, it would be expected that the groups' responses to i–iii above should be identical.

Were there differences in the responses to any of i–iii above depending on the name, Denis or Denise, on the case study profiles? If yes, why did teachers respond differently?

(It may be useful to refer back to the Evidence Base and the Key Terms gender equity, gender stereotype, gender-stereotyped beliefs, and gender equity model).

[1 & 2] *This is a modified version of an instrument found in:*
The Open University. (1986). Girls into mathematics. Cambridge, UK: Cambridge University Press.

ACTIVITY 6:

Gender and careers involving mathematics

This activity is suitable for mathematics teachers and/or students.

The activity involves exploring the AMSI careers website. The goal is to highlight the range of career and job options for which mathematical skills are needed. Much other useful information about mathematics and careers can also be found on the website.

INSTRUCTIONS

Go to the AMSI careers website: https://careers.amsi.org.au/

Scroll down to

1. Click on **SEARCH CAREERS**.
2. Then, click on "I am interested in…" and make a selection. There are 11 options including Education, Science and Environment, Sports and Recreation.

Allow students/teachers ample time to explore the various options. Then open a discussion about what they found that they did not know about previously.

FURTHER EXPLORATIONS

Start at https://careers.amsi.org.au/

1. Scroll down the page and explore the "Profiles"
2. Now, at the top of the page, select:
   - "Parents" and explore the options on the "Take home tips" page
3. Again, from the top of the page, select:
   - "Resources" and explore the range of "videos" and/or the "download resources"

PROVOCATIONS

What are the effects of limited knowledge of the career/job options that draw on mathematical skills?

Who should be helping students to be more aware of the range of options, and when?

How might more knowledge of career/job opportunities affect mathematics subject choices in Years 11 and 12?

NB. The impact of not studying higher level mathematics on girls' career options and the factors contributing to girls' decisions are discussed in many areas in this monograph. The Chief Scientist of Australia's words quoted in the Introduction to the monograph encapsulate why this issue needs to be addressed. Doing so is important for Australia's future.

ACTIVITY 7:

Mathematics classroom observation of practice

Observation of classroom practices can be viewed as threatening. However, with appropriate discussion of the purposes for the observations – professional learning, ongoing reflection on current practices, and developing a gender equitable mathematics classroom with enhanced learning opportunities for students – observations can be rewarding and inspirational.

Inside the mathematics classroom – observation of practice

This classroom observation activity may be adapted and modified to cover a wider range of lessons (e.g., in other subject areas) or interactions and serve as a group engagement activity.

[An alternative approach, described below, is to make a video of your lesson.]

OBSERVATION OF A MATHEMATICS LESSON

You can use one or more colleagues to serve as classroom observers.

WHAT YOU NEED TO DO BEFORE THE OBSERVATION PERIOD

The layout of the classroom should be recorded on a sheet of paper (or using appropriate computer software) to indicate:

- The location of the tables/desks.
- Seating arrangements – who is sitting where.

Do this by earmarking a square for each student to indicate where she/he will be sitting. Label each square so you can easily recognize who was sitting there (e.g., for each student, use the student's initials as well as an 'M' or an 'F').

Now, prepare a copy of the observation sheet for the particular observation task (e.g., types of questions asked of whom) for a lesson. [Clearly, you will need to provide a stopwatch or equivalent if you are interested in wait time data.]

If you wish to focus on different types of observation tasks in the one lesson, you will need multiple observers, each having a copy of the observation sheet. Each observer should focus on only one of observation task.

FOR THE OBSERVER(S)

Ask the observer(s) to carry out the observation task(s). Provide each observer with the relevant guidance notes.

1. If you are interested where you spend most of your time: ask the observer to record, every 60 seconds, a "t" on each square which most nearly identifies your position in the room.
2. If you are interested in the feedback to the students in your class, ask the observer to record in the appropriate square:
   - "p" for praise relating to an academic aspect of the student's work (e.g., that is a great idea)
   - "c" for criticism relating to an academic aspect of the student's work (e.g., that is a silly mistake)
   - "np" for praise relating to a non-intellectual aspect of the work (e.g., that is very neat writing)
   - "nc" for criticism relating to a non-intellectual aspect of the work (e.g., this is not set out properly)
   - as well, add "s" in the square if the student asked a question
3. If you are interested in the quality of the questions you ask your students, ask the observer to record in the appropriate square the code:
   - "r" for a routine/procedural question requiring only a short answer
   - "ho" for a higher order, complex question
   - "d" for a reprimand/ discipline
4. If you are interested in the wait time allowed before a response is required from the student, you will need to prepare a slightly different, appropriate observation sheet for the observer to record the times (e.g. < 2 seconds, 3<time<10 seconds, >10 seconds) for questions to boys and to girls.

Follow up/provocations:

- Analyse the data once you have gathered and collated the data from the sheets.
- How well do you know your students?
- Are there any implications for the ways you interact with the boys and girls in your class?

