AMSI CHOOSE**MATHS** RESEARCH

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Gender Report 2017: Participation, Performance, and Attitudes Towards Mathematics

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AMSI AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

Executive Summary

A partnership between the Australian Mathematical Sciences Institute (AMSI) and the BHP Billiton Foundation, the Choose Maths project is working to build mathematical capability and increase participation of girls and young women across the Science, Technology, Engineering and Mathematics (STEM) pipeline from classroom to industry. These core aims reflect findings of the Chief Scientist's 2012 report *Mathematics, Engineering and Science in the National Interest*, which called for action to encourage female STEM participation.

With a focus on Australian and Choose Maths data, this report provides a comprehensive analysis of Australian primary and secondary mathematics education trends in relation to gender difference and its impact on Year 12 participation, students performance and attitudes over the last 10 years.

Australian mathematical capability remains under threat. While the overall total number of Year 12 students enrolling in mathematics has increased, participation in intermediate and advanced mathematics remains at historic lows. The gender gap also remains, with more boys enrolled in intermediate and, particularly advanced, mathematics than girls. The very low participation of girls in advanced mathematics threatens female participation in many STEM professions including mathematics teaching. We do note however, the proportion of girls in advanced mathematics has reached a decadal high due to a slight increase in female participation since 2012 and the recent decline in male participation.

Gender disparity in mathematics performance is evident from Year 3, but the gap could have started earlier. The average mathematics performance of boys is higher than that of girls, with the gap deepening by Year 5 and remaining into lower secondary school. Yet girls' performance exceeded boys' in some cognitive domains of mathematics. Low self-confidence about their mathematics ability could be a significant factor in this gender gap. It must be recognised that the impacts of socio-economic status and geographic location on school mathematics achievement are far greater than the gender differences.

Girls are less confident in their self-perceived ability to learn mathematics than boys, however, students can be motivated through focussed intervention to develop positive attitudes towards mathematics and the learning of mathematics. Young female students in particular show a much larger change in attitude towards mathematics as a result of specific interventions. This gives us cause for optimism.

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This report was written for CHOOSE**MATHS** by Ning Li and Inge Koch from the Australian Mathematical Sciences Institute.

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Highlights

1

Evident by Year 3, the mathematics **gender gap deepens** by Year 5 with little change into lower secondary school

2

Girls are 25 per cent **less confident** in their self-perceived abilities to learn mathematics than boys

3

Interventions to address student attitudes towards mathematics learning, particularly among girls, have been shown to be **effective in changing self-perception** and increasing engagement

4

While still at historic lows, there has been **a slight increase** in Year 12 girls' participation in advanced mathematics since 2012

5

While the total number of Year 12 students taking some form of mathematics has increased since 2009, participation in intermediate and advanced mathematics **continues to decline**

6

Declining faster than the OECD average, Australia's PISA Mathematical Literacy ranking has dropped from 5th place in 2000 to 25th place in 2015

7

Educational disadvantage through lack of resources and low socio-economic status has the biggest impact on mathematical performance; at least **four times that due to gender**

Recommendations

Supporting our Students

- Improve access to learning resources with a focus on growth mindset approaches to encourage self-confidence, particularly among girls
- Incorporate careers awareness into classroom learning to strengthen understanding of the application and value of mathematics and the participation of women in STEM
- Improve mentoring access, particularly for girls, to support learning outcomes and subject selection in Year 10

Supporting our Teachers

- Equip all pre-service primary teachers with adequate mathematics knowledge and teaching strategies to improve capability and confidence and address maths anxiety in the classroom
- For current primary teachers provide professional development in mathematics content and pedagogy to improve capability and confidence and address maths anxiety
- Provide common training to primary and secondary pre-service and in-service teachers to support student transition from primary to secondary school, with a focus on the continuity of mathematical learning
- Provide better access to growth mindset resources to pre-service and in-service teachers to support mathematics learning outcomes and engagement
- Provide access to professional development for all teachers to improve understanding and implementation of emerging teaching strategies, in particular growth mindset approaches, for improving girls' confidence and self-perception

Supporting our Parents

- Create positive home learning environments through better access to resources including those supporting growth mindset learning
- Develop stronger engagement between school and home with access to better information for parents about the application and value of mathematics as an enabling discipline and career pathways, particularly for girls

Main Findings

Participation in mathematics in Year 12, 2006–2016

There have been about 5 per cent more boys than girls in the Year 12 potential population (Section 2.1)

One-third of boys and one-fifth of girls in the Year 12 potential population did not study Year 12 (Section 2.2)

The gender distribution for Year 12 mathematics has become more disproportionate, while the gender distribution for Year 12 total enrolments has become more even (Section 2.3)

The percentage of students not participating in mathematics has been stable, 2006–2016 (Section 2.4)

Four times as many boys and seven times as many girls in Year 12 have enrolled in elementary mathematics as have enrolled in advanced mathematics (Section 2.5)

The gender distribution in advanced mathematics has been severely skewed towards boys (Section 2.6)

Girls' participation in advanced mathematics decreased from 2006 to 2014, but has increased since, and for the first time in the last decade there were 61 girls for every 100 boys among the advanced mathematics students in 2016 (Section 2.6)

Performance in mathematics and reading

Boys have outperformed girls in every NAPLAN numeracy test that has been conducted so far (Section 3.1)

Girls have outperformed boys in reading tests in Years 3, 5, 7 and 9, NAPLAN 2008–2016 (Section 3.2)

Performance has varied more in Year 3 than Year 9, more for boys than girls, and more in reading than numeracy in primary schools in NAPLAN 2009–2016 (Section 3.2)

Boys have shown better performance than girls in mathematical literacy tests, PISA 2000–2015 (Section 3.3)

Boys maintained stable performance in TIMSS Year 8 mathematics tests 1995–2015, while girls have been improving since 2007 (Section 3.4)

Gender gaps in cognitive and content domains have almost disappeared, and girls have performed better in algebra than boys in TIMSS 2015 Year 8 mathematics test (Section 3.4)

Australia's ranking in the PISA Mathematical Literacy tests has dropped from 5th in 2000 to 25th in 2015 among OECD countries (Section 3.5)

42 per cent more Year 4 and 32 per cent more Year 8 students in Australia than in the world do not like learning mathematics (Section 3.5)

The Australian students' average score is higher than the world average in each mathematical confidence group. However, there were fewer mathematically confident students and more mathematically not confident students in Australia than in the world (Section 3.5)

Home learning resources and socio-economic backgrounds of students have a much stronger impact than gender on students' mathematics performance (Section 3.6)

Attitude towards mathematics in Choose Maths schools

The majority of students hold a positive attitude towards the usefulness of mathematics (Section 4.2)

More than 97 per cent of girls agree that girls can do mathematics as well as boys, while 13 per cent points fewer boys in Year 5 and a further 5 per cent points fewer boys in Year 8 think so (Section 4.2)

Girls appear to enjoy more working with others compared to boys, when learning mathematics (Section 4.2)

More boys than girls like doing mathematics, in both Year 5 and Year 8 (Section 4.2)

Girls are 25 per cent less confident than boys in their self-perceived ability to learn mathematics, but can be motivated to believe that they can learn mathematics (Section 4.3)

Female teachers have rated higher the level of mathematics required in most occupations than male teachers (Section 4.4)

Teachers have perceived students' previous achievements in mathematics as the most influential factor in students' decisions to continue studying mathematics in voluntary enrolments (Section 4.5)

1 Introduction

In Australia, girls and young women continue to be under-represented in advanced mathematics courses in secondary schools, in university mathematics degree programs and in careers involving mathematics (Roberts 2014). The under-representation of women in mathematics and mathematics-related careers in many western countries is of concern for economic and gender-equity reasons.

The need to address the severe under-representation of women in the Science, Technology, Engineering and Mathematics (STEM) workforce motivated the BHP Billiton Foundation to fund the Choose Maths project, a five-year initiative being delivered by AMSI. The central voice for Australia's mathematical sciences, AMSI has been driving a policy and advocacy agenda to achieve critical reform at key stages of the mathematics pipeline through its four programs: AMSI Schools, AMSI Research, AMSI Higher Education and AMSI Intern—see **amsi.org.au**. Within the AMSI framework, Choose Maths started in mid-2015, with the aim of increasing participation of girls and young women in STEM or MES by considering the whole pipeline.

School → University → Workforce

A brief description of Choose Maths and our approaches are given at the beginning of Section 4.

Participation and performance in tests are quantities we can measure, but they are not the same as a person's understanding of mathematics, their innate ability for mathematical thinking, or their self-perceived ability and confidence in learning mathematics. It would be interesting to find out whether boys and girls 'score' equally on mathematical understanding and insight. In this report we primarily focus on participation and performance in tests, but also touch on confidence and attitudes regarding mathematics.

Data from the Australian Department of Education and Training and reported in AMSI's *Discipline Profile 2016* (AMSI 2016) show a steady decline of bachelor completions in the mathematical sciences over the last 15 years, with the proportion of women decreasing more than that of men. Similarly, at the secondary school level, longitudinal results of school students indicate a large difference in participation rates of boys and girls choosing higher-level mathematics subjects during their last years of secondary school, in addition to an overall decrease in the proportion of students who take higher-level mathematics (Forgasz 2006, Kennedy *et al* 2014, Wilson and Mack 2014, Cimpian *et al* 2016, Wilson *et al* 2017). Although this trend is partly explained by the Australian education system, which does not require students to participate in mathematics subjects in the last years of secondary school, the lack of engagement and participation of young women in particular can no longer be overlooked.

The decline in the proportion of students taking higher-level mathematics in Years 11 and 12 is closely related to a disengagement of students, and in particular girls, with the discipline. 'Disengagement' in this report refers to students' decisions to not choose mathematics—irrespective of their reasons to do so. In line with the aims of Choose Maths, we wish to gain insight into this process of disengagement, find its onset and ascertain whether it affects boys and girls in the same way and at the same time. To do so, we present a comprehensive analysis of the data from the following sources:

- Australian Bureau of Statistics (ABS) demographics data
- Participation and enrolment data of Year 12 students in Australian schools
- The Australian National Assessment Program—Literacy and Numeracy (NAPLAN)
- The Programme for International Student Assessment (PISA)
- Trends in International Mathematics and Science Study (TIMSS)
- Teacher and student data collected in the Choose Maths schools in 2016

By connecting different aspects in these sources we are able to gain a more complete picture of the situation, including the likely onset of students' disengagement and of the gender gap. The report further includes interpretations of the analyses and suggestions for actions.

PRIMARY SCHOOL

Self-perceived ability and confidence in learning mathematics affects performance and participation

↓

SECONDARY SCHOOL

Girls and young women are less likely to choose advanced mathematics courses in secondary schools

↓

UNIVERSITY

There are far fewer female students than male students in university mathematics degree programs

↓

WORKFORCE

Under-representation of women in the Science, Technology, Engineering and Mathematics (STEM) workforce

2 Year 12 Enrolments in Mathematics, 2006–2016 Australia

In Australia, primary and secondary school education is compulsory for all children between the ages 6 and 16 or 17. The school education is divided into primary school, for seven or eight years, starting with Kindergarten/Foundation through to Year 6 or 7; secondary school, for another three or four years from Year 7 or 8 to 10; and senior secondary school that runs for two years, Years 11 and 12.

2.1 The Year 12 potential population

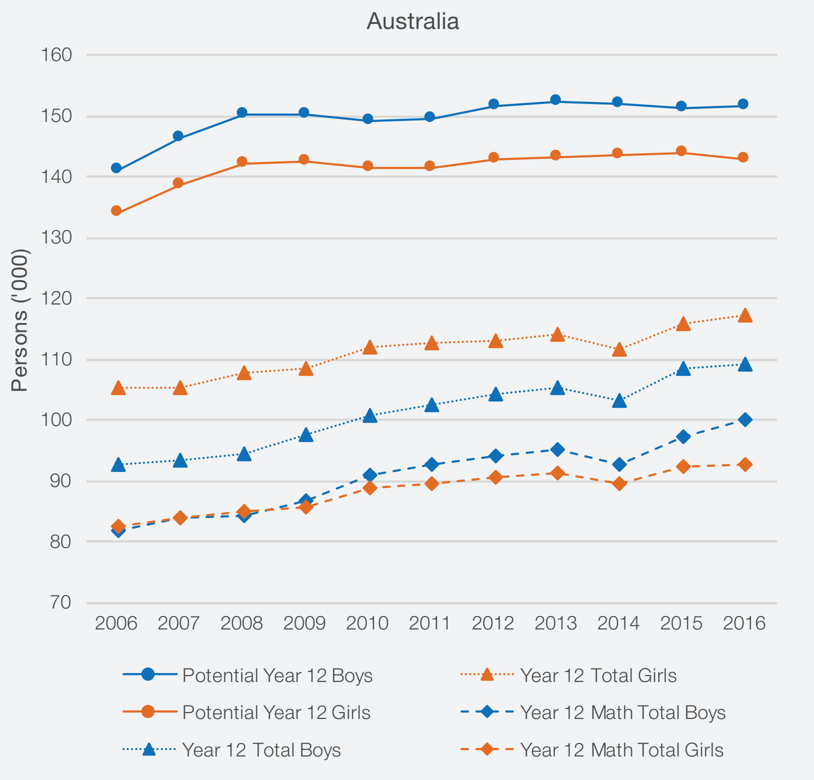
The typical age of Year 12 students in Australia is between 17 and 18 years. Persons in the age group of 17–18 form the Year 12 *potential population*, whose size can be estimated by the average number of 17 or 18 year olds in the Australian population. Shown as the solid lines in Figure 1, the average number of youths in the Year 12 potential population has grown at an average annual rate of 0.73 per cent for boys and 0.65 per cent for girls between 2006 and 2016. The potential population has evolved from 141,344 to 151,698 for boys and from 134,330 to 143,083 for girls, with the biggest growths occurring between 2006 and 2007. Over the period there have been 7015 to 9128 more boys than girls, or about 4.9 per cent more boys than girls, in the Year 12 potential population each year.

There have been about 5 per cent more boys than girls in the Year 12 potential population.

