Symposium: CHOOSE**MATHS** – an Australian Approach to Increasing Participation of Women in Mathematics

Overview and Individual Contributions

The underrepresentation of women in Science, Technology, Engineering and Mathematics (STEM) in Australian is well known throughout the educational pipeline and in STEM careers. Girls have a lower average performance in mathematics, and fewer young women participate in the higher levels of mathematics in senior secondary school, in STEM degrees and in the STEM-related workforce. To address this underrepresentation of women in STEM and in particular in mathematics, the BHP Billiton Foundation has been funding Choose Maths, a 5-year initiative, since mid-2015 in collaboration with the Australian Mathematical Sciences Institute, the national institute for mathematics education.

The Choose Maths team has 18 staff, including eight full-time mathematics teachers, the Outreach Officers, who work with 120 schools across Australia. Choose Maths also focusses on Career Awareness, a Women in Mathematics Network which includes Mentoring for young women, Teacher and Student Awards, and statistical research. An advisory committee oversees the work of the team.

In this research symposium we consider different aspects through the mathematical pipeline and into the workforce as they relate to gender.

Inge Koch: *Attitude towards Mathematics and Confidence in Mathematical Ability of Students – Can it Change?* presents survey instruments and results of student interventions of Year 5 to Year 9 students that were conducted in 120 schools across Australia in 2017. The effectiveness of the interventions, which focus on growth mindset ideas and year-appropriate mathematical activities, is shown for the more than 2300 students in Year 5, and the differences between the pre- and post-survey results of boys and girls are highlighted.

Ning Li: *Gender Gaps in Participation and Performance in Mathematics at Australian Schools 2006 – 2016* looks at the difference of male and female students' performance in mathematics tests, and their participation in mathematics subjects in Years 11 and 12, when mathematics is no longer compulsory. In both areas female students score lower than male students. These results are complemented by teachers' opinions on factors that are most influence students in their subject choices,

Gilah Leder: *Mathematics, gender, and careers* reviews the participation of women in the workforce and starts with potential reasons for the lower participation of women in senior mathematics classes that have been presented in psychology and related disciplines. Leder ask the question of what influences the choice of career of young men and women, relates male and female teachers' surprisingly different ratings of the level of mathematics required for different career pathways and examines the occupational pathways by gender.

Janine McIntosh, AMSI, and Helen Forgasz, University of Monash, have agreed to chair the session and to be discussant respectively.

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Attitude towards Mathematics and Confidence in Mathematical Ability of Students – Can it Change?

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We study students' confidence in their mathematical ability and attitude to mathematics before and after an intervention in 120 schools in Australia. The 2017 Choose Maths intervention measures the effect of growth mindset ideas and targeted mathematical activities in students in Years 5 to 9. The analysis of the pre- and post-survey responses shows: boys are more confident and have a more positive attitude than girls, there is positive change in both domains, and the change for girls is much larger than that for boys.

Introduction

Australian primary and secondary students show similar performances across different national and international tests such as NAPLAN, PISA and TIMSS: on average boys outperform girls in numeracy, while girls outperform boys in literacy at every year level. Almost twice as many boys participate in Year 11 and 12 intermediate and advanced mathematics courses as girls, that is, in the years when students in Australian schools can choose different levels of mathematics including none (Li & Koch, 2017).

It is too simplistic to assume that girls' participation in Year 11 and 12 mathematics courses is lower as a consequence of their lower average performance. TIMSS and PISA results (Mullis *et. al.*, 2015; Thomson *et. al*., 2017) demonstrate clearly that students' economic background has a much stronger influence on mathematics performance than gender. However, the effect of gender is not negligible, and it is important to examine the causes for the lower performance and lower participation of girls.

Based on our understanding and belief that a more positive attitude to mathematics and increased confidence in one's own ability are positively correlated with more enjoyment and engagement in the subject and that the latter are expected to have a positive effect on performance, we focus on attitude and confidence of students with regards to mathematics.

In this paper we discuss results of surveys of more than 4800 students which we conducted as part of the Choose Maths Outreach in 120 Australian schools throughout 2017. We report students' attitudes towards mathematics, and confidence in their mathematical ability. Informed by the changes observed in the data, we comment on the potential for change. A better understanding of underlying processes affecting mathematics performance will inform if and how we can change students' confidence, attitude, engagement and ultimately performance regarding mathematics.