USING VIDEO: EXAMINING ASPECTS OF YOUR INTERACTIONS WITH THE STUDENTS IN YOUR MATHEMATICS CLASSROOM

Rather than having a colleague observe your mathematics lesson, you can arrange for a video of your mathematics lesson to be made. The advantage of a video is that you can review (and re-review) the lesson at your leisure.

But before embarking on the making of the video:

a Consider a brief excerpt of the use of video material to reflect on classroom practice. Watch the YouTube video found at https://www.youtube.com/watch?v=RlnOlEdY47Y. Check that you have access to the appropriate video equipment. Could the approach adopted at that school be modified to focus on the classroom interactions of the teacher with boys and girls and ultimately ensure that boys and girls are treated equitably?

b Watch the YouTube video clip found at https://www.youtube.com/watch?v=tAz7TD02ytU and think how this could be used for an analysis of teacher-student interactions. Could capturing and reviewing such lessons, and modifying the interaction patterns if necessary, be used to ensure gender equity in the classroom?

c Watch the YouTube video of a snapshot from a grade 4 classroom found at https://www.youtube.com/watch?v=no9RYZA9t2g. Is there sufficient evidence to assess whether boys and girls are treated equitably?

Again, before making the video, you need to decide on which teacher/student interactions you want to focus on and have recorded. For example, you may be interested in knowing which students (boys/girls) you spend most of your time with, or you may wish to focus on the types of questions you ask and to whom (boys/girls), or what type of feedback you provide and to whom (boys/girls). Through repeated viewing of the video you may be able to focus on each of these types of interactions sequentially.

Suppose you are interested in looking at the types of questions you pose, the wait time you provide, and the feedback you give. Here are some aspects you may want to consider when examining the video for gender equity:

The questions you ask

1 Who is asked (boys/girls):

- Questions requiring only a short answer? (e.g., a routine or procedural question).

2 How long did you wait for an answer (wait time)?

- More searching, higher order, complex questions.

3 How long did you wait for an answer?

- Who is involved in extended exchanges: prompts, cues, follow up questions etc.?

Feedback you give

1. When you give feedback, who (boys/girls):

- is praised?
- receives critical feedback?
- receives no feedback?
- gets a neutral response?
- receives a non-verbal response?

NB. It is often most informative if you also later watch the video without sound.

PROVOCATIONS

- Did you treat boys and girls equitably in your lesson?
- Is this what you expected to find?
- What now?

COMPARISONS WITH PREVIOUS RESEARCH

Under the sub-heading "What about teachers" in the Evidence base of this monograph, previous research findings on classroom observations are presented.

Whether you completed the classroom observations with observer(s) or using a video, reflect on:

- How do the findings from your mathematics classroom compare with what earlier researchers have found?
- What are the implications of the findings for you as the teacher, and for the students in your mathematics class?

OTHER POTENTIAL FOCI FOR OBSERVATIONS TO DETERMINE IF GENDER EQUITY IS EVIDENT IN THE MATHEMATICS CLASSROOM

- Which teaching strategies predominate?
  - Teacher-centred?
  - Student-centred?
  - Are particular teaching strategies valued over others?
- Are different learning styles (collaborative/competitive/individual) catered for?
  - Are particular learning styles privileged over others?

ACTIVITY 8:

Assessment of mathematical knowledge

This activity is aimed at mathematics students.[3]

As discussed in the Evidence Base section of this monograph, it has been found that, on average, boys outperform girls on timed tests/exams (e.g., NAPLAN, VCE mathematics subjects – examination components, PISA, TIMSS), but that girls' performance on many other assessment types is equal to or better than boys'.

Responses to the instrument, Assessment questionnaire (click here) will provide teachers information about: students' beliefs and perspective on mathematics assessment.

INSTRUCTIONS

Prepare multiple copies of the Assessment questionnaire (provided on page 20). Administer the questionnaire to students. It should not take more than 20 minutes to complete.

DATA ANALYSIS

Analyse the data separately for girls and for boys.

Questions 1a and 1b

Tally the responses to Q1a for each category. Compare the results for girls and for boys.

Carefully examine and categorise the responses to Q1b. Common explanations for the choice made include, for example, "girls are no good at maths" and "boys are naturally good at maths".

Question 2

There were ten assessment types presented. Tally the responses on students' most preferred assessment type (ranked 1) and their least preferred assessment type (ranked 10).

Questions 3a and 3b.

For Q3a, tally the responses for the most and for the least preferred question type.

For Q3b, examine closely which question type/s girls and boys believe they do best in.

PROVOCATIONS

- Do girls and boys hold similar or different beliefs about who is better at mathematics?
- How do the girls' and boys' beliefs compare with previous research findings? (See Students section in the Evidence Base and the key terms, gender-stereotyped beliefs, self-rating of mathematics, and confidence as a learner of maths)
- Are girls' and boys' most (and least) preferred assessment types the same?
- Are girls' and boys' most and least preferred question type (with or without people – men/women) the same?
- Are the types of questions on which girls and boys think they will perform best the same?
- Overall, are there gender differences in students' beliefs and preferences related to assessment and question types? What are the implications of these findings?