To investigate the participation of Year 12 students in mathematics, the Year 12 enrolments data (AMSI 2017), previously reported by Barrington and Evans (2016, 2017a, 2017b) and in the *Discipline Profile of the Mathematical Sciences 2017* (AMSI 2017), will be analysed in detail from different angles. Specifically, we calculate the following quantities:

- Yearly enrolments of Year 12 students
- Percentage of Year 12 students choosing at least one mathematics subject
- Percentage of Year 12 students choosing intermediate and advanced mathematics
- The ratio of number of students choosing intermediate and advanced mathematics relative to the number of students choosing elementary mathematics
- Percentage of girls among all Year 12 students who studied mathematics and percentage of girls among all Year 12 students who studied intermediate and advanced mathematics

Figure 1. Year 12 potential, actual, and mathematical populations, 2006–2016



Data sources: ABS data series 3101059, Australian Demographic Statistics, Table 59 (Estimated resident population by single year of age, Australia); Year 12 enrolments data (AMSI 2017)

It would have been desirable to use the number of students enrolled in each level of mathematics subjects. However, in the Year 12 enrolment data (AMSI 2017), while the number of advanced mathematics students and the number of intermediate mathematics students are counted with high accuracy, the number of elementary mathematics students is an estimate based on the number of subject enrolments in elementary mathematics. Since some students may have taken multiple elementary subjects or have taken elementary and non-elementary subjects concurrently, there is an overlap. For the period 2006–2015, the number of elementary mathematics students has been estimated to be between 93 per cent and 94 per cent of the total number of the elementary mathematics subject enrolments (Barrington and Evans 2016, 2017a and 2017b). For 2016, Barrington and Evans adopted a higher overlapping rate of more than 10 per cent, partly to reflect the increase in elementary enrolments due to the introduction of new Level A mathematics subjects in some states (Barrington and Evans 2017c). This higher overlapping rate affects the estimate of student numbers in elementary mathematics that we will use in this report. Hence, our investigation will be affected by the limited information.

Following Barrington and Evans (2016, 2017a and 2017b), an advanced mathematics student is a student who takes the advanced subject(s) in Year 12. The advanced subjects are usually the highest level of mathematics subject offered in each state, except in NSW where advanced mathematics refers to mathematics Extension 1 and Extension 2. An intermediate mathematics student is a student who takes intermediate subjects but not any advanced subjects, and an elementary mathematics student is the one who takes elementary subjects but not any intermediate or advanced subjects. Appendix I contains a detailed list of the subjects in each state corresponding to each level.

2.2 The Year 12 non-attendants

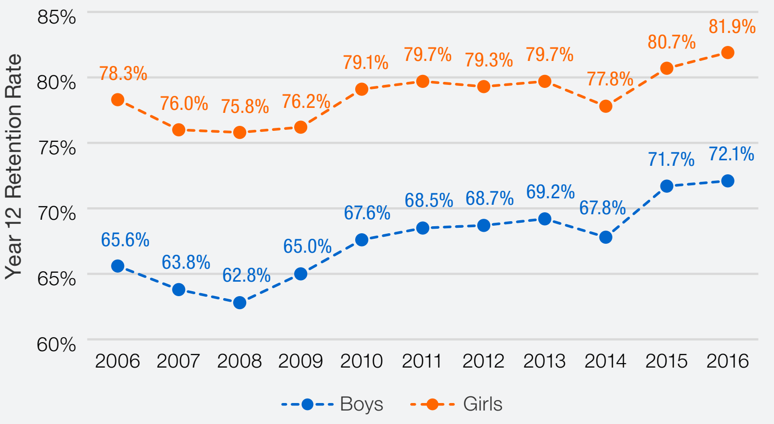
Throughout this report we use blue and orange to represent respectively boys and girls in graphs, unless otherwise specified. Shown in the middle part of Figure 1, the total number of Year 12 students has increased between 2006 and 2016 for both boys and girls. The number of boys climbed from 92,752 in 2006 to 109,318 in 2016, a 17.9 per cent growth. The number of girls climbed from 105,240 in 2006 to 117,212 in 2016, an 11.4 per cent growth. The total number of Year 12 boys and girls has increased from 197,992 in 2006 to 226,530 in 2016, a 14.4 per cent growth. The growth rate in this period is much slower than that three decades ago (Dekkers *et al* 2000). The dips in the enrolments of 2014 were mainly associated with a restructure in Western Australia of the secondary curriculum that has resulted in a half-cohort reduction in the state in that year: the total number of Year 12 students in WA for 2014 was not much more than half of that for 2013. This half-cohort temporarily interrupted the monotonic growth of the Australian Year 12 population. Although there have been more boys of an age suitable for studying Year 12 in schools, 7381 to 13,357, or 6.8 per cent to 14.1 per cent, more girls have actually enrolled in Year 12 each year.

One-third of boys and one-fifth of girls in the Year 12 potential population did not study Year 12.

The Year 12 retention rate—also referred to as the Year 12 participation rate and calculated as the percentage of adolescents in the potential population who actually studied Year 12—is displayed in Figure 2. The graph shows that, over the period of 2006 to 2016, the number of adolescents enrolling in Year 12 has a growth trend with small fluctuations. The percent increase in Year 12 participation rate for boys is twice as large as that for girls in the period. In 2006 and 2016 respectively, 65.6 per cent and 72.1 per cent of the Year 12 male potential population and 78.3 per cent and 81.9 per cent of the Year 12 female potential population actually studied Year 12.

On average, about one-third of boys (48,549) and one-fifth of girls (30,286) left school after Year 10 and before Year 12 each year[1]. These early school leavers are likely to have entered labour markets or have been seeking other career pathways. A large proportion of this cohort is possibly from rural Australia which has a higher male population.

Figure 2. Year 12 retention rates by gender, 2006–2016



Data source: Year 12 enrolments data (AMSI 2017)

1 Assuming that all people in the ages between 6 and 16 attain school educations as required.

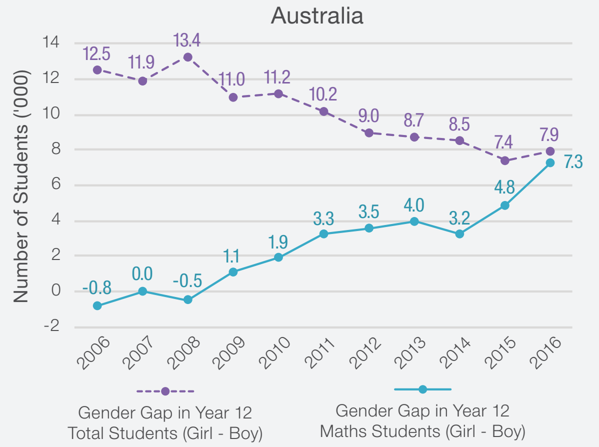
2.3 Gender differences in Year 12 total students and in Year 12 mathematics students

Adding up the number of Year 12 advanced, intermediate and elementary mathematics students gives the total number of mathematics students in Year 12. The totals in each calendar year between 2006 and 2016 are displayed by the diamonds in the bottom part of Figure 1. Using the middle pair of graphs and the bottom pair of graphs in Figure 1, we obtain the gender difference for Year 12 total students and the gender difference for Year 12 mathematics students and show them in Figure 3. The dashed line in the figure shows the number of Year 12 girls minus that of boys, while the solid line shows the number of Year 12 mathematics boys minus the number of Year 12 mathematics girls. The slower growing rate and a larger initial number of girls in Year 12 have led to a declining trend[2] in the gender gap of Year 12 total enrolments.

Figure 3 shows that from 2006 to 2016, despite between 7406 and 12,488 more girls than boys enrolling in Year 12 each year, fewer girls than boys chose to study mathematics in Year 12. In 2006 Year 12, about 770 more girls than boys studied mathematics. By 2009, however, 1089 more boys than girls studied mathematics and the extra number of mathematics boys climbed to 7308 in 2016. Hence, compared to boys, fewer and fewer Year 12 girls have chosen mathematics every year in the period.

The gender distribution for Year 12 mathematics has become more disproportionate, while the gender distribution for Year 12 total enrolments has become more even[3].

Figure 3. Gender gaps in Year 12 actual population and in mathematical population, 2006–2016



Data source: Year 12 enrolments data (AMSI 2017)

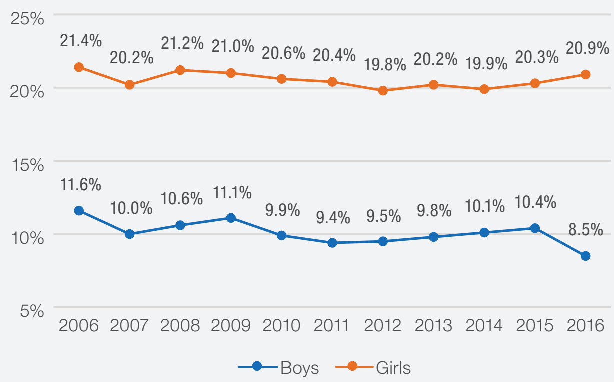
2.4 Proportion of Year 12 students choosing no mathematics subjects

Figure 4 displays the percentage of Year 12 students who did not study any mathematics. As stated earlier, the number of elementary mathematics students has involved an estimation of the overlap of students who studied multiple elementary mathematics subjects and who studied elementary and non-elementary mathematics subjects, hence the total number of students not participating in mathematics is an estimate.

The figure indicates that the disengagement rate of Year 12 students from mathematics is higher for girls than boys, by at least 9.7 per cent points. The disengagement rate has been relatively stable with a mild decrease over the period 2006 to 2015, for both boys and girls. From 2015 to 2016 it has increased by 3.0 per cent for girls, but has decreased by 18.3 per cent for boys. Hence a slightly higher proportion of girls and a substantially lower proportion of boys did not take any mathematics subjects in 2016 as compared to 2015.

The percentage of students not participating in mathematics has been stable, 2006–2016.

Figure 4. Estimated disengagement rate in mathematics among Year 12 students 2006–2016



Data source: Year 12 enrolments data (AMSI 2017)

2.5 Participation in advanced mathematics and in elementary mathematics

The elementary level mathematics subjects vary in level of difficulty and involve little or no calculus. These subjects are not intended to provide a foundation for any future tertiary studies involving mathematics, and sometimes are described as terminal courses (Forgasz 2006). On the other hand, the intermediate and advanced mathematics subjects are required for tertiary studies in which mathematics is an integral part of the discipline, as in STEM. For this reason, it is of interest to know how the mathematics students in Year 12 distribute over the three levels and how the distribution changes over time.

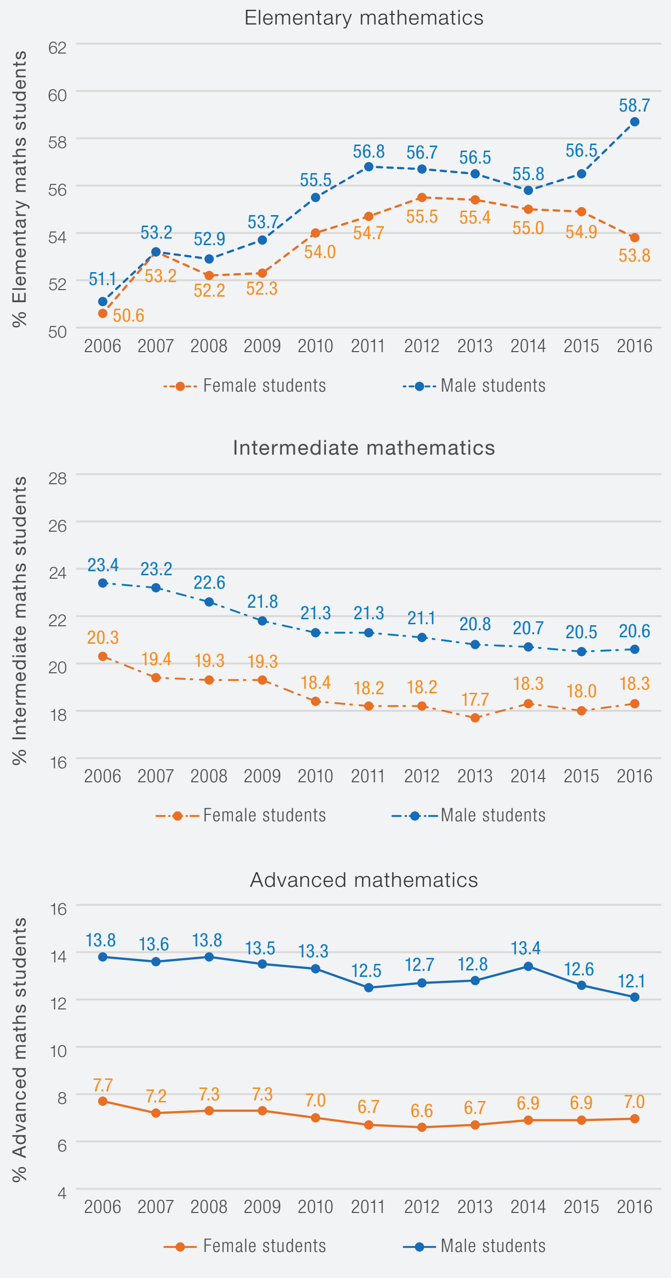
2 This was based on a p-value 0.004, by the extended rank sum test (Cuzick 1985, Altman 1991).
3 This does not contradict the evidence that the proportion of girls and proportion of boys taking mathematics have been stagnant, because the proportions refer to changes over time within a gender but the gender gap refers to comparisons between the genders.

From top to bottom, Figure 5 displays the percentage of Year 12 students studying mathematics subjects at elementary, intermediate and advanced levels. An inspection of the graphs leads to the following findings for the period between 2006 and 2016:

Four times as many boys and seven times as many girls in Year 12 have enrolled in elementary mathematics as have enrolled in advanced mathematics.

- The participation is highest for elementary mathematics and lowest for advanced mathematics, among both boys and girls. The extra level of participation by boys, that is, the gender gap in mathematics participation, is smallest for elementary mathematics and biggest for advanced mathematics.
- The percentage of boys within the Year 12 male cohort studying elementary mathematics has increased by 14.9 per cent, from 51.1 per cent in 2006 to 58.7 per cent in 2016. The corresponding percentage for girls has increased by 6.32 per cent, from 50.6 per cent in 2006 to 53.8 per cent in 2016.
- In contrast, the percentage of boys (within the Year 12 male cohort) studying intermediate mathematics has decreased by 12.1 per cent from 23.4 per cent in 2006 to 20.6 per cent in 2016, and the percentage of girls studying intermediate mathematics has decreased by 10.0 per cent from 20.3 per cent in 2006 to 18.3 per cent in 2016.
- Furthermore, the percentage of boys (within the Year 12 male cohort) studying advanced mathematics has decreased by 12.1 per cent, from 13.8 per cent in 2006 to 12.1 per cent in 2016; and the corresponding percentage for girls has decreased by 9.6 per cent, from 7.7 per cent in 2006 to 7.0 per cent in 2016[4]. The sequence of decreases forms a statistically significant trend under the extended rank sum test. The 18 per cent increase in elementary mathematics and 10 per cent decrease in intermediate and advanced mathematics for boys and girls are in line with the findings of Kennedy *et al* (2014).
- Girls were less likely than boys to study mathematics at any levels of mathematics in Year 12. On average, boys were slightly (1.3 per cent) more likely than girls to study elementary mathematics between 2006 and 2016. Girls were 22.5 per cent to 27.9 per cent less likely than boys to study mathematics subjects at or above the intermediate level, and were 43.4 per cent to 49.0 per cent less likely than boys to study advanced mathematics.
- Each year between 2006 and 2016, at least twice as many boys and girls enrolled in elementary mathematics as in intermediate mathematics. Four times as many boys and seven times as many girls enrolled in elementary mathematics as in advanced mathematics. Overall, students shifted away from advanced or intermediate towards elementary mathematics.
- Denoting the average percentage decrease or percentage change[5] in participation between successive years in a period as the *leaking rate* in the period, we see that the leaking rate in advanced mathematics participation for Year 12 students is 1.1 per cent for boys and 0.9 per cent for girls between 2006 and 2016. The participation of Year 12 students in intermediate or advanced mathematics is leaking at the rate of 1.6 per cent for boys and 0.7 per cent for girls in the period.