The Choose Maths Outreach Component

Choose Maths has eight experienced primary and secondary teachers -- Outreach Officers -- who work in 120 primary and secondary schools across Australia. They provide professional development for the local teachers, conduct teacher surveys and student surveys and engage with students, their parents and teachers (Koch & Li, 2017; Li & Koch; 2017). Principals of the participating schools participate in Choose Maths with the

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conviction that their teachers' increase in confidence and competence through involvement with Choose Maths will have a flow-on effect on students' engagement and performance.

To study attitudes and confidence of students with respect to mathematics Choose Maths developed annual intervention strategies, described in more detail below, for Year 5 to Year 9 students. We obtained ethics approval for these interventions through the University of Melbourne in late 2016 and conducted a pilot study involving about 300 Year 5 and 300 Year 8 students in Term 4, 2016. Following analysis of the pilot survey data, we modified the original intervention strategies and survey instruments, and, in 2017, collected survey data from more than 4800 students in Years 5, 6, 8 and 9.

Here we focus mostly on the Year 5 and Year 8 interventions conducted in 2017. The Year 5 cohort represents the largest sample – about 2300 students. The Year 8 data from about 1360 students are included to show that the changes observed in primary school students are also evident in the secondary students' data. The Year 5 data form a baseline for comparisons with Year 5 cohorts in 2018 and subsequent years; and assessment of the changes of the Year 5 students in their later school years.

Classroom Intervention and Survey Instruments

The Outreach Officers conducted the intervention classes with the local teacher present. Each intervention consists of a pre-survey, a presentation on growth mindset ideas (Boaler, 2015), a mathematical group activity appropriate for their year level and a post-survey. Each intervention class presents a snapshot in time. Due to time and organisational reasons, it was not possible to measure the effect of the intervention a few months later again. Interventions and surveys in 2018 and in later years will allow a follow-up. The questions for the pre- and post-survey and admissible responses are shown in Table 1.

Table 1 *Survey questions 2017*

	Pre-survey	Responses	Post-survey	Responses
Q1	It is okay to feel confused about maths	Agree/ Disagree	It is okay to feel confused about maths	Agree/ Disagree
Q2	Girls and boys can learn maths equally well	Agree/ Disagree	Girls and boys can learn maths equally well	Agree/ Disagree
Q3	Sharing tasks with others helps me to understand maths better	Agree/ Disagree	Working with others on the task today helped me understand this maths better	Agree/ Disagree
Q4	When I think about maths I would describe myself as	Very confident/ Confident/ Neutral/ Not Confident	After the lesson today, I feel	Very confident/ Confident/ Neutral/ Not Confident
Q5	When I think about maths I feel	Enthusiastic/ Somewhat Enthusiastic/ Neutral/ Bored	After the lesson today, I feel	Enthusiastic/ Somewhat Enthusiastic/ Neutral/ Bored
Q6	I have a maths brain	Agree/ Disagree	My brain allows me to learn new maths	Agree/ Disagree

We collect the answers in the pre- and post-survey using *Plickers* cards (see https://www.plickers.com/). The answers are collected with the Outreach Officer's mobile phone. We record the gender of the students, and the students use the same Plickers card for the pre- and post-survey as this allows us to record and study the change in their responses as a consequence of the intervention activities.

A growth mindset presentation explains how the brain learns and introduces the '*power of YET*': 'I can't do fractions **yet**'. The Year 5 group activity required students to create geometric shapes and use language to describe the shape, so the other members of the team could construct the identical shape without seeing it. This activity focused strongly on the interplay of language and mathematics and made students aware that the language of mathematics must be very precise. The Year 8 activity focussed on discovering and generalising patterns which will ultimately lead to quadratic equations.

Analysis of Year 5 and Year 8 Student Surveys

Table 2 Percentages for each response category in Q4 for Year 5 and Year 8

	Y5 n conf	Y5 neutral	Y5 conf	Y5 v conf	Y8 n conf	Y8 neutral	Y8 conf	Y8 v conf
Boys pre	8.0	23.6	36.5	31.9	12.1	35.8	34.0	18.0
Boys post	7.8	13.7	33.3	45.0	11.7	29.5	32.9	26.0
Girls pre	9.2	32.6	40.7	17.5	14.7	43.5	32.7	9.1
Girls post	6.5	21.8	35.7	36.1	8.4	34.7	41.0	15.9

Notation used in the table: Y5 = Year 5; Y8 = Year 8; n conf = not confident; conf = confident; v conf = very confident.