[3] *This is a modified version of an instrument found in: The Open University. (1986). Girls into mathematics. Cambridge, UK: Cambridge University Press.*

ACTIVITY 9:

Analyses of mathematics textbooks for gender equity (also suitable for other mathematics teaching resources)

This activity is suitable for mathematics teachers.

Gender equity issues to watch out for when selecting a mathematics textbook (or other mathematics teaching resource).

See Forgasz (1996) – reference below.

Photographs, illustrations, and the wording of problems/examples should be examined. For a textbook (or other teaching resource) to reflect gender equity, the following should be evident:

- Close to equal numbers of males and females.
- Males and females fairly equally sharing active ('doer') and passive (helper/observer) roles.
- A balance of contextual settings of interest to males and to females (not necessarily gender-neutral activities).
- The settings, occupations, and professions illustrated or mentioned are not gender-stereotyped.

Forgasz, H. (1996). Equity and the selection of textbooks: an analysed example and a checklist. Vinculum, 33(4), 6-8.

THE TASK

Teachers can work in pairs on this task using a mathematics textbook that is being used at Year 7, 8, 9, or 10.

PHOTOGRAPHS AND ILLUSTRATIONS

At least one pair should focus on photographs and illustrations in the textbook.

Each pair should work on every 10th page in the book but with a different starting page (e.g., 1 group working from p.1 and every 10th page; the next pair starting at p.2 and every 10th page; etc.)

For each photograph or illustration, the pair should record:

- The number of males, females, or gender-neutral people.
- The number of active roles taken and the gender breakup of them AND the number of passive roles and the gender breakup of them.
- Wording of problems/examples.

At least one pair should focus on the wording of problems/examples.

Each pair should randomly select 5 pages from the textbook which has problems/examples.

For each problem/example, the pair should record:

1. Whether there is a context for the problem/example or if it mathematically symbolic only.
2. If there is a context:
   - Is the setting, occupation, or profession used gender-stereotyped or not?
   - Whether the context of the problem/example is likely to be of more interest to males, to females, or whether it is gender-neutral.

REPORTING BACK AND DISCUSSION

On a whiteboard or projected Excel sheet, each pair should record their results – the whiteboard/Excel sheet should be pre-prepared with the appropriate headings. Totals should be calculated. Discuss the findings with respect to each of the tasks undertaken in the activity.

PROVOCATIONS

- In the introduction to this activity, features to focus on when selecting a mathematics textbook for gender equity were outlined. How do your findings match with the issues listed? Has anything changed over time?
- Will changes need to be made in the mathematics textbook selection process adopted in your school?

GLOSSARY

KEY TERMS AND DEFINITIONS

It is important to know how gender is defined and used in this monograph, and how sex and gender differ.

Term	Definition	Notes
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.

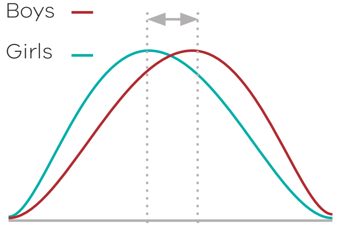
Since the study of "gender differences" with respect to mathematics learning has generally focussed on the binary categories of Males/Boys/Men and Females/Girls/Women, in this monograph we focus on these two categories. At the same time, we wish to emphasize that we recognise that there are a number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

Term	Definition	Notes
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).

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.

KEY TERMS USED IN RESEARCH ON GENDER AND MATHEMATICS

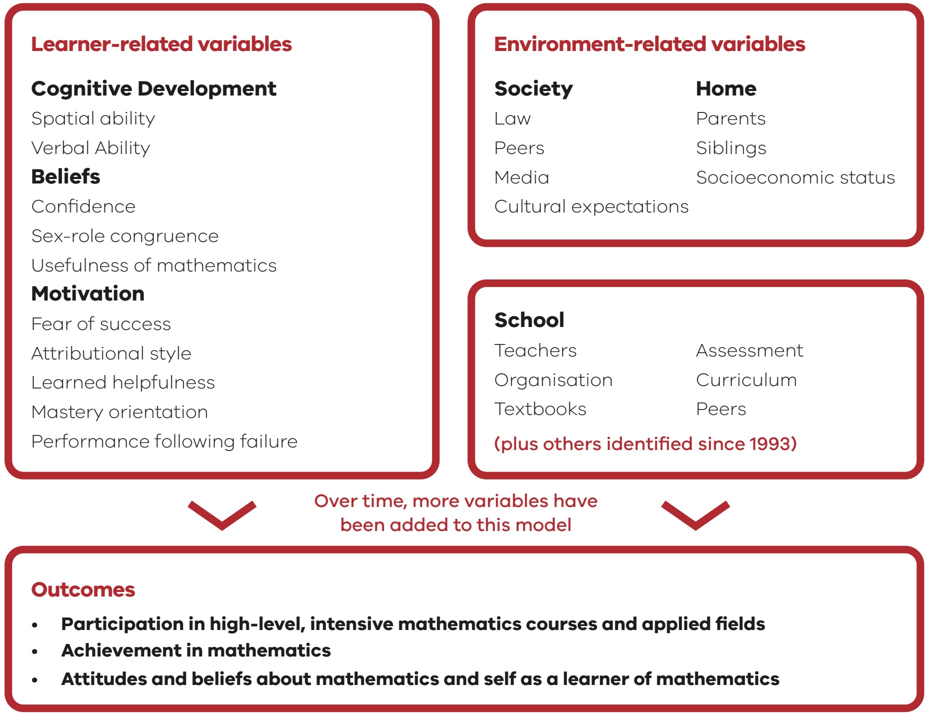
Term	Definition	Notes
Male domain	A subject/discipline or career/job that is considered more appropriate for boys/men than for girls/women.	Examples include: mathematics, physics, computing, plumbers, CEOs, prime ministers/presidents. Researchers have reported that boys are more likely than girls to believe that mathematics is a male domain; girls are more likely than boys to view mathematics as a gender-neutral domain. When asked to "draw a mathematician", students most often draw a Caucasian (white) man, with glasses and/or a beard, balding or with weird hair, at a blackboard or with a calculator (or computer); mathematical equations/symbols are frequently included in the drawings. If a woman is drawn, she tends to be shown as a mathematics teacher. *(e.g., Berry, & Picker, 2000).*
Female domain	A subject/discipline or career/job that is considered more appropriate for girls/women than for boys/men.	Examples include: English, languages, teaching, nursing, personal assistants, hairdressers.
Gender equity	Gender equity in mathematics education "will be achieved when there are no perceivable differences between the mathematics known [that is, with respect to achievement and participation in higher level mathematics studies], or how females and males feel about themselves and mathematics [their attitudes and beliefs]" *(Fennema, 2000, n.p.)*	