Figure 5. Percentages of elementary, intermediate, and advanced mathematics students in Year 12, 2006–2016



Data source: Year 12 enrolments data (AMSI 2017)

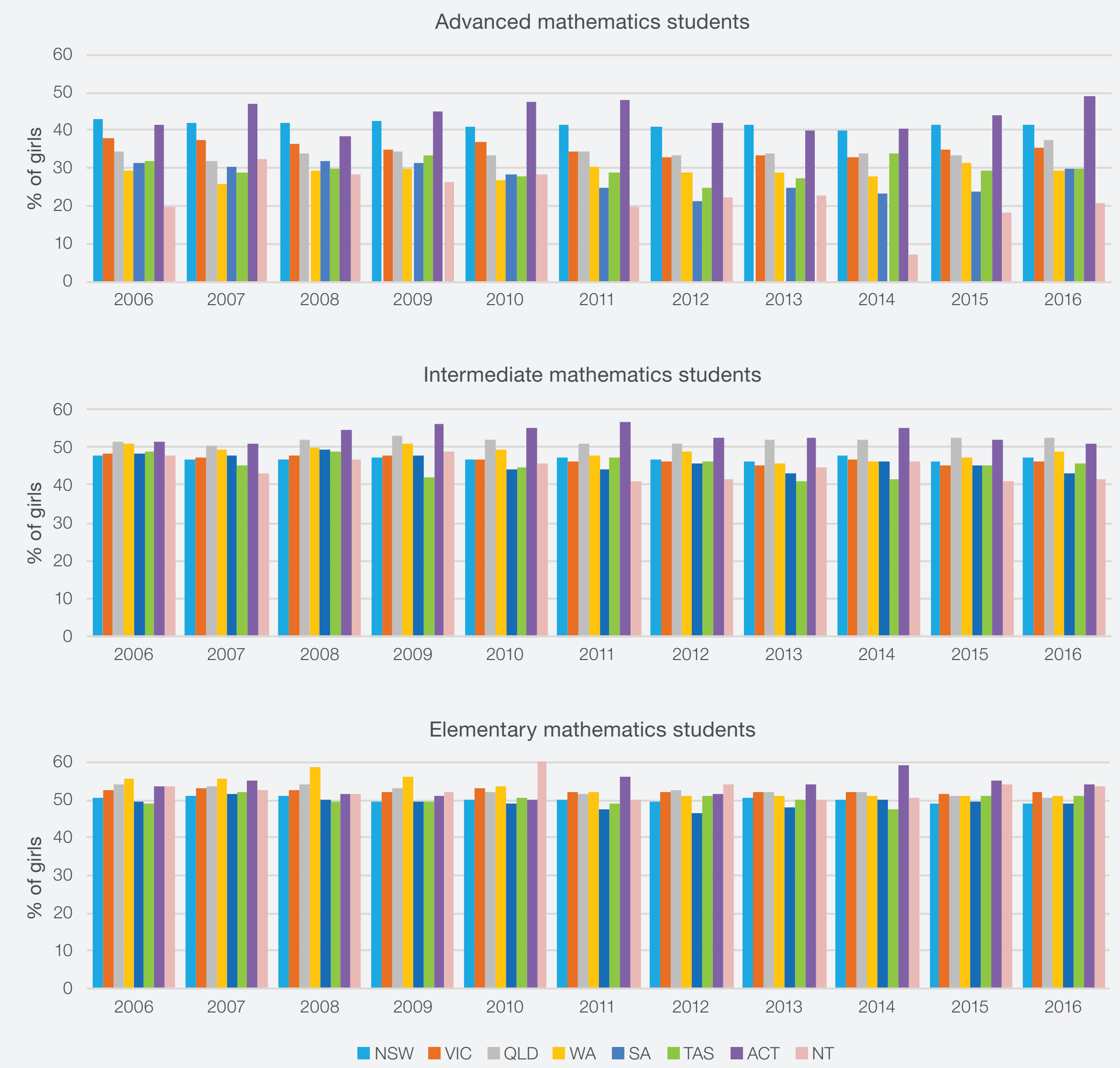
4 It was based on 7.70 per cent in 2006 and 6.96 per cent in 2016.
5 We still call the average the leaking rate even if some yearly changes are positive, provided the average yearly change of the entire period is negative.

2.6 Gender ratios of elementary, intermediate, and advanced mathematics students

The gender distribution in advanced mathematics has been severely skewed towards boys.

The percentage of girls among the cohort of Year 12 advanced, intermediate and elementary mathematics students respectively is displayed by jurisdiction in the upper, middle and lower panel of Figure 6. In the graphs, each jurisdiction corresponds to a unique colour. NSW, for example, corresponds to the bright blue.

Figure 6. Percentages of girls in Year 12 advanced, intermediate and elementary mathematics by jurisdiction, 2006–2016

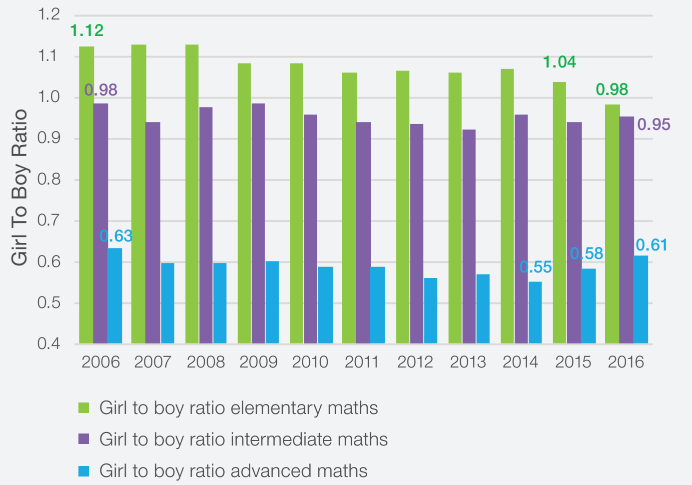


Data source: Year 12 enrolments data (AMSI 2017)

Figure 6 reveals that the percentage of girls in advanced mathematics is overall lower than that in intermediate mathematics and considerably lower than that in elementary mathematics for every year in every jurisdiction. An exception is the ACT where almost an equal number of girls and boys studied advanced mathematics in 2016. Over the entire period, at the advanced level the percentage of mathematics girls is highest in the ACT and NSW. VIC was the next highest until 2011 when it was overtaken by QLD. The lowest percentage occurred in the NT for most years, and it was less than a quarter of the national average in 2014. SA experienced a continuous decline over the 5-year span, from 32.1 per cent in 2008 to 21.4 per cent in 2012. Even the highest percentage of girls in advanced mathematics—in the ACT in 2016—is less than 48 per cent. On the other hand, more than half of the elementary students are girls across most years and jurisdictions. In the NT in 2010, 60.7 per cent of Year 12 elementary mathematics students were girls. In the ACT and QLD more than half of the intermediate mathematics students were girls, persistently over time between 2006 and 2016.

To increase our understanding, we calculate the girl to boy ratio among the students at each level of mathematics subjects, and display the results in Figure 7. A perfect gender balance with an equal number of girls and boys in a group will give a girl to boy ratio of 1 for the group. Because all blue bars are well below 1, all purple bars are slightly below 1, and most green bars are above 1 across years, girls are therefore severely under-represented in advanced mathematics, slightly under-represented in intermediate mathematics, and over-represented in elementary mathematics subjects. Among all the elementary mathematics students, for every 100 boys there were 112 girls in 2006 and 98 girls in 2016. Among all the intermediate mathematics students, for every 100 boys there were 98 girls in 2006 and 95 girls in 2016. Among all the advanced mathematics students, for every 100 boys there were 61 girls in 2006, 55 girls in 2014, and 61 girls in 2016. From 2015 to 2016, the number of boys taking elementary mathematics increased by 4.6 per cent, while the corresponding number of girls decreased by 1.0 per cent. For the first time in the last decade more boys than girls enrolled in elementary mathematics in 2016, leading to the girl to boy ratio of 0.98. The girl to boy ratio for intermediate mathematics students shows a mild decrease from 0.98 in 2006 to 0.95 in 2016, with a 1.2 per cent growth for boys and a 3.0 per cent growth for girls over the period. The number of advanced mathematics girls increased by 4.0 per cent from 2014 to 2015, and further increased by 2.4 per cent in 2016. In contrast, the number of advanced mathematics boys decreased continuously by 1.1 per cent and 3.1 per cent from 2014 to 2015 and then to 2016. Hence in 2016, for the first time in the last decade, the girl to boy ratio for advanced mathematics students reached the level of 61 per cent, as evident from the increasing blue bars between 2014 and 2016.

Figure 7. The girl to boy ratios in elementary, intermediate, and advanced mathematics students, 2006–2016



Data source: Year 12 enrolments data (AMSI 2017)

Girls' participation in advanced mathematics decreased from 2006 to 2014, but has increased since, and for the first time in the last decade there were 61 girls for every 100 boys among the advanced mathematics students in 2016.

2.7 Summary

There were more boys than girls in the Year 12 potential population between 2006 and 2016. The potential population of Year 12 boys and girls has grown over time. Despite the fact that there are more male candidates in the Year 12 potential population, more girls have actually enrolled in Year 12 each year. Nonetheless, the Year 12 enrolment of boys has increased at a faster rate than that of girls, which has led to a decreasing gender gap in Year 12 total enrolments. Over time an increasing percentage of boys and girls in the Year 12 potential population have received a Year 12 education, with a higher retention rate for girls.

The number of students who studied some form of mathematics in Year 12 has grown, for both boys and girls. Although more girls than boys enrolled in Year 12 in every year in the period, more boys have engaged in the study of mathematics, particularly advanced mathematics, subjects.

Consistent with other studies (Wilson and Mack 2014, Wilson 2015, Watt 2005), this report found that the growth of mathematics students is largely due to the growth in numbers of elementary mathematics students. Boys are more likely to enrol in mathematics at all levels. Compared to elementary mathematics, a decreasing proportion of boys and girls chose to study intermediate or advanced mathematics over the period.

Although the percentage of students studying some form of mathematics in Year 12 has been relatively stable over time, the distribution of the students over different levels of mathematics subjects has shifted away from intermediate and advanced mathematics towards elementary mathematics, with a larger shift for boys than girls.

3 Student Performance in Mathematics Subjects

We compare student performance in mathematics between boys and girls using aggregated data from the following resources:

- National Assessment Program—Literacy and Numeracy (NAPLAN)
- Programme for International Student Assessment (PISA)
- Trends in International Mathematics and Science Study (TIMSS)

The focus is on performance trends and changes over time which extends the (international) comparisons obtained in one cycle, and, in addition to the gender perspective, we include aspects such as attitudes to mathematics in our analysis. Note that the aggregated data in most cases do not permit formal statistical tests on the differences.

NAPLAN assesses Australian students of Years 3, 5, 7 and 9 in reading, writing, spelling, grammar and punctuation and numeracy using a national unified test, annually since 2008 on the same days each year. The NAPLAN scaling system explicitly expresses the progression of students in Years 3, 5, 7 and 9 in an ascending order from 0 to 1000 points. A higher school year level is expected to achieve a higher NAPLAN score. The data we used are extracted from the NAPLAN national reports for 2008 through to 2016.

PISA, which started in 2000 with 32 Organisation for Economic Co-operation and Development (OECD) countries, assesses students in Reading Literacy, Mathematical Literacy, Scientific Literacy, Collaborative Problem Solving and Financial Literacy across countries every three years. Participants in PISA are between 15 years 3 months and 16 years 2 months at the time of the tests. More than half a million 15-year olds from 72 countries sat the test in 2015, the latest PISA cycle. Our comments and analyses related to PISA are based on the aggregated data from the National PISA reports from 2000 to 2015 (Lokan *et al* 2001, Thomson *et al* 2004, Thomson and Bortoli 2008, Thomson *et al* 2010, Thomson *et al* 2013 and Thomson and Bortoli 2016, 2017).

Declining faster than the OECD average, Australia's PISA Mathematical Literacy ranking has dropped from 5th place in 2000 to 25th place in 2015.

TIMSS has the longest history of performance assessment among the three data sets (Mullis *et al* 2015, Thomson *et al* 2017). Every four years since 1995, TIMSS assesses educational achievements of Year 4 and Year 8 students internationally. In TIMSS 2015, 49 educational systems conducted tests for Year 4 students, and 39 for Year 8 students. TIMSS and PISA are parallel in many aspects. However, unlike PISA, which controls for student ages, the students in TIMSS vary in age, to reflect different school-starting ages across countries. We note that students in top performing countries typically start school one to two years later than in Australia. Unlike NAPLAN, in which students from a higher school year level are designed to score higher, TIMSS measures student performance of Year 4 and Year 8 using the same scaling range.

3.1 Gender difference in NAPLAN numeracy tests

The average scores of NAPLAN numeracy tests for each year between 2008 and 2016 are displayed in Figure 8 by school year levels.

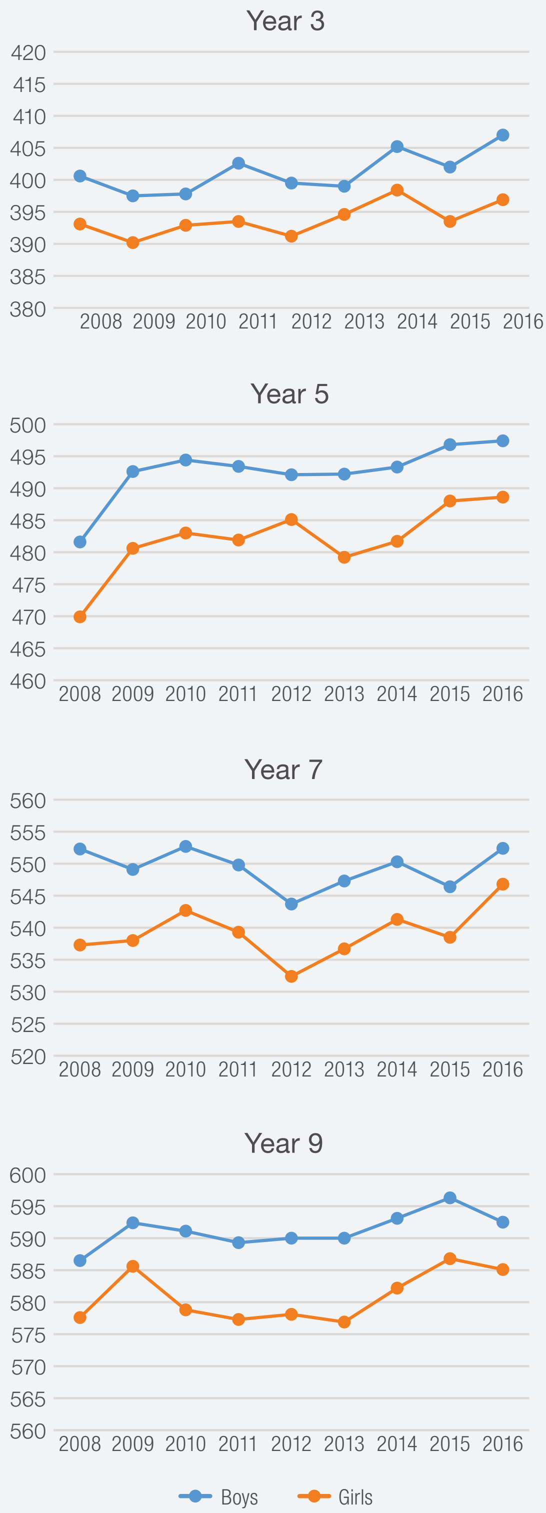
The NAPLAN national report for 2008 provided standard errors for the average test scores in each domain. From 2009 onwards, however, the NAPLAN national reports provided standard deviations (SD) of student test scores. We hence conducted the sign test on average scores between boys and girls paired in each calendar year of the period. The test results showed highly significant statistical differences in the median of average scores between boys and girls for each test level. On average, boys have scored higher than girls, consistently in all NAPLAN tests since its inception. Figure 8 also shows that the average gender difference in performance, represented by the vertical distance between the blue and orange dots of the same year, was approximately 7.4 points in Year 3 tests. It jumped by 43 per cent to 10.6 points in Year 5, and remained at a similar level in Years 7 and 9.