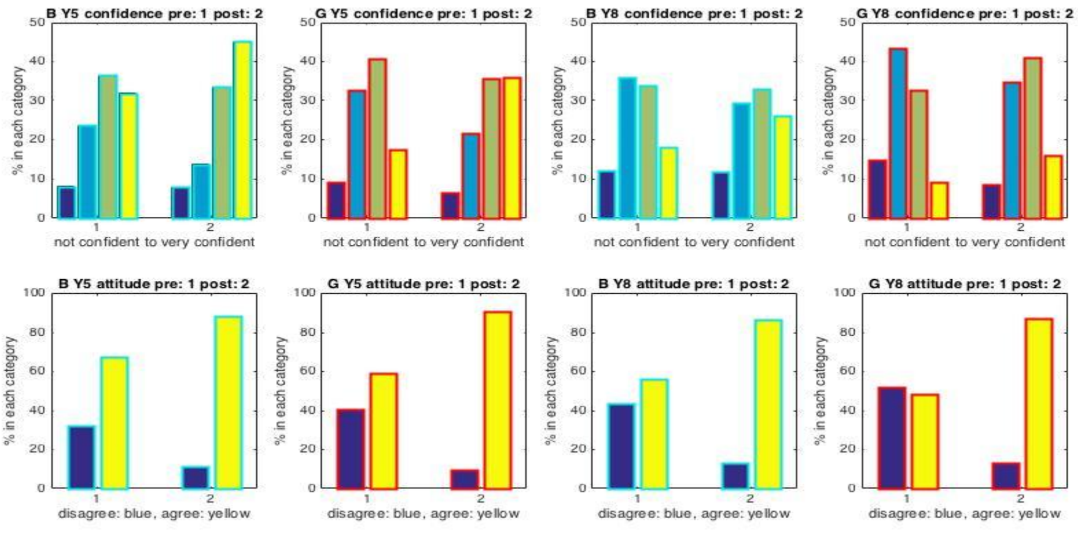

Figure 1. Change in confidence and attitude Year 5 and Year 8.

The proportion of boys in the sample is about 46% across all years. There are more girls than boys in the sample, as some of our schools are single-sex girls' schools. The results for the Year 6 and Year 9 cohorts are similar to those reported below.

As can be seen in Table 2, the results from Q4 and, the pattern of change from pre- to post-survey, are similar for Year 5 and Year 8 students, but the percentage of confident and very confident students decreased for the higher school year. The responses to Q4 show an increase of the very confident students: 13.1% (resp. 8%) for boys and 18.6% (resp. 8.3%) for girls in Year 5 – with the Year 8 results in brackets – while the other three response groups, and in particular the 'neutral' group, decrease. For girls the changes are bigger than for boys; the not confident group for girls shrinks by about one third and is smaller than that for boys in the post-survey, although the girls started with a higher not confident percentage than the boys.

Figure 1 shows the change in confidence and attitude in the form of histograms, separately for boys – with blue edging -- and girls – with red edging. In each panel the first block of bars – four in the top row and two in the bottom row – refers to the pre-survey, and the second block of bars in each panel refers to the post-survey. The Year 5 data are shown in the first two panels and the Year 8 data follow in panels three and four in each row. Percentages of responses in each category are shown on the vertical axis.

The top panels in Figure 1 refer to the change in confidence, Q4: the four differently coloured columns are given in the same order as in Table 2: not confident, neutral, confident, very confident. The bottom panels refer to change in attitude, Q6. The dark blue bar shows the percentage of 'disagree' responses and yellow refers to 'agree' responses. For the changes in positive attitude, Q6, we find: boys show a 21.1% in Year 5, and a 31.5% in Year 8 and girls show a 31.3% in Year 5 and a 38.8% in Year 8, that is, about one third of girls changed their attitude as a result of the intervention activities.

In Q4 and Q6 we note that the change due to the intervention is particularly large for girls, and overall the results suggest that students' confidence in and attitude towards mathematics is not fixed but can be affected and changed in a positive way.