Term	Definition	Notes
Gender difference	Differences in performance, enrolments, and attitudes/beliefs by gender are usually examined for statistically significant differences[4] on mean (average) scores. It is also recommended by many researchers that effect sizes[5] are also included. Statistically significant differences in mean scores for mathematics achievement and attitudinal measures are usually small, and there is much overlap in the scores. Findings relate to differences in mean scores for boys/men and girls/women as two (binary) GROUPS. Gender Difference: 	It is IMPORTANT that people do not essentialise the results, that is, THAT they do not speak of ALL girls/women or ALL boys/men, or expect that each individual conforms to the gender difference found. Just as every boy/man is not taller than every girl/woman, so too not every boy/man is more suited to study mathematics or be a scientist than every girl/woman. It should also be noted that sometimes medians are used for comparisons between boys/men and girls/women. Often only trends are described.
Gender stereotype	A stereotype is a fixed, over generalized belief (positive or negative) about a particular group of people (e.g., about girls/women). When stereotyping, it is believed that an individual has the characteristics and abilities that all members of that group are assumed to have.	

[4] *Statistically significant difference: the difference found cannot be explained by chance. That is, the difference is unlikely to have occurred because the sample happened to be atypical.*
[5] *Effect size: a quantitative measure of the magnitude of the difference that is independent of sample size.*

Term	Definition	Notes
Self-rating of mathematics capabilities/ achievements	Typical question used in research is: How good are you at mathematics? (with 5 rating levels to select from)	It is generally found that, on average, boys/men rate their mathematical capabilities higher than do girls/ women, even among individuals whose achievements are the same.
Gender equity model **(explaining gender differences in mathematics)**	Shown in Figure 1. This model was put forward by Leder (1993).	Several researchers have developed explanatory models for observed gender differences in mathematics learning. Each model included factors identified as contributors to the gender. The model used here represents a summary of the factors identified. There are two main categories of factors: learner-related, and environment-related (including the school, classroom, home, and wider social context) The model remains relevant today.

Figure 1. Gender Equity Model



Term	Definition	Notes
Attitudes and beliefs	A person's attitude towards an object (e.g., mathematics, or self as a learner of mathematics) refers to the emotional reactions to the object, behaviour towards the object, and beliefs about the object.	Attitudes and beliefs relevant to research on gender and mathematics learning include: • Liking of mathematics. • Interest in mathematics. • Perceived usefulness of mathematics. Researchers have found that, compared to girls/women, boys/men are more likely to like mathematics, be interested in mathematics, and see mathematics as more useful to them in future.
Gender stereotyped beliefs	With respect to mathematics, gender stereotyped attitudes/ beliefs are said to be held by people who think that: boys/men are naturally better at mathematics than girls/women, that is, that they are biologically disposed to be better at mathematics	It should be noted that there is little biological/genetic evidence to support this belief. In addition, cultural/racial/ethnic stereotypes often interact with gender stereotypes.
Confidence as a learner of mathematics	"Students with high mathematics confidence believe they obtain value for effort, do not worry about learning hard topics, expect to get good results, and feel good about mathematics as a subject. Students with low confidence are nervous about learning new material, expect that all mathematics will be difficult, feel that they are naturally weak at mathematics, and worry more about mathematics than any other subject." *(Galbraith & Haines, 1998, p.278)*	Researchers have found that, on average, boys/men are likely to display higher confidence about themselves as mathematics learners than are girls/women, even in the early years of schooling.