An earlier meta-analysis (Lindberg *et al* 2010) of mostly US college students and adults concludes that overall there is no gender difference in mathematics performance. However, for their subgroup of high school students, their findings are consistent with the findings of this report.

As NAPLAN measures the performance of students in lower year levels using lower scales and students in higher year levels using higher scales, it is not possible to compare student performances across different year levels directly using the NAPLAN raw scores. Hence, NAPLAN has provided a set of six bands for each school year level based on its raw scaling. Students in the same position of the set of bands, say the 3rd band, across different year levels are ranked as having achieved an equivalent academic performance relative to their peers in the same year level. The change in students' distribution over different sets of the bands facilitates a comparison of performance across different year levels. The next two figures display NAPLAN results in terms of the bands.

Boys have outperformed girls in every NAPLAN numeracy test that has been conducted so far.

Figure 8. Average scores in NAPLAN numeracy tests of boys and girls by year level, 2008–2016



Data source: NAPLAN national reports for 2008 until 2016

Figure 9. Percentage of boys and girls in each band in NAPLAN numeracy tests by school year level, 2008–2016

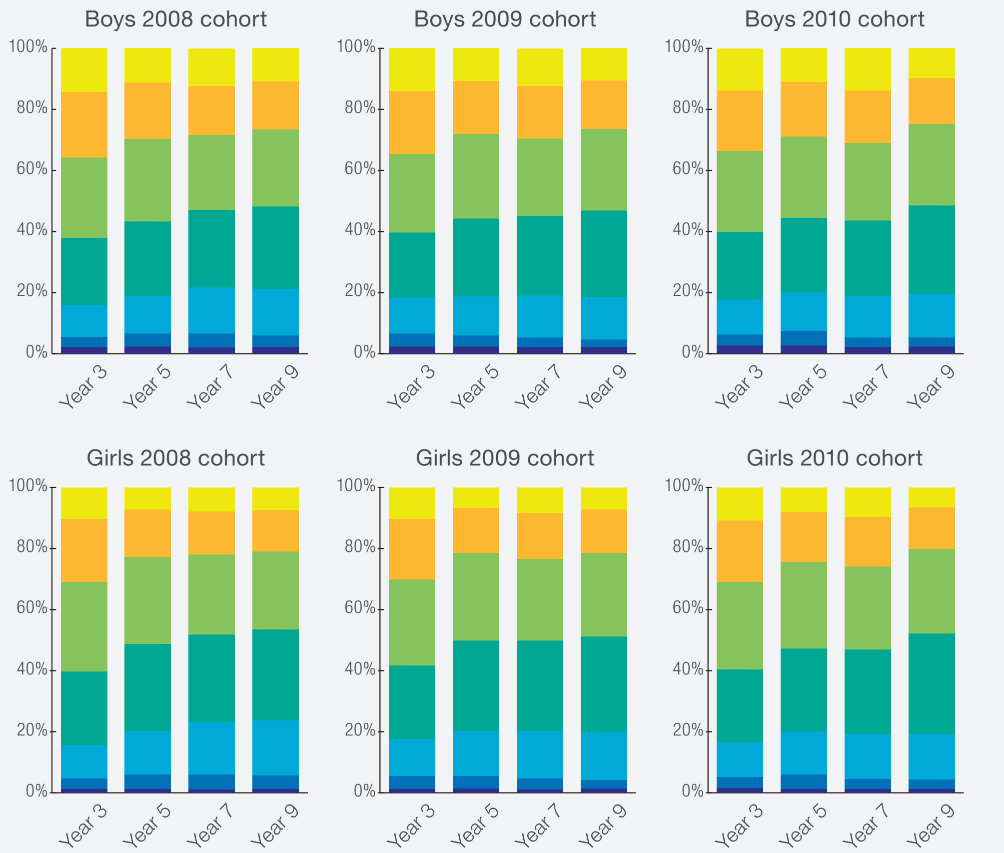
Data Source: NAPLAN national report for 2008 until 2016

The top and bottom rows in Figure 9 show, respectively, the proportion of boys and girls within each performance band in NAPLAN numeracy tests between 2008 and 2016. From bottom to top of each bar in a calendar year the black band denotes the percentage of absentees; the blue, aqua, teal, green, orange and yellow bands denote, in order, the percentage of students in bands 1–6 for Year 3, bands 3–8 for Year 5, bands 4–9 for Year 7 and bands 5–10 for Year 9. The aqua band in each year level represents the minimum national standard for students of that year level. Band 4, for example, is the minimum required level for Year 5 students. The yellow colour in each school year level includes the percentage of students within and above the corresponding band, so 6 and above for Year 3.

The small variations in the bar plots within each panel showed little difference in the patterns from year to year. However, a comparison between boys and girls showed that in each calendar year the teal band—4th from the bottom—is wider for girls than for boys and the yellow band for boys is about 1.5 times as wide as that for girls in the corresponding year. This means that while more girls have performed one level above the minimum national standard, more boys have reached the top band in all year levels and consistently over time.

These performance results, and especially the larger proportion of boys in the top performance band for each school year, do **not** imply that there is a difference in mathematical ability between boys and girls. Indeed, results from PISA 2015 show that in a number of countries including high-performing countries like Finland, Korea, Norway and Singapore girls' average performance equals or exceed that of boys.

Figure 10. Percentage of boys and girls in each band in NAPLAN numeracy tests by student cohort, 2008–2010



Data Source: NAPLAN national report for 2008 until 2016

Year 3 students in 2008 sat further NAPLAN tests in 2010, 2012, and 2014 when they were in Year 5, 7, and 9 respectively. The performances in mathematics of this cohort are displayed in the first panel of Figure 10, top for boys and bottom for girls. The next two panels in Figure 10 correspond, respectively, to the results from the cohorts who entered NAPLAN in 2009 and 2010[6]. The colours and bands in the bar plots are identical to those in Figure 9. In addition to the boy-girl comparison seen in Figure 9, we also observe that percentages in the highest (yellow) band decrease with increasing year level within each cohort, while the size of the teal band (one level above the minimum standard) increases after Year 3 and then stays roughly constant thereafter.

With more data it would be of interest to see whether the gender difference exists from the beginning of school or, if not, when the gender gap in performance begins to exist. Nonetheless, Figure 8 indicates that the gender gap in mathematics performance exists as early as in Year 3. A similar phenomenon has been observed by Cimpian *et al* (2016) in other studies. Hence, the period between Year 3 and Year 5 can be identified as a critical stage in the development of children's mathematical performance skills.

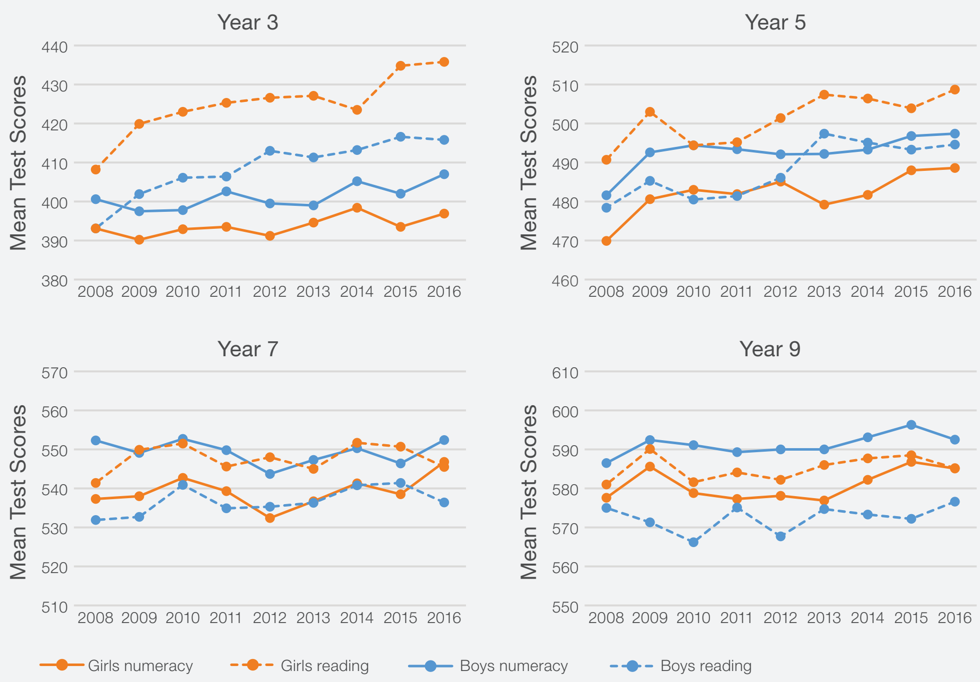
6 Other NAPLAN cohorts have not completed the whole cycle of the tests and hence have been omitted here.

3.2 Comparison with performance in reading

Figure 11 extends Figure 8 by including students' average scores in NAPLAN reading tests as dashed lines in addition to the solid lines of average numeracy scores. In NAPLAN, lower year levels correspond to lower average scores, the vertical axis in each graph of Figure 11 hence displays a different range. The dashed and solid lines in the graph represent the average scores for reading and numeracy respectively.

Girls have outperformed boys in reading tests in Years 3, 5, 7 and 9, NAPLAN 2008–2016.

Figure 11. Average NAPLAN scores in reading and numeracy 2008–2016



Data source: NAPLAN national reports 2008 to 2016

Figure 11 reveals that the average score in reading for girls has been consistently higher[7] than that for boys (orange dashed lines are above blue dashed lines), and that the average score in numeracy for girls has been consistently lower than that for boys (orange solid lines are below blue solid lines) in all NAPLAN tests. Year 3 girls were much better at reading than at numeracy, and from 2009 to 2016 Year 3 boys were also better at reading than at numeracy, though not as distinctly as the girls.

The difference in performance between numeracy and reading within each gender reveals different patterns for boys and girls. The difference decreases with year levels for girls but increases with year levels for boys. By Year 9, on average girls' performance in reading is slightly higher than that in numeracy. In contrast, boys' average performance in reading became substantially lower than that in numeracy. Across gender, the difference of boys and girls in reading performance has decreased by 18.9 per cent from Year 3 to Year 5[8]. In contrast, the gender difference in numeracy performance has jumped by 43.2 per cent from Year 3 to Year 5 and remained similar thereafter[9]. Hence the evidence appears to indicate that the time between Year 3 and Year 5 is an important stage in children's development of reading and numeracy skills.

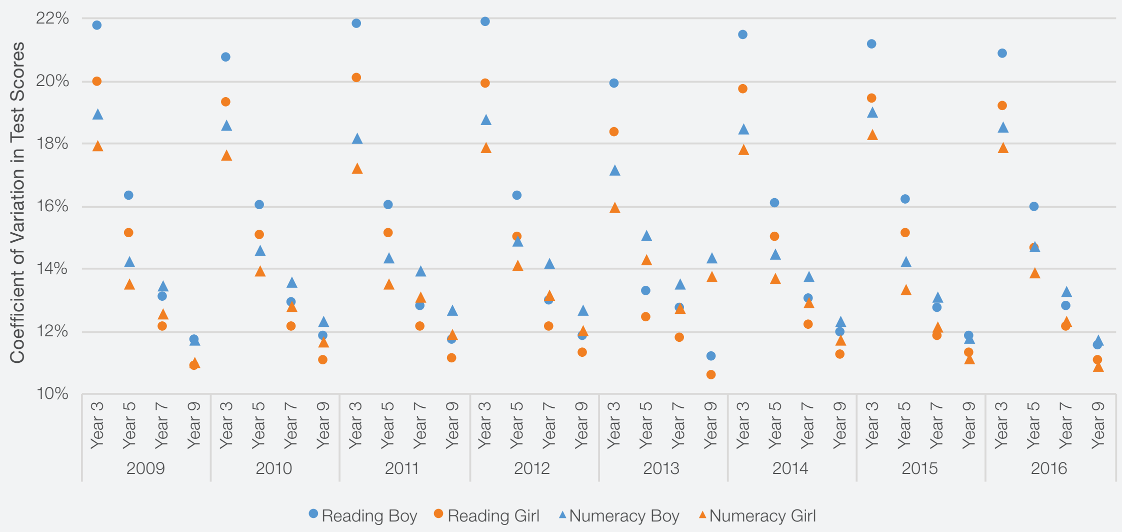
Performance has varied more in Year 3 than Year 9, more for boys than girls, and more in reading than numeracy in primary schools in NAPLAN 2009–2016.

How does an individual student's performance deviate from the group average? To compare the variability in performance across year levels and across different domains, we have calculated the coefficient of variation (CV) for student scores in reading and in numeracy and show them in Figure 12. Dots and triangles in Figure 12 represent CVs of the test scores in reading and numeracy respectively. The figure shows that, except in 2013[10], the CVs exhibit a similar pattern within each calendar year for both domains and genders. The CVs decrease with school year levels, and are higher for boys than girls in each domain. The large variation in Year 3 performance may reflect a residual effect of students' pre-school training. It could also mean that there is more room for

7 The sign test for equal median of the average scores between boys and girls across years was highly significant, for each year level.
8 The average performance in reading across the years is 16.3, 13.2, 11.0, 12.7 for Year 3, 5, 7 and 9 respectively.
9 The average performance in numeracy across the year between 2008 and 2016 is 7.4, 10.6, 10.1 and 10.3 for Year 3, 5 7 and 9 respectively.
10 We do not have an explanation for the different behaviour in 2013.

improvement among junior students than their senior peers. When the duration of schooling increases, the heterogeneity in students' knowledge is reduced by the effect of education. The implication is that a higher level of differentiation must be accommodated when teaching junior students, particularly junior boys.