Final Words

Survey results of classroom interventions of more than 4800 students in Years 5, 6, 8 and 9, which comprised a pre-survey, mathematical activities and a post-survey during one lesson, show that students' confidence in their mathematical ability and their attitude to mathematics can change through intervention – with change occurring in a positive direction. The larger change particularly for girls is encouraging and there is hope that growth mindset approaches and appropriate teaching methods will lead to longer-lasting effects which allow students to become more confident and ultimately perform better.

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Gender Gaps in Participation and Performance in Mathematics at Australian Schools 2006-2016

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How do boys and girls differ in voluntary mathematical studies in Years 11&12? Do boys and girls perform differently in standardized mathematics exams? What factors affect students' decisions to choose or not choose mathematics? This document updates the previous literature using recent data from various sources. It is found that between 2006 and 2016 participation in Year 12 mathematics has been stable for both boys and girls, with the boys' percentage being higher than girls', both being shifted away from advanced mathematics. Students' previous achievement has been recognized by the teachers as an important influential factor for students' decisions to continue studying mathematics in senior high schools.

Participation rate in mathematics in senior high school is a basic indicator for the progress of mathematics education, the quality of the prospective labor market, and the future economic competence. In Australia, mathematics is not compulsory in senior high school. The participation rate determines the supply pool for many university courses, which may affect gender balance in the STEM workforce (Roberts, 2014). Previous research findings show the existence of a gender gap in mathematics enrolments of Year 12 students between 1990 and 2004 (Forgasz, 2006 Sec 1.1). A few years passed since the call for action to encourage females into STEM disciplines (Office of the Chief Scientist, 2012). What is the current situation?

Students Taking At Least One Mathematics Subject

The typical age of Year 12 students in Australia is between seventeen and eighteen 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 Australia (Li & Koch, 2017). According to Australian Bureau of Statistics (ABS data series 3101059, Table 59), between 2006 and 2016 the sizes of the Year 12 potential population, displayed as solid lines in Figure 1, have grown from 141344 to 151698 for boys and from 134330 to 143083 for girls. Data on Year 12 enrolments (Barrington & Evans 2017) indicate that each year, on average, one third of the boys and one fifth of the girls in the potential population did not study Year 12 between 2006 and 2016. While there were 7015 to 9128 more boys in the potential population each year, during this period 7381 to 13357 more girls enrolled in Year 12 each year. A restructuring of the secondary curriculum in Western Australia led to a half-cohort reduction in the state in that year, evident from the dips in 2014 enrolments in Figure 1. The extra number of boys, or the gender gap, in the Year 12 potential population has shown a decreasing trend. In contrast, the extra number of girls, or the gender gap, in the Year 12 actual population has shown an increasing trend between 2006 and 2016.

Mathematics subjects are offered to Year 12 students at various levels of difficulty. A student who takes any of these subjects is referred to as a mathematics student. Between 2006 and 2016 the total number of Year 12 mathematics students has been growing

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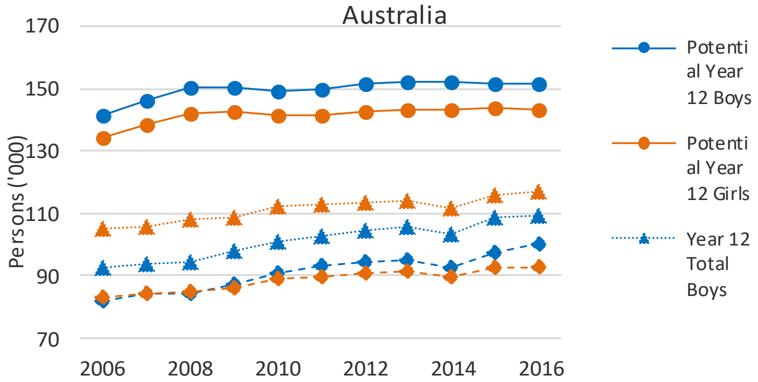
proportionally to the total number of Year 12 students, for both girls and boys. Each year, despite more girls enrolled in Year 12, fewer girls than boys chose mathematics, being evident from the long-dashed lines in Figure 1. Moreover, the difference between male and female mathematics students has been widening over time in the period.