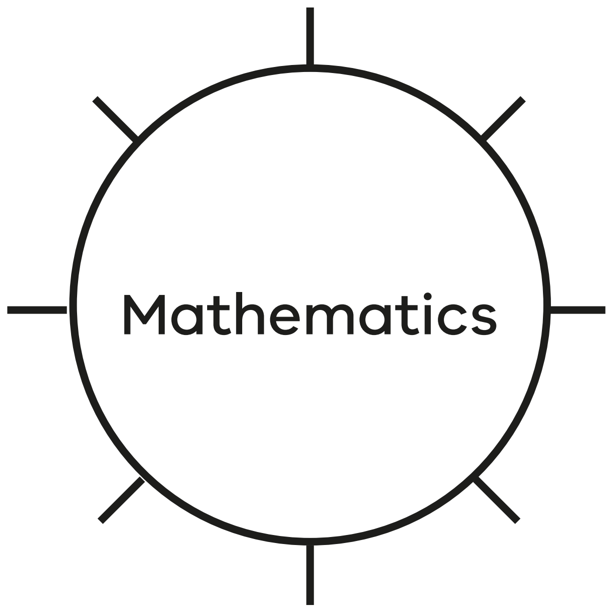
Term	Definition	Notes
Attributions for success/ failure in mathematics	Attributions are the reasons or explanations given for success and/or failure in mathematics. Based on the Mathematics Attribution Scale *(Fennema, Wolleat, & Pedro, 1979)*, four attributions are frequently examined with respect to success and failure in mathematics: ability, effort, task, and environment (includes: luck, the teacher etc)	Researchers have generally found that: boys/men are more likely than girls/ women to attribute success to ability, and more likely to attribute failure to lack of effort girls/women are more likely than boys/men to attribute success to effort.
School factors	A range of school factors are implicated as contributors to gender differences in mathematics learning that are found. Examples of school factors include: • Curricular content. • Textbook/resource selection. • Pedagogical strategies. • Teachers.	At the school level, researchers have found that: In different topic areas/strands of mathematics, gender differences in achievement can vary. For example, boys often outperform girls in geometry-related topics and challenging problems, while girls often do better than boys in arithmetic and algebra. In the past, textbooks tended to have more illustrations of boys/men than girls/women. Boys/men were also found to be more prevalent in worded problems. The context of problems also tended to be in sporting and other areas that were of more interest to boys/men than to girls/women. In the traditional, teacher-centred classroom (chalk and talk classes), the teaching approaches are more consistent with learning styles (individual and/or competitive) that are more likely to be preferred by boys than girls. The introduction of collaborative/cooperative approaches (a learning style more likely to be preferred by girls) provides balance. Some teachers hold gender-stereotyped beliefs and expectations of boys' and girls' mathematical capabilities.

Term	Definition	Notes
Mathematics anxiety	A negative emotional reaction to mathematics that can be debilitating. While mathematics anxiety and performance are related, it is not known if mathematics anxiety leads to poorer performance or vice versa.	Findings indicate that the more anxious female primary teachers are about mathematics, the more likely girls (but not boys) are to endorse the stereotypes that 'boys are good at maths', and 'girls are good at reading', and the girls' maths achievements are lower than boys' *(Beilock, Gunderson, Ramirez, & Levine, 2010)*. Findings are mixed as to whether, on average, girls are more mathematics anxious than boys. While no gender differences are often found at lower levels of schooling, as grade level increases there is evidence that girls' mathematics anxiety levels increase more than boys'.
Significant others	Significant others in students' lives are also implicated in the gender differences in mathematics learning outcomes found. Significant others include: parents, siblings, extended family, friends/peer group, career advisers.	Society at large, and the home environment (parents, siblings) have greater impact on students' attitudes and beliefs than school factors. Parents' expectations and beliefs about girls/women and boys/men rub off on all of their children. In their desire to be accepted, a student's peer group can have an impact on beliefs and attitudes. Careers advisers (at home and/or at school) can also influence and guide boys and girls into stereotyped subject choices and career paths.

APPENDIX

Views of mathematics

Are you: Boy ◯ Girl ◯ Non-binary ◯



Attitudes towards mathematics

Are you: Boy ◯ Girl ◯ Non-binary ◯

Read each of the following statements carefully.
For each statement, indicate "Yes" if you feel this way, "No" if you do not, and "Neutral" if you have no particular feelings either way.