Figure 12. Performance variability in reading and numeracy by gender, 2009–2016

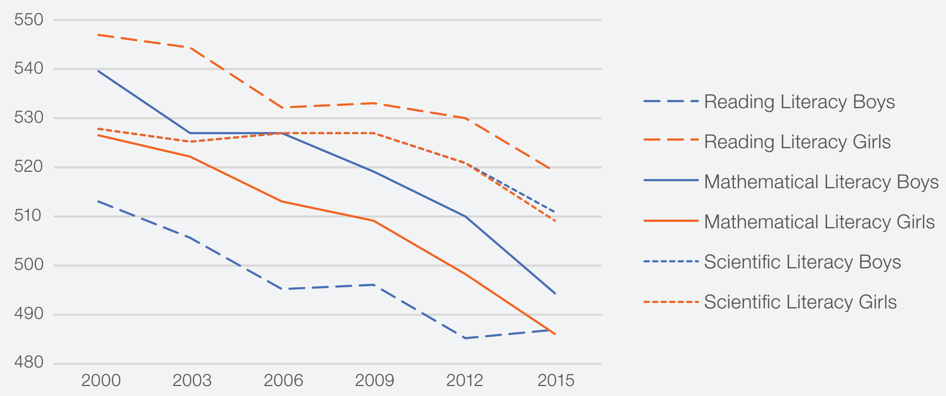


Data source: NAPLAN national reports 2008 to 2016

3.3 Gender difference in PISA Mathematical Literacy tests

Figure 13 displays average scores of Australian students in PISA tests in: Mathematical Literacy (solid lines), Reading Literacy (dashed lines), and Scientific Literacy (short dashes) for male (blue) and female (red) against calendar year on the horizontal axis. The initial PISA tests were standardised to an OECD average of 500 points in each of the three domains.

Figure 13. Australian students' average scores in Mathematical Literacy, Reading Literacy and Scientific Literacy by gender, PISA 2000–2015



Data source: Australian results from the PISA reports, 2000 to 2015.

Boys have shown better performance than girls in Mathematical Literacy tests, PISA 2000–2015.

In Mathematical Literacy, boys outperformed girls in every cycle by amounts that are statistically significant before 2015 and are no longer statistically significant in 2015. Girls outperformed boys in Reading Literacy every time, by 30–40 PISA points, as the wide gap between the red and blue dashed lines shows, these results are consistent with the findings from NAPLAN results reported in 3.2. In Scientific Literacy, there is hardly any gender difference in performance. Since the tests cover three areas: Living Systems, Physical Systems, and Earth and Space Systems, it is possible that girls perform better in some of the areas and boys in others, thus the differences may have cancelled out in the overall score. It is noticeable that the performance of boys is more variable than that of girls in each domain. These larger variations of boys' performance weaken the relevance of `statistically significant results' when comparing performance of boys and girls.

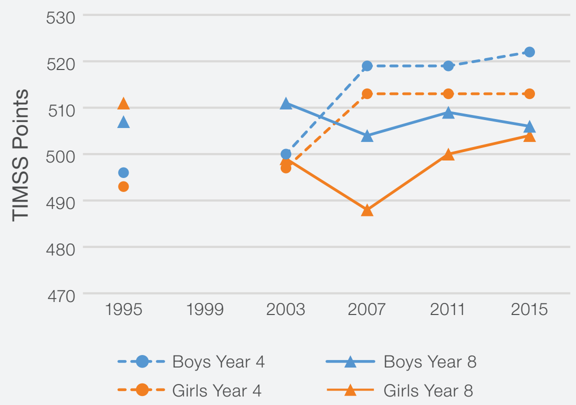
It is important to see the differences in performance of boys and girls as part of a bigger picture. By far the biggest effect on performance of Australian students in all three domains is their socio-economic status (SES) which results in a gap of 86 points in 2015 between the lowest and highest SES quartiles and corresponds to a difference of two years of schooling. Other large single effects are indigenous status (70 points), school type (55 points), school location (42 points), and jurisdiction (36 points). Compared to these differences, the mean performance gap of 8 points between boys and girls in 2015 is negligible.

3.4 Gender difference in TIMSS mathematics tests

Figure 14 displays average mathematics scores of Australian students in all TIMSS cycles[11]. Unlike the NAPLAN scores, TIMSS scores are centred at 500 points for both year levels. In 2015, boys in Years 4 and 8 achieved an average score of 522 and 506 points respectively, a 12-point difference; and girls achieved an average of 513 and 504 in Years 4 and 8 respectively, a 9-point difference, so a small decrease in performance in the higher year level. Since 2003, boys on average had a higher score than girls at both year levels. The difference between boys' and girls' performance and the difference over time within gender are small compared to the difference due to socio-economic backgrounds. The performance trends over time differ in Years 4 and 8. The Year 4 gender difference in 2015 has tripled since 1995, with boys progressing at a faster rate than girls over time. However, in 2015 the Year 8 gender difference has shrunk to one sixth of that measured in 2003. This suggests that girls, in recent years have been catching up by Year 8. These changes are reflected in the change in performance in cognitive domains in Figure 15 and content domains in Figure 16.

Boys maintained stable performance in TIMSS Year 8 mathematics tests 1995–2015, while girls have been improving since 2007.

Figure 14. Australian Year 4 and Year 8 students' average scores in mathematics tests by gender, TIMSS 1995–2015

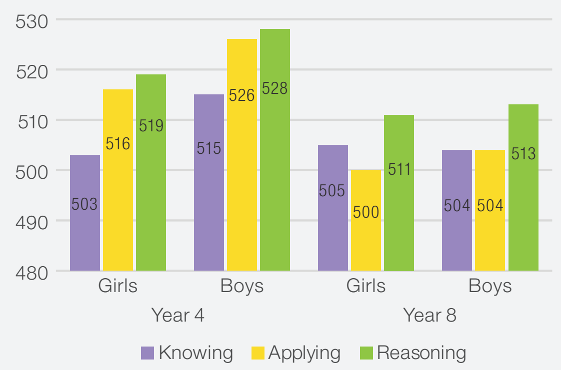


Data source: TIMSS 2015 International results in mathematics (Mullis et al 2016, Exhibit 1.12 and Exhibit 1.13)

Gender gaps in cognitive and content domains have almost disappeared, and girls have performed better in algebra than boys in TIMSS 2015 Year 8 mathematics test.

Figure 15 displays Australian students' average performance in TIMSS 2015 for mathematics cognitive domains and by year level; purple for 'Knowing', yellow for 'Applying', and green for 'Reasoning'. The results indicate that on average, a Year 4 boy was 12 points better than a Year 4 girl at 'Knowing', and 10 and 9 points better at 'Applying' and 'Reasoning' respectively. By Year 8, the average scores in most cognitive domains have decreased compared to Year 4 within gender. Girls in Year 8 are now better than boys at 'Knowing', and are only 4 and 2 points behind boys in 'Applying' and 'Reasoning' respectively. The average achievements of Australian students in mathematics content domains, given in Figure 16, reveal that on average Year 4 boys were 12, 8, and 5 points better than Year 4 girls at number, shapes and measures, and data display, respectively. By Year 8 the gender difference has almost disappeared: despite some differences that still exist in the domain of numbers, the overall difference was negligible. These TIMSS results are consistent with the latest PISA results.

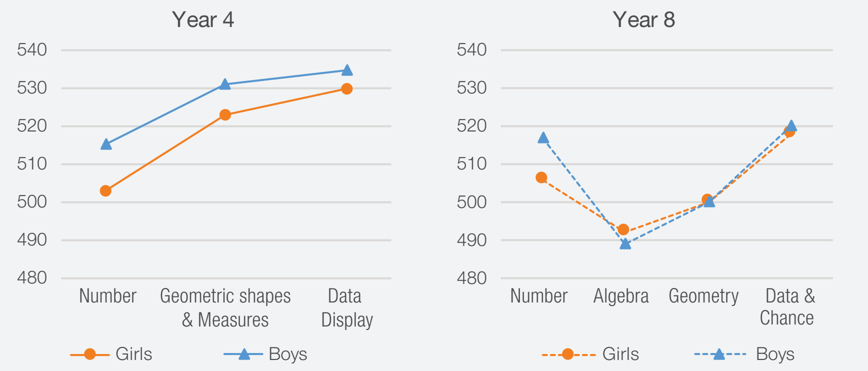
Figure 15. Achievements of Australian students in mathematics cognitive domains, TIMSS 2015



Data source: TIMSS 2015 International results in mathematics (Mullis et al 2016, Exhibit 3.11 and Exhibit 3.12)

11 Australia did not participate in TIMSS 1999.

Figure 16. Achievements of Australian students in mathematics content domains, TIMSS 2015



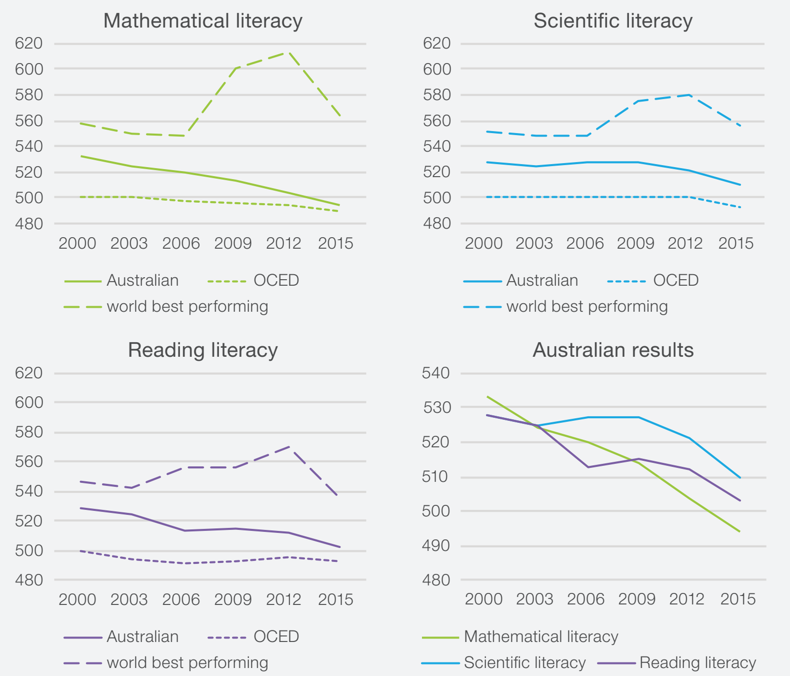
Data source: TIMSS 2015 International results in mathematics (Mullis et al 2016, Exhibit 3.9 and Exhibit 3.10)

3.5 International standing of Australian students in mathematics

The solid, short dashed, and long dashed lines in Figure 17, respectively, represent the average scores of Australia, OECD countries, and the best performer each year in the PISA Mathematical Literacy test.

Australia's ranking in the PISA Mathematical Literacy tests has dropped from 5th in 2000 to 25th in 2015 among OECD countries.

Figure 17. Australian, OCED, and the world best performing country's average scores, PISA 2000–2015



Data source: secondary data from PISA reports

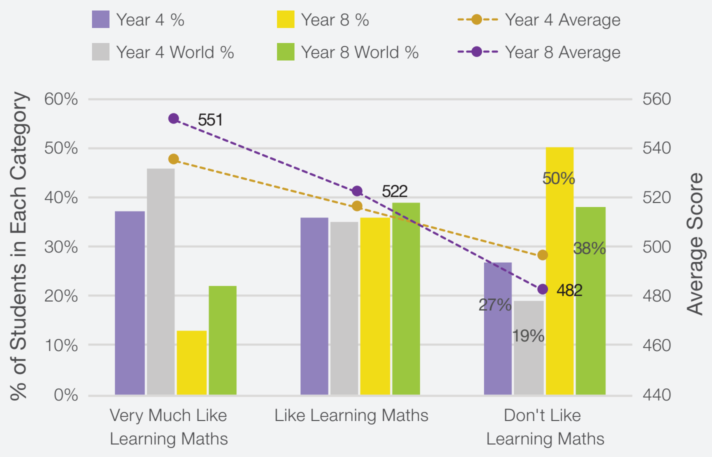
From Figure 17 we see that Australia's performance is better than the OECD average in all domains between 2000 and 2015. However, the average OECD performance was decreasing over time and the average performance of Australian students was decreasing at a rate faster than the OECD average in all domains and particularly in mathematical literacy. This latter trend is of particular concern and requires more careful exploration. The trends in results for boys and girls are similar to the trend in their combined results and thus not shown here. Among the 32 OECD countries that participated in 2000, Australia's average performance in the PISA Mathematics Literacy test in 2000 is only below Japan, Korea, NZ, and Finland, that is, Australia ranked 5th. By 2015, Australia ranked 25th out of 37 OECD countries[12]. Although not all of these countries took part in the test in 2000, the trend is concerning.

42 per cent more Year 4 and 32 per cent more Year 8 students in Australia than in the world do not like learning mathematics.

12 Australia ranked below Singapore, Hong Kong, Macao, Taipei, Japan, China (Beijing, Shanghai, Jiangsu and Guangdong), Korea, Switzerland, Estonia, Canada, Netherlands, Denmark, Finland, Slovenia, Belgium, Germany, Poland, Ireland, Norway, Austria, NZ, Vietnam, Russian Federation, and Sweden

In TIMSS mathematics results, students are divided into three sub-groups 'Very Much Like/Like/Don't Like learning mathematics', according to the extent of their agreement with nine statements on the 'Students Like Learning Mathematics' scale (Mullis *et al* 2016, p313–316). The percentages of students[13] in each sub-group are displayed by bars in Figure 18, purple and grey for Year 4 students in Australia and in the world respectively, and yellow and green for Year 8 in Australia and in the world respectively. The average performance scores of Australian students in each sub-group are displayed as dots, brown for Year 4 and purple for Year 8, to be read against the RHS axis.