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

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

Elementary, Intermediate, and Advanced Mathematics Students

Based on the definitions by Barrington and Evans (2016, 2017), the elementary level mathematics subjects involve little or no calculus, and are not intended to provide a foundation for any future tertiary studies involving mathematics (Forgasz, 2006). On the other hand, the intermediate and advanced mathematics subjects meet the minimum requirement for tertiary studies in which mathematics is an integral part of the discipline. By estimating the overlap of students concurrently taking elementary and non-elementary *subjects*, Barrington and Evans (2017) estimated the number of *students* taking elementary subjects only. The data reveal that the yearly increments of mathematics students between 2006 and 2016 are mainly due to increments in elementary mathematics students. Over time, students were shifting away from advanced towards elementary subjects, for both boys and girls. It is found that in Year 12 between 2006 and 2016 (Li & Koch, 2017)

- Each year, on average, 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.
- The percentage of elementary mathematics students has increased by 15% for boys and by 6% for girls in the period.
- In contrast, the percentage of intermediate mathematics students has decreased by 12% for boys and by 10% for girls.
- The percentage of advanced mathematics students has decreased by 12% for boys and by 10% for girls.
- Girls were, on average, at least 43% less likely than boys to study advanced mathematics.
- The percentage of Year 12 advanced mathematics girls appears to have a mild increase from 6.6% to 7.0% monotonically over the period between 2012 and 2016.

- The girl to boy ratio within advanced mathematics students has decreased from 2006 to 2014, but has increased since, and reached 6:10, the highest in the last decade.

Performance in Standardized Mathematical Tests

Students' average scores in mathematics tests in the National Assessment Program — Literacy and Numeracy (NAPLAN), the Programme for International Student Assessment (PISA), and the Trends in International Mathematics and Science Study (TIMSS) are displayed in Table 1, blue for boys and red for girls respectively. They show that boys outperformed girls in every year level and all tests that have been conducted. Li & Koch (2017) also find evidence that girls outperformed boys in reading in the above tests most of the time, that the gender difference in reading is larger than the gender difference in mathematics, and that the performance varies more among boys than among girls.

Table 1

Average scores of students' mathematics tests in NAPAN, PISA, TIMSS, by gender

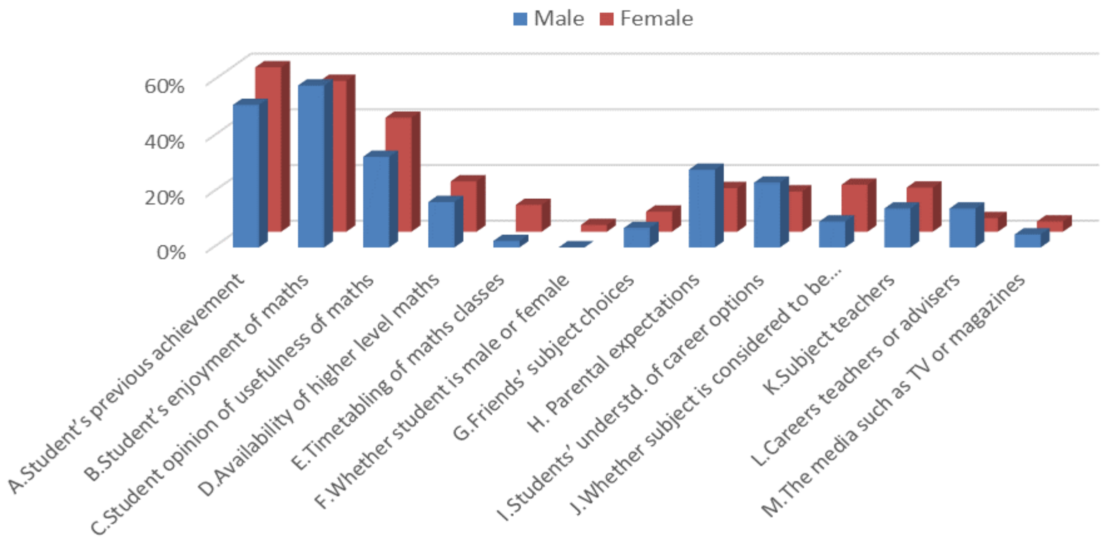
			1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
NAPLAN	Year 3	Boy										401	398	398	403	400	399	405	402	407
		Girl										393	390	393	394	391	395	398	394	397
	Year 5	Boy										482	493	494	493	492	492	493	497	497
		Girl										470	481	483	482	485	479	482	488	489
	Year 7	Boy										552	549	553	550	544	547	550	546	552
		Girl										537	538	543	539	532	537	541	539	547
	Year 9	Boy										587	592	591	589	590	590	593	596	593
		Girl										578	586	579	577	578	577	582	587	585
PISA		Boy		540			527			527			519			510			494	
		Girl		527			522			513			509			498			486	
TIMSS	Year 4	Boy	496				500				519				519				522	
		Girl	493				497				513				513				513	
	Year 8	Boy	507				511				504				509				506	
		Girl	511				499				488				500				504	