	Item	Yes	No	Neutral
1	When doing maths, I prefer to work on my own.	◯	◯	◯
2	You have to be brainy to do well at maths.	◯	◯	◯
3	I enjoy working with friends on maths problems.	◯	◯	◯
4	I usually understand a new idea in maths quickly.	◯	◯	◯
5	I usually get most of my maths right.	◯	◯	◯
6	I usually feel confident about maths tests.	◯	◯	◯
7	Boys generally do not like it if girls beat them in maths.	◯	◯	◯
8	I really enjoy solving maths problems.	◯	◯	◯
9	Knowing maths will help me get a job.	◯	◯	◯
10	I always feel nervous when I look at a maths problem.	◯	◯	◯
11	I am lucky when I do well on a maths test.	◯	◯	◯
12	I feel nervous when I am asked questions in maths.	◯	◯	◯
13	I am disappointed when I miss a maths lesson.	◯	◯	◯
14	I cannot understand how anyone could enjoy maths.	◯	◯	◯
15	If I work **carefully** I find maths easy.	◯	◯	◯
16	If I do well at maths some **people** make fun of me.	◯	◯	◯
17	I do not see the point of most of the maths we do.	◯	◯	◯
18	I think my maths teacher thinks I'm stupid.	◯	◯	◯
19	I think my maths teacher enjoys teaching me.	◯	◯	◯

For each of the following statements, select the explanation that is most relevant to you:

20 If I do well in maths, it is usually because:

◯ I'm naturally good at it.
◯ I work very hard.
◯ I have a good teacher.
◯ The work is very easy.

21 If I do badly in maths, it is usually because:

◯ I'm hopeless at it.
◯ I did not try hard enough.
◯ I was unlucky.
◯ The work was too hard.

Complete the following statement:

When I need help with maths at home, I usually ask:

Gender bias and mathematics: evaluating students' capabilities and potential

The two case studies:

Case Study 1

Denis Johnson has just completed Year 11 of the two-year VCE.

Denis has the following characteristics:

- He is good looking.
- He is well-liked by teachers and his peer group.
- He satisfactorily completed the following Year 11 VCE subjects with average to good grades:
  - English
  - Specialist Mathematics
  - Mathematical Methods
  - Chemistry
  - Biology
  - Ancient History
- He is interested in 'helping people'.
- He likes school.
- He would like to go to university.

Case Study 2

Denise Johnson has just completed Year 11 of the two-year VCE.

Denise has the following characteristics:

- She is good looking.
- She is well-liked by teachers and his peer group.
- She satisfactorily completed the following Year 11 VCE subjects with average to good grades:
  - English
  - Specialist Mathematics
  - Mathematical Methods
  - Chemistry
  - Biology
  - Ancient History
- She is interested in 'helping people'.
- She likes school.
- She would like to go to university.

Assessment questionnaire

Are you: Boy ◯ Girl ◯ Non-binary ◯

1a Indicate which **one** of the following three statements best describes how boys and girls perform in maths assessments?

◯ In general, girls do better than boys.

◯ In general, boys do better than girls.

◯ In general, there is no difference between boys and girls.

1b Explain your choice.

2 Order the following types of assessment tasks according to your preferences: 1 = most preferred, 2 = next preferred etc. Leave blank the assessment types that are not used in your maths class.

- ☐ Multiple choice test
- ☐ Oral test
- ☐ Investigations/Extended open-ended problems
- ☐ Test with short answer questions
- ☐ Test with longer questions requiring working to be shown
- ☐ Assessed classwork
- ☐ Assessed homework
- ☐ Practical work
- ☐ No calculator tests
- ☐ Online tests
- ☐ Group tasks
- ☐ Examinations

3a Which **one** of the following types of questions do you like most?

Which **one** do you like least?

Question Type	Like MOST	Like LEAST
Questions that do not include people.	◯	◯
Questions about women or girls.	◯	◯
Questions about men or boys.	◯	◯
Questions about people in general.	◯	◯
Questions about topics that interest me.	◯	◯

3b On which types of questions do you think you do best?

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Leder, G. C. (1995). Equity inside the mathematics classroom: Fact or artefact? In W. G. Secada, E. Fennema, & L. B. Adajian (Eds.), New directions for equity in mathematics education (pp. 209-224). New York: Cambridge University Press.

Leder, G. C., Forgasz, H. J., & Jackson, G. (2014). Mathematics, English and gender: Do teachers count? Australian Journal of Teacher Education, 39(9), 1-18.

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Peterson, P. L., & Fennema, E. (1985). Effective teaching, student engagement in classroom activities, and sex-related differences in learning mathematics. American Educational Research Journal, 22(3), 309-335.

Prinsley, R., Beavis, A. S., & Clifford-Hordacre, N. (2016). Busting myths about women in STEM. Occasional Papers Series, 13. Canberra, ACT: Office of the Chief Scientist. Retrieved from https://www.chiefscientist.gov.au/sites/default/files/OCS-paper-13.pdf

RESOURCES: READINGS AND YOUTUBE VIDEOS

Here, we provide a range of useful resources (readings and YouTube videos) that can be used in a variety of ways.

For individual mathematics teachers, the resources provide opportunities to broaden knowledge on a range of issues related to gender and mathematics learning. They can also be used as "discussion starters" with colleagues or secondary students, as well as in professional learning settings.

Having engaged with a reading or YouTube video, reflect on the following:

- What message is conveyed in the resource?
- What is your reaction to that message?
- How did you and/or your students react to that message?
- What change/s might be needed to address the issues raised and/or challenge the status quo?

READINGS

A short synopsis is provided for each of the readings listed in the table. We have grouped the readings under pertinent topic headings.

Clicking on a hyperlink will take you directly to the particular online article.