Figure 18. Average mathematics scores by students' degree of 'Like learning mathematics', TIMSS 2015

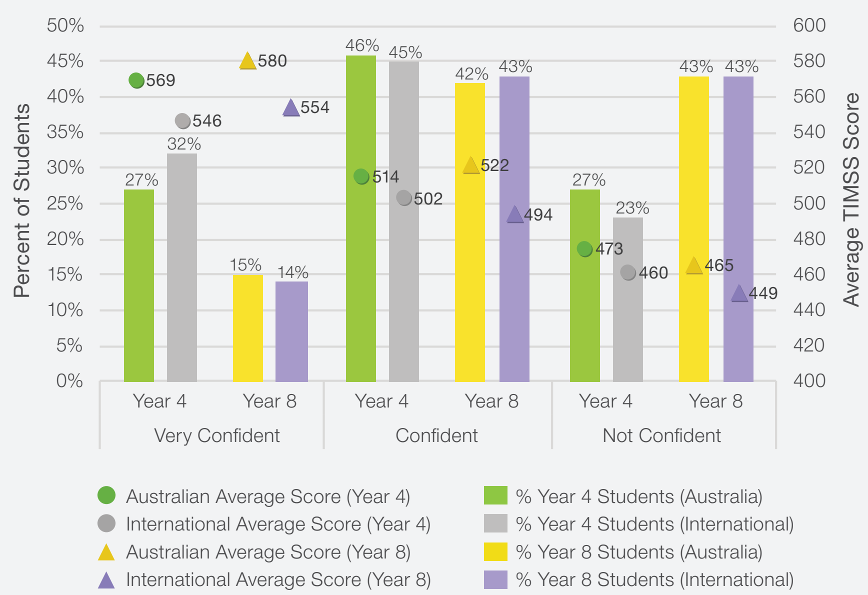


Data source: TIMSS 2015 International results in mathematics (Mullis et al 2016, Exhibit 10.3 and Exhibit 10.4)

In 2015, about 73 per cent of Year 4 students and 49 per cent of Year 8 students reported that they like or very much like learning mathematics. The percentage of students who very much like learning mathematics is lower in Year 8 than in Year 4, by 24 per cent points (or 64.9 per cent). The average score of mathematics tests is highest for students who 'Very much like learning mathematics', at both year levels. On average, students who 'Very much like learning mathematics' scored 39 and 69 points higher than students who 'Don't like learning mathematics' in Years 4 and 8 respectively. Figure 16 reveals that a lower percentage of students favour mathematics in Australia than in the world and a higher percentage of students do not like mathematics in Australia than in the world, at both Year 4 and Year 8. One in four Year 4 students in Australia and one in five students in the world 'Don't like learning mathematics'. The percentage of students who 'Very much like learning mathematics' is much lower in Year 8 than in Year 4 and the percentage of students who 'Don't like learning mathematics' is much higher in Year 8 than in Year 4, both in Australia and in the world, with 42 per cent more Year 4 and 32 per cent more Year 8 students in Australia than in the world reported to not like learning mathematics in TIMSS 2015.

The Australian students' average score is higher than the world average in each mathematical confidence group. However, there were fewer mathematically confident students and more mathematically not confident students in Australia than in the world.

Figure 19. Average mathematics scores by students' level of mathematical confidence[14], TIMSS 2015



Data source: TIMSS 2015 International results in mathematics (Mullis et al 2016, Exhibit 10.5 and Exhibit 10.6)

The green and grey dots in Figure 19 represent, respectively, Australian and international average mathematics scores for Year 4 students. The yellow and purple triangles represent the same for Year 8 students. The green and yellow bars respectively represent the percentages of Years 4 and 8 students in each confidence category in Australia, and the grey and purple bars correspond to the percentages of students in each confidence category in the world.

Within Australia, the proportion of 'Very confident' students is 12 per cent points lower in Year 8 compared to Year 4, and the proportion of 'Not confident' students is 16 per cent points higher in Year 8 compared to Year 4. Relative to the international averages, the average mathematics achievements by Australian students are higher in all confidence categories. However, the proportion of 'Very confident' students in Australia

13 Data on this variable for gender break are unavailable in Mullis *et al* 2016.
14 The gender break for this variable is unavailable to us (Mullis *et al* 2016). The data here are pooled data of boys and girls.

is 16 per cent lower than that in the world, and the proportion of 'Not confident' students in Australia is 17 per cent higher than that in the world.

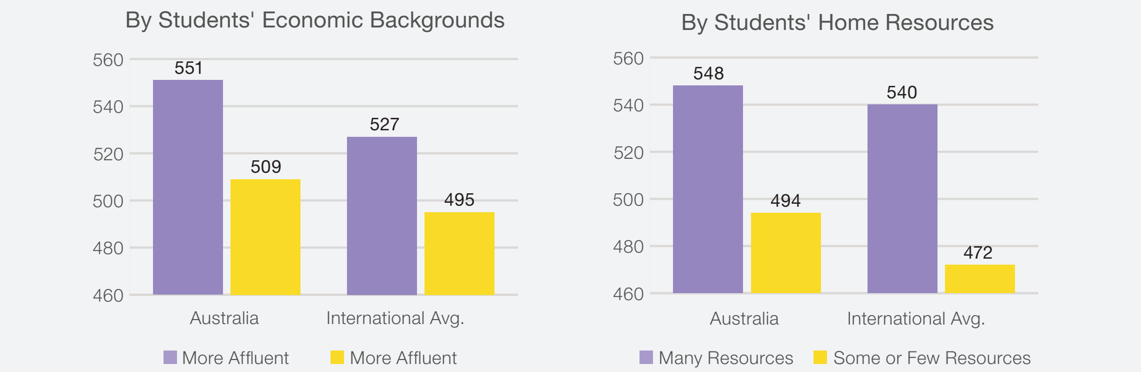
3.6 Gender effects compared with effects of economic backgrounds and home learning resources

Home learning resources and socio-economic backgrounds of students have a much stronger impact than gender on students' mathematics performance.

To understand the magnitude of the gender difference in mathematics performance better, we consider the variables about student economic backgrounds and home learning resources, from the TIMSS 2015 data[15], to make a comparison.

Principals in TIMSS participating schools have estimated the percentage of students in their schools who come from economically disadvantaged homes and the percentage of students who come from economically affluent homes. A school is called 'More Affluent' if more than a quarter of the student body comes from economically affluent homes and less than a quarter from economically disadvantaged homes (Mullis *et al* 2016, p188), and a school is otherwise called 'Less Affluent'. The left panel of Figure 20 displays average mathematics test scores for students of the two groups in Australia and in the world. TIMSS also have a derived variable on 'home resources for learning' based on the number of books at a student's home, the number of children's books at the home, the highest level of education of either parent, and the highest level of occupation of either parent. The right panel in Figure 20 displays TIMSS 2015 results on this variable.

Figure 20. Average mathematics scores by students' socioeconomic backgrounds and home resources, TIMSS 2015



Data source: TIMSS 2015 International results in mathematics (Mullis et al 2016, Exhibit 4.1, 4.2, 5.1, 5.2)

The figure reveals that students from economically 'More Affluent' homes, on average, have an advantage of 42 TIMSS points over the rest of the students, and students with 'Many Home Learning Resources' have an advantage of 54 points. The corresponding advantages in the international data are 32 and 68 points respectively. Hence, students' economic backgrounds and in particular the availability of books at home and learning support from parent(s) have much stronger impacts on students' performance, compared to the gender difference in performance that has a maximum effect of 12 points (Figure 16, Year 4 value). However, as will be discussed later, the gender difference in performance has a big impact on students' participation in the subject.

3.7 Summary

Gender difference in performance of mathematics exists in Australia, at all school year levels for which data are available. The gender difference is small compared to the effects on performance from socio-economic disparities. Boys on average have scored higher than girls', boys' performance varied more than girls', and students from economically more affluent homes or from homes with more learning resources have performed much better.

The status of 'Like learning mathematics' and being 'Very confident' in learning mathematics are positively associated with better performances, for both boys and girls. A lower proportion of students in Year 8 than Year 4 like learning mathematics or are 'Very confident' in learning mathematics for each gender.

For students holding the same level of confidence in learning mathematics, Australia has scored higher than the world average in TIMSS 2015 mathematics tests. Yet, the distribution of students in Australia is sparser on 'Very confident' and denser on 'Not confident' than the world average. Australia's ranking in mathematics performance has dropped from 5th in 2000 to 25th in 2015 among the PISA OECD countries.

15 There is no data separately for boys and girls on these two variables in TIMSS 2015.

4 Gender Difference in Attitude Towards Mathematics

AMSI's Choose Maths initiative comprises a multilevel approach to increasing participation of women in the STEM pipeline by:

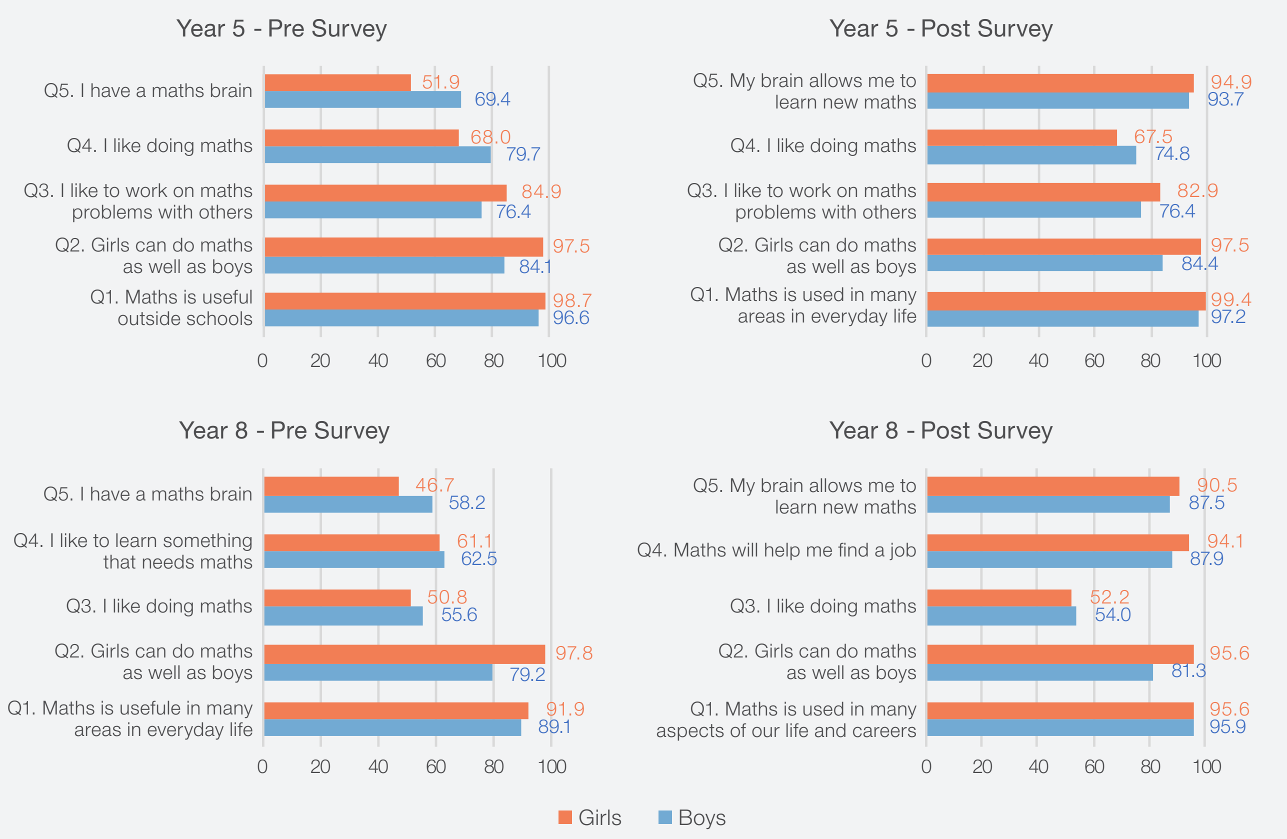
- working directly with teachers and students in 120 schools across Australia;
- promoting careers awareness ambassadors and developing career awareness material for students, teachers and the general Australian community;
- creating and maintaining a Women in Maths network within schools, universities and workplace which integrates role models and mentoring at different career stages;
- celebrating the successes of mathematics teachers and students across Australia in annual award ceremonies;
- supporting its activities by gender-related research in mathematics education and the mathematical sciences.

As part of the program, Choose Maths conducts a teacher survey and a student survey annually. Koch and Li (2017) reported on teacher confidence in teaching mathematics based on the 2016 Teacher Survey. With appropriate research ethics approvals, a pilot study of the Choose Maths Student Survey and intervention was administered in 2016 to 300 students each in Years 5 and 8 from 27 classes across different states. All school types, that is, government, catholic and independent, were represented in the sample. Most schools in the sample were co-educational and some were single-sex girls schools. The intervention consisted of two teaching modules, conducted between a pre-intervention and a post-intervention survey of the students. The first module explained how the human brain works and introduced students to the idea that the human brain and its ability to learn mathematics can grow (Boaler 2015). The second module reinforced students' awareness of the usefulness of and need for mathematics in daily life via a game of pairing 'title' and 'description' cards through collaborative work. The pre and post surveys each comprised five statements that anticipated a 'Yes' or 'No' response. A mobile phone app, Plickers, was used to collect the responses.

4.1 The Choose Maths Student Survey 2016: items and responses

Figure 21 depicts the survey items or statements and the percentage of students who responded 'Yes' to each statement in the pilot study, with the survey statements being displayed along the vertical axis and the percentage of 'Yes' responses along the horizontal axis. In the following sections, we will look at the survey results individually.

Figure 21. Percentage of 'Yes' responses in the pilot Choose Maths Student Survey 2016



Data source: Choose Maths Student Survey 2016 pilot study

4.2 Students' attitude towards mathematics

Responses to Question 1 in the pre surveys revealed that 96.6 per cent of boys and 98.7 per cent of girls in Year 4 and 89.1 per cent of boys and 91.9 per cent of girls in Year 8 agreed that mathematics is useful in everyday life. The proportion of students with positive views of mathematics has increased in the post surveys at both year levels—most likely as a result of the Choose Maths intervention.

At both year levels the largest gender gap exists in students' perception on girls' capacity to learn mathematics compared to that of boys' (Question 2). The intervention appears to have had little impact on this perception, since the before and after intervention responses are almost identical. The agreement rate of girls is some 97 per cent at both year levels. In the Year 5 pre survey, girls were 13 per cent points more likely than boys to agree that 'Girls can do maths as well as boys'. The gap in Year 8 has widened by almost 18 per cent points. Both gaps are statistically highly significant.

Some 84 per cent of girls and 76 per cent of boys in Year 5 agreed with Question 3 'I like to work on maths problems with others'; the gender gap of 8 per cent point is statistically not significant in a test for equal proportions. The percentage agreements are similar between the pre and post surveys within each gender.

In response to Question 4 in the Year 8 post survey 'Maths will help me find a job', 94 per cent of girls and 88 per cent of boys agreed. Girls appeared to value the usefulness of mathematics in job hunting more highly than boys, but the gender difference in this aspect is statistically not significant[16].

In response to the statement 'I like doing maths', Question 4 for Year 5 and Question 3 for Year 8, 11.7 per cent points more boys than girls in Year 5 and 4.8 per cent points more boys than girls in Year 8 agreed in the pre survey. After the intervention, there were decreases of 4.8 per cent and 0.5 per cent in the proportion who responded 'like doing maths' among boys and girls respectively; the gender gap for Year 5 students has reduced to about 7 per cent points and almost disappeared in Year 8 due to an increase from girls and a decrease from boys in the percentage of 'Yes' answers. The narrower gap in Year 8 of the attitudinal results confirms a similar phenomenon for performance results in Year 8 TIMSS results.