Source: NAPLAN National Report 2008 – 2016. Mullis et al (2015), TIMSS 2015 International Results in Mathematics. Thomson et al (2017), PISA 2015: Reporting Australia's results.

Teachers' View about Factors influencing Students' Decisions to Choose or Not Choose Mathematics in Years 11 & 12

Factors that may potentially affect students' decisions to continue studying mathematics in Years 11 & 12 are obtained from a survey of mathematics teachers (Li & Koch, 2017), and are displayed along the horizontal axis in Figures 2. The teachers expressed their opinions by selecting one box from five choices 'Strongly Disagree', 'Disagree', 'Neither Agree Nor Disagree', 'Agree', and 'Strongly Agree' for each factor. The percentage of 'Strongly Agree' responses is displayed along the vertical axis in Figure 2.

The teachers reported that students' previous achievements in mathematics and students' enjoyment of mathematics are the most influential factors to students' decisions in the subject selection. The next most influential factors, as reported by the teachers, are students' perceptions of the usefulness of mathematics, followed by parental expectations, students' views of career options with Mathematics, whether the subject is regarded to be easy, the subject teachers, and the media.



*Data source: CHOOSE**MATHS** Teacher Survey 2016*

Figure 2. Number of Year 12 elementary, intermediate, and advanced mathematics students, by gender 2006 – 2016

Final Words

Girls are less likely to choose mathematics when they have the option not to, and girls on average perform less well than boys on standardized tests. According to teachers' opinions, students' previous achievements and enjoyment in mathematics are important factors regarding whether students chooses mathematics in Years 11& 12. There seems to be little data of Australian students on their thoughts in the process of subject selection. Nonetheless, effective teaching practices must be identified and used in classrooms to encourage students', particularly girls' participation in mathematics. It is also important to show students career opportunities involving mathematics. It is crucial for teachers to show the fun and wonder of mathematics to motivate and maintain students' intrinsic interest in mathematics.

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Mathematics, gender, and careers

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Gender differences in mathematics learning continue to attract attention – from educators, researchers, and stake holders. The genesis of this topic and early research findings are outlined briefly. Contemporary occupational participation data are provided, generally and for those with a sound mathematics background. Teachers' beliefs about the mathematical pre-requisites for selected occupations are also presented.

Mathematics is generally recognized as a critical component of the school curriculum and as a gatekeeper to many tertiary pathways and career opportunities. Historically, mathematics has been considered to be a male domain, that is, an area more suitable for males than for females. "There are perhaps only three or four women until the nineteenth century who have left behind a name in mathematics. Women were lucky to receive any education at all" (Mckinnon, 1990, p. 347). Over time, and as schooling became more widely accessible, it was recognized that females, particularly those in a sympathetic social environment and from a financially comfortable milieu, could cope adequately with the mathematical curriculum demands imposed on males (Clements, 1979). Yet small but persistent gender differences in mathematics achievement, typically in favour of males have continued to be reported.

Gender and mathematics learning – a snapshot of research

A number of findings emerged from the early research work. On average, females' achievement levels were found to be lower than males, particularly when it came to solving challenging mathematics problems. When mathematics was no longer compulsory, females' participation rates were lower than males. Females' views were found to be less functional regarding future success than those of males, on a range of affective/attitudinal measures about mathematics and about themselves as mathematics learners. At the same time it was regularly emphasized that, when observed, gender differences were small compared to much larger within-group variations.