Author	URL	Brief synopsis
Statistics on gender and mathematics participation		
Office of the Chief Scientist	https://www.industry.gov.au/data-and-publications/stem-equity-monitor/primary-and-secondary-school	Explore this website for up-to-date statistics and interactive data on NAPLAN, PISA, and Youth in STEM Research; the latter includes attitudes to STEM data.
Australian Mathematical Sciences Institute (AMSI)	https://amsi.org.au/preview-year-12-mathematics-participation-in-australia-2008-2017/	Year 12 higher mathematics participation across Australia.
Pallavi Singhal. SMH. 15/10/2018	https://www.smh.com.au/education/hsc-gender-stem-subjects-trends-education-20181009-p508jl.html	NSW. HSC and tertiary enrolment patterns.
Leder, G. C. 2019.	https://link.springer.com/content/pdf/10.1007%2F978-3-030-15636-7_13.pdf	An overview of "gender and mathematics education".
Chief Scientist's Office. Data sheet 2. 2016	https://www.chiefscientist.gov.au/sites/default/files/OCS_Women_in_STEM_datasheet.pdf	Women in STEM – a story of attrition. Statistics on girls'/women's participation in STEM at all levels, achievements, and attitudes.
Lindberg, S. M., Hyde, J. S., Petersen, J. L., & Linn, M. C. 2010.	https://www.researchgate.net/publication/47642285_New_Trends_in_Gender_and_Mathematics_Performance_A_Meta-Analysis	New trends in gender and mathematics performance: A meta analysis.
Debunking myths about women and STEM (including mathematics)		
Prinsley, R., Beavis, A. S., Clifford-Hordacre, N. 2016.	https://www.chiefscientist.gov.au/sites/default/files/OCS-paper-13.pdf	Office of the Chief Scientist of Australia. Busting myths about women in stem.
Harcourt, A. 2018.	https://www.abc.net.au/news/2018-10-08/meet-alison-harcourt-the-grandmother-of-australian-mathematics/10350170	The ground-breaking grandmother of Australian mathematics.
Careers and mathematics		
J. Lucy Boyd. Chron. 29/6/2018	https://work.chron.com/nurses-use-math-jobs-10475.html	How do nurses use math in their jobs?
Dicke A-L, Safavian N. & Eccles, J. S. 2019.	https://www.frontiersin.org/articles/10.3389/fpsyg.2019.01053/full	Adolescents' traditional work/family related gender role beliefs influence gender disparity in educational and STEM occupational attainment.
Rose Johnson. Chron. 2020	https://work.chron.com/careers-use-math-day-16295.html	Careers That Use Math Every Day.

Author	URL	Brief synopsis
Influence of parents on attitudes towards mathematics		
Nicole Bryan. Code like a girl. 27/9/2016	https://code.likeagirl.io/calling-all-moms-stop-saying-that-8505a7ce6eb8#.igzyjygms pdf/10.1007%2F978-3-030-15636-7_13.pdf	What parents say can shape the child's views on mathematics.
Kelly Wallace. CNN. 12/10/16	https://edition.cnn.com/2016/10/12/health/female-scientists-engineers-math-gender-gap/index.html	Prof Jo Boaler is cited in this article. She explains why some girls avoid STEM due to messaging from parents and society.
Effect of changes in mathematics classroom teaching practices		
Dominique Russell. Teacher. 13/4/2020	https://www.teachermagazine.com.au/articles/school-improvement-episode-24-mentoring-girls-in-maths?utm_source=CM&utm_medium=Bulletin&utm_content=28April	ChooseMaths 2020 award winner: story (and audio) in Teacher Magazine article: "Mentoring girls in mathematics".
Research on gender and mathematics		
Maths Pathway	https://mathspathway.com/the-gender-gap-in-maths/	The gender gap in maths – possible explanations.
Maths Pathway	https://mathspathway.com/australia-needs-more-girls-in-advanced-maths/	Why Australia needs more girls in advanced maths.
Leder, G. C., Forgasz, H. J., & Jackson, G. 2014.	https://ro.ecu.edu.au/ajte/vol39/iss9/2/	Teachers' and parents' views about mathematics, English and gender issues.
Ganley, C. 2018.	https://www.scientificamerican.com/article/are-boys-better-than-girls-at-math	Are boys better than girls at mathematics?
Hargreaves, M., Homer, M., & Swinnerton, B. 2008.	https://doi.org/10.1080/09695940701876037	A comparison of performance and attitudes in mathematics amongst the 'gifted'. Do boys just think they are better?
Sarah Buckley. ACER. Occasional essays. 2011	https://www.acer.org/au/occasional-essays/deconstructing-maths-anxiety-helping-students-to-develop-a-positive-attitud	Addressing mathematics anxiety and developing positive attitudes.