To compare the responses across year levels, we re-display the pre survey results in Figure 22; darker colours represent Year 5 results and the lighter colours Year 8 results, and the green bars represent percentage changes from Year 5 to Year 8 of students who agreed with the statement of the survey.

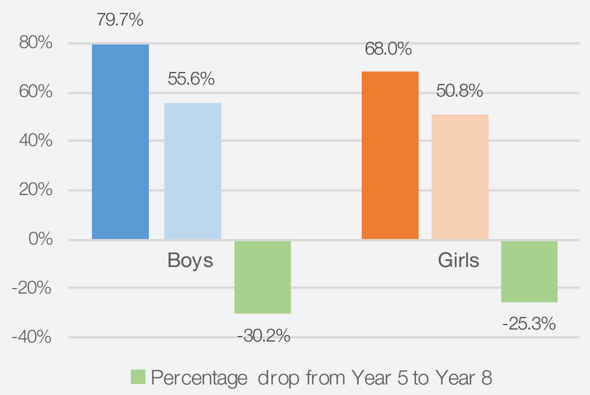
The graph shows that 79.7 per cent of boys in Year 5 and 55.6 per cent of boys in Year 8 like doing mathematics, a 30.2 per cent decline (shown as the green bar under Boys in the graph). The proportion of girls who like doing mathematics is 25.3 per cent lower in Year 8 than in Year 5, but fewer girls in Year 5 agree than boys. These results are consistent with the TIMSS data of Figure 18 which shows that the proportion of students who like or very much like learning mathematics decreased from Year 4 to Year 8 by 32.9 per cent in Australia[17] and by 24.7 per cent in the world. They also confirm the interpretation of increasing disengagement in mathematics that happens after Year 3 or 4.

The majority of students hold a positive attitude towards the usefulness of mathematics.

More than 97 per cent of girls agree that girls can do mathematics as well as boys, while 13 per cent points fewer boys in Year 5 and a further 5 per cent points fewer boys in Year 8 think so.

Girls appear to enjoy more working with others compared to boys, when learning mathematics.

Figure 22. Students' attitude towards liking mathematics, Choose Maths pilot study 2016



Data source: Choose Maths Student Survey 2016 pilot study

More boys than girls like doing mathematics, in both Year 5 and Year 8.

16 The observed difference in proportion of 'Yes' between boys and girls (boys' minus girls') is -0.062 with the 95per cent confidence interval (-0.138, 0.014).

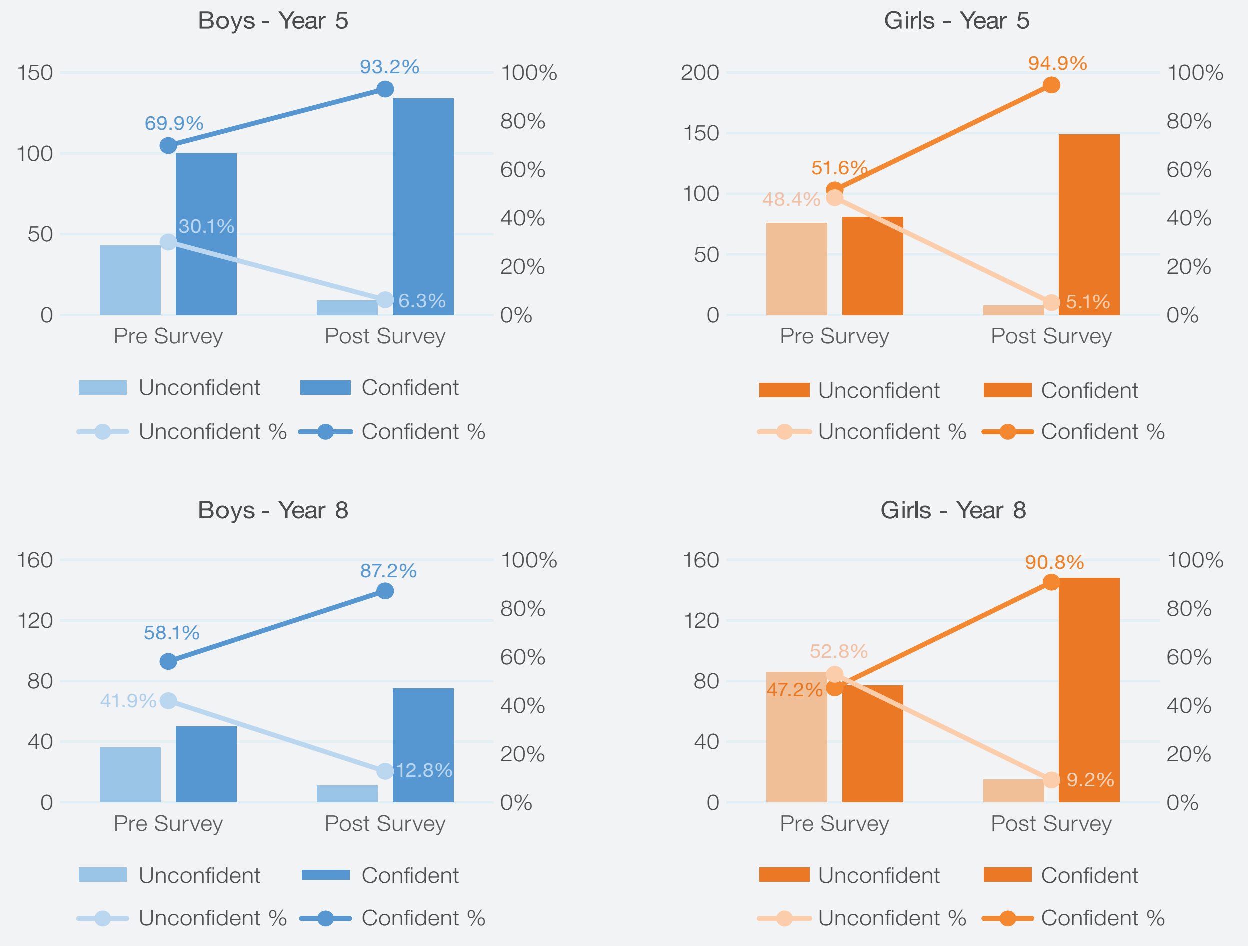
17 The proportion of students who very much like or like learning mathematics is (0.37+0.36) in Year 4 (from the purple bars in Figure 18, and the corresponding proportion in Year 8 is (0.13+0.36) (from the yellow bars), which gives a percentage change of - 32.9per cent.

4.3 Students' confidence in self-perceived ability to learn mathematics (Q.5)

The number of students in each response category of the surveys is displayed as bars in Figure 23, grouped under 'Pre Survey' and 'Post Survey' with the scale shown on the LHS of each panel. Students who disagreed with the statement 'I have a maths brain' or disagreed with 'My brain allows me to learn new maths' are marked as 'Unconfident' and are displayed in lighter colours in the graphs, while students who agreed with the statement(s) are marked as 'Confident' and are displayed in darker colours. The darker coloured line shows the proportions of students who were 'Confident' in the surveys, blue for boys and red for girls as usual. The scale for these percentages is shown on the RHS of each panel.

Girls are 25 per cent less confident than boys in their self-perceived ability to learn mathematics, but can be motivated to believe that they can learn mathematics.

Figure 23. Students' self-perceived ability to learn mathematics, Choose Maths pilot study 2016



Data source: Choose Maths Student Survey 2016 pilot study

A comparison of 'Pre Survey' results in the top row of Figure 23 shows that about 7 out of 10 boys and 5 out of 10 girls in Year 5 were confident in their self-perceived ability to learn mathematics. That is, girls are at least 25 per cent less confident in their mathematical ability than boys. After the intervention, at least 9 out of 10 students reported being confident, regardless of gender. The bottom row in Figure 23 shows that initially 6 out of 10 boys and 5 out of 10 girls were confident in their mathematical ability, with the percentages of confident students increasing to 9 out of 10, regardless of gender.

At both year levels, the significantly higher percentage of confident students in the post surveys suggests that students internalised the idea, taught during the intervention, that **they too** can learn new mathematics and that their brain's capability can be improved by using and challenging it. The girls showed a greater change than boys: they started at a lower level of 'mathematics confidence', but overtook boys in the post survey. These results are very encouraging and indicate that focussed intervention can make a difference in attitude with an expected flow-on effect on engagement and participation in mathematics.

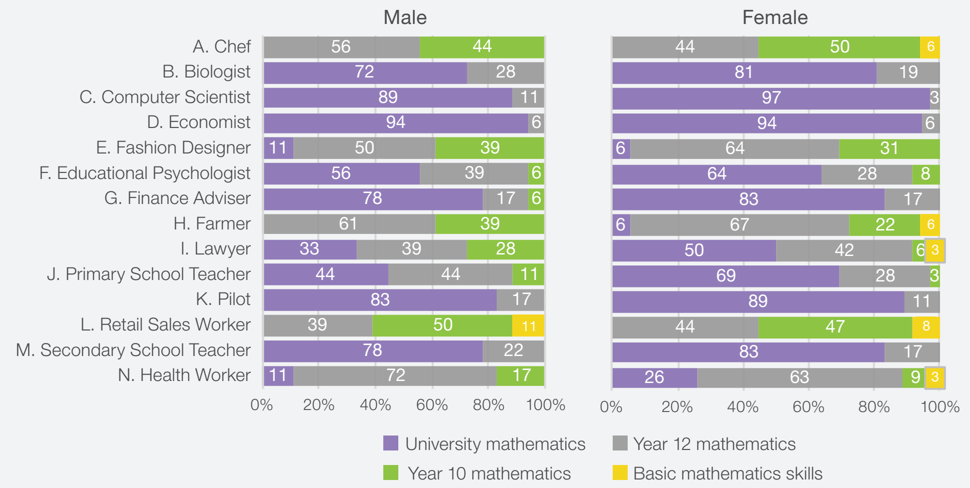
4.4 Teachers' ratings on level of mathematics required in occupations

The Choose Maths Teacher Survey 2016, administered to 620 mathematics teaching staff in 85 schools, collected information on teacher's qualifications, confidence, experience, and views about students' decisions to continue studying mathematics in Years 11 and 12. The teaching staff included classroom teachers, principals, deputy principals and senior teachers who spend some or most of their time in administration. A description of the survey results on teacher confidence, education and experience can be found in Koch and Li (2017). In the following, we focus on teachers' opinions on the level of mathematics required in specific occupations, and teachers' opinions on factors that may influence students' decisions to choose mathematics.

A number of occupations and careers, displayed along the vertical axis of Figure 24, were presented to the survey participants. Teachers were asked to select the level of mathematics required by ticking one box for each occupation from the four possible choices: 'university mathematics', 'Year 12 mathematics', 'Year 10 mathematics', and 'basic mathematics skills'. These different levels of mathematics correspond, in order, to purple, grey, green and yellow in the graphs.

Female teachers have rated higher the level of mathematics required in most occupations than male teachers.

Figure 24. Teachers' opinions on the level of mathematics required in occupations



Data source: Choose Maths Teacher Survey 2016

According to the data, all teachers think that biologists, computer scientists, economists, pilots and secondary school teachers need at least Year 12 mathematics. While 72 per cent and 89 per cent of male teachers think that biologists and computer scientists, respectively, require university mathematics, about 10 per cent points more female teachers think so for each of these occupations. While 5 per cent points more female than male teachers think that secondary school teachers require university mathematics, about 6 per cent points more teachers think that pilots require higher levels of mathematics than secondary school teachers. While most male teachers believe that Year 12 mathematics is enough for lawyers, most female teachers think that university mathematics is required, but 3 per cent of females think that lawyers do not need any mathematics higher than Year 10. Everyone agrees that the minimum level of mathematics required by primary school teachers is Year 10, yet 25 per cent points more females believe that university mathematics is a minimum. More than a quarter of female teachers think university mathematics is required for health workers, while only about one tenth of male teachers think so.

Comparing the lengths of the left-most bars for each occupation between male and female teachers which correponds to the highest required levels of mathematics assigned by the surveyed teachers, we found that a higher percentage of females than males think that mathematics is required in all the occupations except chef and fashion designer. A possible interpretation is that female teachers value the need for mathematics in different careers more highly than men.

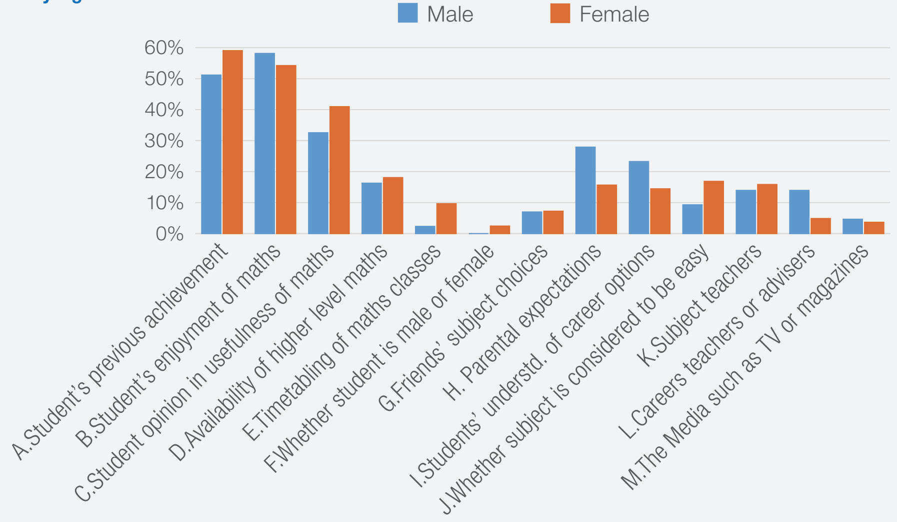
4.5 Teachers' opinion on factors influencing students' decisions to continue studying mathematics in Years 11 and 12

A number of factors that can potentially influence students' decisions to continue studying mathematics in their final school years were presented to teachers in the Choose Maths Teacher Survey 2016, and are displayed along the horizontal axis in Figures 25 and 26. Teachers expressed their opinions on each factor by selecting one box from the five choices 'Strongly Disagree', 'Disagree', 'Neither Agree nor Disagree', 'Agree', and 'Strongly Agree'. Figure 25 displays the percentages of the response 'Strongly Agree' for each factor. In Figure 26 we discarded the sub-group 'Neither Agree nor Disagree' in the data and retained the responses for 'Agree' or 'Strongly Agree' (labelled as Agree) on the positive plane and for 'Disagree' or 'Strongly Disagree' (labelled as Disagree) on the negative plane.

Teachers have perceived students' previous achievements in mathematics as the most influential factor in students' decisions to continue studying mathematics in voluntary enrolments.

The survey results show that teachers regard students' previous achievements in and enjoyment of mathematics as the most important factors guiding students' decision in selecting Year 11 and 12 mathematics subjects. The next most influential factors, as reported by the teachers and ranked by the percentage of teachers who strongly agree with the statement, are students' perceptions of the usefulness of mathematics, followed by parental expectations, students' views of career options with mathematics, whether the subject is considered to be easy, the subject teachers, and the media.