Author	URL	Brief synopsis
Raising awareness about girls and mathematics and addressing the challenges		
GiST (Girls in STEM).	https://www.thegist.edu.au/schools/supporting-girls-in-stem/challenges-and-opportunities-in-stem-education	This website provides information and URL links to informatics, videos etc. to support schools and teachers wanting to raise issues related to girls and STEM (including mathematics) and to move forward. [NB. Also explore under the various tabs at the top of the page].
Carly Berwick. 12/3/2019. George Lucas Educational Foundation.	https://www.edutopia.org/article/keeping-girls-stem-3-barriers-3-solutions	Written by an English teacher, the research on gender and mathematics (STEM) is summarised and steps to address the findings are provided.
Koch, I. 2019.	https://amsi.org.au/wp-content/uploads/2019/07/gender-report-2019.pdf	Mathematics and gender: Are attitudes and anxieties changing towards mathematics?
History of women in mathematics		
Open Learning (UK)	https://www.open.edu/openlearn/science-maths-technology/mathematics-statistics/women-mathematics-the-history-behind-the-gender-gap	ChooseMaths 2020 award winner: story (and audio) in Teacher Magazine article: "Mentoring girls in mathematics".
Suzanne Bearne. The Guardian. 24/7/2018.	https://www.theguardian.com/careers/2018/jul/24/meet-the-female-codebreakers-of-bletchley-park	Article about the female codebreakers of Bletchley Park during WWII.
Matt Blitz. Popular Mechanics. 3/2/2017	https://www.popularmechanics.com/space/rockets/a24429/hidden-figures-real-story-nasa-women-computers/	Article about the film "Hidden Figures" and the women who crunched the numbers for NASA to get astronaut, John Glenn, into space.

YOUTUBE VIDEOS

There are many YouTube videos about the teaching and learning of mathematics, and several with a focus on gender issues. A selection of YouTube videos is listed in the table below.

For each YouTube video, we have provided a short summary of its contents and the time needed to view it. Most are suitable for mathematics teachers to watch individually. They can also serve as "conversation starters" for professional learning settings and for secondary students.

Clicking on a hyperlink will take you directly to the pertinent YouTube video.

Title	Time (mins)	URL	Brief synopsis
Gender differences and mathematics			
Gender bent	0.51	https://www.youtube.com/watch?v=jGLM3_LQRwg	Very brief overview of gender "norms".
Gender and math	3.26	https://www.youtube.com/watch?v=TS6CNMgbszE	The effect of cultural stereotypes on the mathematics performance of female students and how this can be countered.
Inequality in STEM is solvable	3.18	https://www.youtube.com/watch?v=MLdK-qEgVol	General talk about the need to attract more young women into STEM and some suggestions for ways to achieve this.
The Gender divide in math: A youth perspective	3.18	https://www.youtube.com/watch?v=WDihZXg9RAE	Good, succinct overview of key issues by a confident teenager. Reference is made to a range of personal and environmental factors that influence girls' performance as well as to the teacher's role.
Maths - No problem!	7.41	https://www.youtube.com/watch?v=Fxp9RwygPFQ	Easy-to-listen-to Q&A by Dr Hannah Fry at "The Confident Maths Teacher Conference". Focus on ways for encouraging students to succeed in mathematics. Teachers and self-efficacy are highlighted as important "drivers", particularly for girls.
Women and non-binary people in mathematics	2.39	https://www.youtube.com/watch?v=cid9ELpWlCM	Encouraging girls to do a PhD in mathematics but nothing about non-binary people.
Gender bias in mathematics	3.29	https://www.youtube.com/watch?v=5qlXVFmLzHU	Common beliefs and findings are listed and illustrated with exemplar sayings. Includes reference to mindset. Visual presentation rather bland.
The real reason there aren't more female scientists	4.28	https://www.youtube.com/watch?v=l-6usiN4uoA	USA (like many of the other clips) biased. Why do men greatly outnumber women in the STEM subjects? Various explanations are critiqued.
The Simpsons: Gender difference episode	3.41	https://www.youtube.com/watch?v=64PKoAiWhjE	A somewhat satirical depiction of the boys, girls and the learning of mathematics.
Gender equality in Australia	1.17	https://www.youtube.com/watch?v=PRdEcR2lDeY	What (Australian) girls believe about equity issues based on survey of 1500 girls. Offers some suggestions to fight inequality and stereotypes.
Girls vs boys at math	1.55	https://www.youtube.com/watch?v=z-19yWY901Q&t=32s	Two leading US researchers discuss gender differences in mathematics and dispel the relevance of biological differences.
Encouraging girls in math and science	1.26	https://www.youtube.com/watch?v=lf5BLio6qGQ	The role of parents in encouraging girls into mathematics and science is discussed.
About mathematics more generally			
Maths is everywhere	1.20	https://www.youtube.com/watch?v=OGqD6rXtEWU	Suitable for parents and teachers of young children.
Believe in your maths potential – Set yourself free (Jo Boaler)	12.36	https://www.youtube.com/watch?v=al6gO9SLqBY	What teachers can do in the mathematics classroom to help student learning. Boaler talks about mindset; the importance of having "a growth mindset". Covers how brains process mathematics, the importance of visual learning, and self-belief for learning – what we believe affects our learning.
Mathematics is the sense you never knew you had. (Eddie Woo)	13.12	https://www.youtube.com/watch?v=PXwStduNw14	An inspirational talk about mathematics. How teachers can help students see mathematics in the world around us.