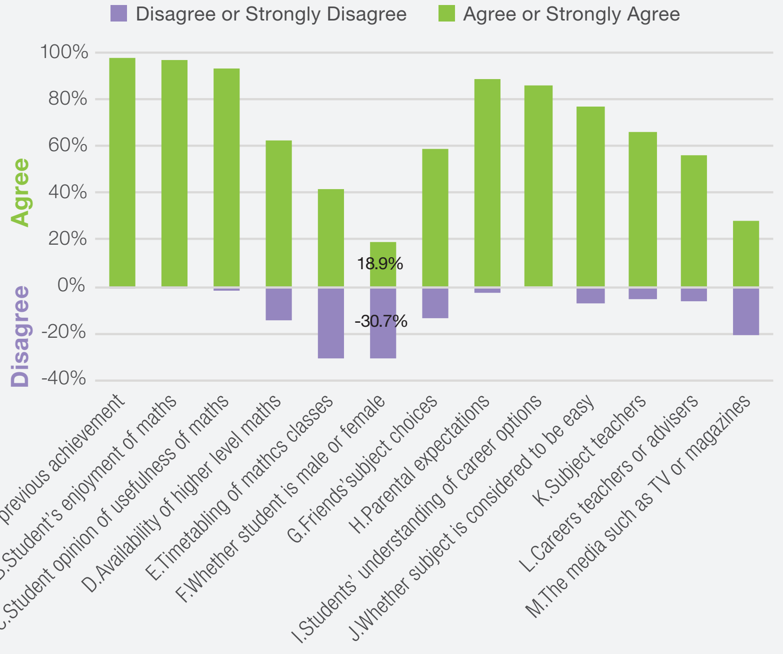
Figure 25. Teachers' opinion on factors influencing students' decisions to continue studying mathematics



Data source: Choose Maths Teacher Survey 2016

The data also show that timetabling, students' gender and friends' choices have low levels of impact. In fact, these items have higher disagreement rates, as seen in Figure 26. Item F is the only item under consideration that has the total percentage of agreement or disagreement below 50 per cent. While 18.9 per cent of the teachers think that a student's gender is an influential factor and 30.7 per cent of the teachers disagree, more than half of the survey participants did not express any opinion on the effect of 'Whether student is male or female' on students' decisions.

Figure 26. Percentage of 'Agree' or 'Strongly Agree' and percentage of 'Disagree' or 'Strongly Disagree'



Data source: Choose Maths Teacher Survey 2016

4.6 Summary

More than 90 per cent of primary as well as secondary students are aware of the usefulness of mathematics in many careers and in everyday life and basically no gender difference was found in the Choose Maths Student Survey pilot study. The percentage of students holding positive attitudes towards mathematics, however, has reduced from Year 5 to Year 8. There are highly significant gender-oriented opinions on whether girls and boys have the same capacity to do mathematics: some 80 per cent agreement for boys compared to 96 per cent agreement for girls, and the gender difference in this regard is widening from Year 5 to Year 8.

Consistent with international trends, the percentage of students who like doing mathematics and the percentage of students who are confident in learning mathematics in Australia have decreased from Year 5 to Year 8, with the decreases being larger for boys than girls. Girls are less confident by Year 4 or Year 5 than boys about their self-perceived ability to learn mathematics. However, the Choose Maths intervention appears to have had a large effect on girls' beliefs and girls' confidence in their ability to learn mathematics. The change from pre survey to post survey was most dramatic in Year 5 girls: about 52 per cent agreed that they had a maths brain in the pre survey (compared to almost 70 per cent of boys) and after the interventions a surprisingly high 95 per cent of Year 5 girls agreed that their brain allowed them to learn new maths (compared to 94 per cent of boys). The trend in Year 8 is similar with a shift to a lower percentage agreement in the pre survey (just below 47 per cent) and the post survey (90.5 per cent). These findings are very encouraging as they tell us that students, and in particular female students, can be encouraged and motivated to change their attitude to mathematics.

Interventions to address student attitudes towards mathematics learning, particularly among girls, have been shown to be effective in changing self-perception and increasing engagement.

Confidence in, attitudes to and enjoyment of mathematics are all closely linked and typically are mirrored in students' achievements. A decrease in any one of them negatively affects the others. An understanding of this relationship is particularly relevant in light of the teacher surveys which shows that the enjoyment of and achievement in mathematics are the two most important factors in influencing students' subject choices in Years 11 and 12.

5 Conclusions and Recommendations

The severe under-representation of women in the STEM workforce is well documented and is partially a consequence of the under-representation of young women in many STEM disciplines at universities, which in turn is a consequence of the lagging participation of girls in mathematics in schools.

Focusing on the primary and secondary schools of the pipeline in Australia, we conducted an analysis of students' participation in, performance in, and attitude towards mathematics in the last decade, using the most current data from Year 12 mathematics enrolments, major domestic and international mathematics assessments, and Choose Maths surveys.

Between 2006 and 2016 the proportion of young people in Australia who have completed Year 12 education has increased, yet the proportion of Year 12 students who studied mathematics has remained stagnant. In particular:

- the proportion of Year 12 boys taking mathematics has been higher than the proportion of Year 12 girls taking mathematics, at all levels of mathematics
- the proportion of students, in particular boys, taking advanced mathematics in Year 12 has been decreasing, while the proportion of students, in particular boys, taking elementary mathematics in Year 12 has been increasing
- more boys than girls have enrolled in intermediate and advanced mathematics in Year 12, while more girls than boys have enrolled in elementary mathematics in Year 12
- among all mathematics students, girls have been over-represented in elementary mathematics, slightly under-represented in intermediate mathematics, and severely under-represented in advanced mathematics
- the girl-to-boy ratio in intermediate mathematics students has been stable over time in the range of 0.90 to 0.96
- the girl-to-boy ratio in advanced mathematics students has decreased from 2006 to 2014, but has increased since, and for the first time in the last decade exceeded 0.60 in 2016

The decreasing number of advanced mathematics boys and increasing number of elementary mathematics boys in recent years is of a concern, but of greater concern is the very low participation of girls in advanced mathematics, which will seriously limit the supply of potential female mathematics university students.

In performance, girls have exceeded boys in literacy and boys have exceeded girls in numeracy, consistently across the tested year levels and over time. In particular:

- the difference in mathematics performance by gender is very small compared to the difference in performance due to students' home learning resources and socio-economic backgrounds
- girls have outperformed boys in reading by a large margin, and have been outperformed by boys in mathematics by a smaller difference
- the average performance in mathematics of Australian 15 year olds has decreased over time, faster than the world average
- Australia's performance in mathematics of Year 4 and Year 8 students has decreased faster than the OECD average performance, and Australia's international ranking has dropped sharply
- the performance in mathematics has varied more among boys than girls and more at low year levels than higher levels, consistently over time
- the gender gap in mathematics performance exists from Year 3 onwards, increases by 40 per cent from Year 3 to Year 5, and then stays stable
- Australian students with the same level of their confidence in learning mathematics have scored higher than the world average
- the proportion of Australian students who like mathematics or are mathematically confident is lower than the world average
- the proportion of Australian students who like mathematics or are mathematically confident decreases with year levels, with a faster decrease for boys

This evidence combined with the opinion that students' previous achievements and their enjoyment in learning mathematics are the most influential factors in students' decisions to continue studying mathematics appears to suggest that students' performance is closely related to their enjoyment, attitude, engagement and confidence in the discipline. Although is relatively small compared to the differences due to socioeconomic background disparities, the gender difference in mathematics performance interacts with the gender difference in reading to impact students' future participation in mathematics. Nonetheless, our analyses do not suggest the existence of an innate difference between the academic achievements of boys and girls, nor do they imply that boys are intrinsically better at mathematics.

The existence of a gender gap in mathematics performance in Year 3 and the 40 per cent increase in this gender gap from Year 3 onwards clearly suggests that positive action is required from early primary school through to secondary school, in order to increase the enjoyment and engagement of mathematics and, as a flow-on effect, participation and improved mathematics performance of female students in particular.

The evidence from Choose Maths Survey 2016 has also shown that changes are possible: in the pilot intervention of 300 students in each of Year 5 and Year 8, the proportion of students who were confident in learning mathematics increased by more than 80 per cent for girls and more than 30 per cent for boys as a result of the intervention.

We make the following recommendations, indicated by the dot points below together with some supporting information.

Supporting our Students

- Improve access to learning resources with a focus on growth mindset approaches to encourage self-confidence, particularly among girls
- Incorporate careers awareness into classroom learning to strengthen understanding of the application and value of mathematics and the participation of women in STEM
- Improve mentoring access, particularly for girls, to support learning outcomes and subject selection in Year 10

Consistent findings from NAPLAN, TIMSS and Choose Maths surveys imply that there is a need for effective teaching strategies for female students which start in year 3 or earlier to avoid the development of the performance gap and which differentiate in the teaching approaches according to the abilities present in the cohort or classroom.

As demonstrated in Choose Maths interventions, growth mindset activities are very effective in helping increase students' confidence. Growth mindset and other interventions need to start early and become a standard part of teaching practice in order to reduce the gap between boys and girls and between literacy and numeracy so that students, in particular girls, have a longer period of time in which to enjoy learning mathematics that might lead to them choosing a higher level of mathematics in their senior years.

Supporting our Teachers

- Equip all pre-service primary teachers with adequate mathematics knowledge and teaching strategies to improve capability and confidence and address maths anxiety in the classroom
- For current primary teachers, provide professional development in mathematics content and pedagogy to improve capability and confidence and address maths anxiety
- Provide common training to primary and secondary pre-service and in-service teachers to support student transition from primary to secondary school, with a focus on the continuity of mathematical learning
- Provide better access to growth mindset resources to pre-service and in-service teachers to support maths learning outcomes and engagement
- Provide access to professional development for all teachers to improve understanding and implementation of emerging teaching strategies, in particular growth mindset approaches, for improving girls' confidence and self-perception

Effective teaching strategies for pre-service and current primary school teachers may require additional support for teachers who are not confident in their own mathematical abilities.

The split of Year 4 and Year 8 into primary and secondary schools demands coordination and collaboration between primary and secondary teachers. It is not possible to determine from the available data how much the transition from primary to secondary school contributes to the decrease in students' confidence in learning mathematics, however, a more consistent approach in teaching will make the transition less disruptive to a students' learning and in particular to the confidence of female students in their abilities.

Programs, resources or courses will need to be provided with strategies to support the development of a growth mindset in themselves and all their students. Growth mindset and other interventions need to start early and become a standard part of teaching practice.

Improved access to professional learning which supports teachers in the use of research to design, implement, evaluate and refine practices in the mathematics classroom and engage teachers to become research practitioners who are able to design and implement 'best practice' in their classroom teaching should be provided.

Improved access should be provided to professional development and implementation strategies on teaching mathematics conceptually as opposed to procedurally. The former approach enables teachers to support students in making connections to other mathematical concepts, improving their understanding of mathematical ideas and applying their knowledge as well as in enhancing their problem-solving skills.

Supporting our Parents

- Create positive home learning environments through better access to resources including those supporting growth mindset learning
- Develop stronger engagement between school and home with access to better information for parents about the application and value of maths as an enabling discipline and career pathways, particularly for girls

As evidenced in the TIMSS results, the biggest effect on performance is a student's socio-economic background and learning resources at home. Therefore avenues for positively influencing the home environment and addressing the lack of resources are needed.

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APPENDIX I

Classification of the level of mathematics subjects taught in Year 12 Australia, 2006–2017

	Subject	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
NSW	Mathematics Life Skills	E	E	E	E	E	E	E	E	E	E	E	E
	General Mathematics 1											E	E
	General Mathematics 2											E	E
	Mathematics General	E	E	E	E	E	E	E	E	E	E	E	E
	Mathematics (2U)	I	I	I	I	I	I	I	I	I	I	I	I
	Mathematics Extension 1	A	A	A	A	A	A	A	A	A	A	A	A
	Mathematics Extension 2	A	A	A	A	A	A	A	A	A	A	A	A
VIC	Further Mathematics	E	E	E	E	E	E	E	E	E	E	E	E
	Mathematical Methods	I	I	I	I	I	I	I	I	I	I	I	I
	Specialist Mathematics	A	A	A	A	A	A	A	A	A	A	A	A
QLD	Prevocational Mathematics	E	E	E	E	E	E	E	E	E	E	E	E
	Functional Mathematics	E	E	E	E	E	E	E	E	E	E	E	E
	Numeracy: A short course senior syllabus	E	E	E	E	E	E	E	E	E	E	E	E
	Mathematics A	E	E	E	E	E	E	E	E	E	E	E	E
	Mathematics B	I	I	I	I	I	I	I	I	I	I	I	I
	Mathematics C	A	A	A	A	A	A	A	A	A	A	A	A
	Mathematical Applications											E	E
WA	Mathematics Preliminary									E	E	E	E
	Mathematics Foundation									E	E	E	E
	Mathematics Essential									E	E	E	E
	Mathematics Application									E	E	E	E
	Mathematics Methods									I	I	I	I
	Mathematics Specialist									A	A	A	A
	Modelling with Mathematics	E	E	disct.									
	Discrete Mathematics/Combined	E	E	E	E	E	E	E	E	disct.			
	Applicable Mathematics/M3CD	I	I	I	I	I	I	I	I	disct.			
	Calculus/Spec 3CD	A	A	A	A	A	A	A	A	disct.			
SA	Mathematics: Modified										E	E	E
	Mathematical Pathways						E	E	E	E	E	E	disct.
	Mathematical Methods	E	E	E	E	E	E	E	E	E	E	E	disct.
	Mathematical Applications	E	E	E	E	E	E	E	E	E	E	E	disct.
	Essential Mathematics												E
	General Mathematics												E
	Mathematical Studies	I	I	I	I	I	I	I	I	I	I	I	disct.
	Mathematical Methods												I
	Specialist Mathematics	A	A	A	A	A	A	A	A	A	A	A	A
TAS	Mathematics - Applied/General	E	E	E	E	E	E	E	E	E	E	E	E
	Mathematics - Methods	I	I	I	I	I	I	I	I	I	I	I	I
	Mathematics - Specialised	A	A	A	A	A	A	A	A	A	A	A	A
ACT	Mathematical Applications	E	E	E	E	E	E	E	E	E	E	E	E
	Mathematics Methods	I	I	I	I	I	I	I	I	I	I	I	I
	Specialist Mathematics	A	A	A	A	A	A	A	A	A	A	A	A
NT	Mathematics: modified											E	E
	Mathematical Pathways						E	E	E	E	E	E	E
	Mathematical Methods	E	E	E	E	E	E	E	E	E	E	E	E
	Mathematical Applications	E	E	E	E	E	E	E	E	E	E	E	E
	Mathematical Studies	I	I	I	I	I	I	I	I	I	I	I	I
	Specialist Mathematics	A	A	A	A	A	A	A	A	A	A	A	A

E: Elementary I: Intermediate A: Advanced disct.: discontinued

LIST OF FIGURES

CHOOSE MATHS

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