Recurring differences in mathematics learning in favour of males have continued to be reported including: achievement in post-compulsory mathematics courses, on certain content domains and topic areas, and among high-achieving students (e.g., Li & Koch, 2017; Andreescu, Gallian, Kane, & Mertz, 2012; Leder 2011, 2009).

Multiple models and explanations have been put forward to account for the small yet persistent gender differences in mathematics achievement. Different theoretical and value-driven perspectives have been used to shape and guide research on gender and mathematics learning. Most of the models proposed contain a range of interacting factors, both personal and environmental. Included among the latter are the school culture, social mores, and the values and expectations of peers, parents, and teachers. "It is important to note", wrote Eccles (1986, p. 15) "that any discussion of sex differences in achievement must acknowledge the problems of societal influence". Else-Quest, Hyde, and Linn (2010) argued that "considerable cross-national variability in the gender gap can be explained by important national characteristics reflecting the status and welfare of women" (p. 125).

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Leder (2017) reported that for mathematically able females, more than able males, societal expectations might serve as a barrier to continued participation in mathematics and eventual career intentions.

Why not do mathematics?

However, not all students, whether male or female, necessarily aim for intensive study or proficiency in mathematics. Congruent explanations for turning away from mathematics are found in different theoretical frameworks (e.g. Damarin, 2000; Francis, 2010). The latter argued that some female students in particular struggled to achieve a "'balance' between sociability and high achievement to avoid being 'othered' as a 'boffin' or 'swat'" (p. 31). Within the psychological literature, and within the framework of expectancy-value theory of achievement motivation, the fear of success or motive to avoid success construct has been used to highlight a dilemma considered relevant to high-ability, high-achievement oriented females – those who are capable of, and aspire to success, but at the same time are concerned about the negative consequences that may accompany this success. Success in a male-dominated employment area could be such a situation (see e.g., Leder, 2017).

What influences the choice of occupations which are pursued by males and females in the Australian workforce? Of the myriad of issues that could be examined several are considered here: the gender profiles of different occupations, the occupational choices of mathematical science graduates, and the views of mathematics teachers about the level of mathematics required for different occupations.

Composition of the Australian workforce

Using the Australian and New Zealand Standard Classification of Occupations [ANZSCO], jobs can be clustered into eight major occupational codes, with each further divided into five hierarchical levels bundled together on the basis of the similarities of occupations with respect to skill level and skill specialization. The major groups are: Managers, Professionals, Technicians and Trades Workers, Community and Personal Service Workers, Clerical and Administrative Workers, Sales Workers, Machinery Operators and Drivers, and Labourers. Of these, Professionals is the largest group, followed by Clerical and Administrative Workers, and Technicians and Trades Workers. Educational qualifications vary within and across the groups. In the most highly skilled groups, Managers, Professionals, and Technicians and Trade Workers, more than 70% of workers have post-school qualifications. In contrast, less than half of the workers categorized as Labourers, Machinery Operators and Drivers, and Sales Workers hold any post school qualification (Australian Government, 2017).

Gender composition of the Australian workforce

More detailed inspections of recent collections of occupational data reveal different gender profiles for different occupations. "The Australian labour market is highly gender-segregated by industry and occupation, a pattern that has persisted over the past two decades" (Workplace Gender Equality Agency [WGEA], 2016, p. 2). For males, the three most common occupational codes, technicians and trade workers, professionals, and managers, are the same as those listed for the full workforce. For females, however, professionals, clerical and administrative workers, and community and personal service workers are the largest categories. Examples of starkly different levels of male/female participation in different industries, based on 2016 census data, include Health Care and

Social Assistance (F: 78%; M: 22%), Education and Training (F: 71%; M: 29%), Mining (F: 14%; M: 86%); Construction (F: 12%; M: 88%) (WGEA, 2016). The career directions of those drawn to mathematical studies, that is, those who have completed a mathematical science degree are the focus of the next section.

Mathematical science graduates, pathways by gender

For many years Graduate Careers Australia [GCA] surveyed newly qualified higher education graduates. In 2015, well over 100,000 graduates (38% males and 62% females) responded. Among the respondents there were 750 graduates in the field of mathematics. Of these, two-thirds were males. The Office of the Chief Scientist (2016) also reported somewhat older, but still relevant gender related data. In 2011 there were more than 25,000 individuals in Australia with a degree in mathematical science. The majority of these (61%) were males. The employment pathways of the graduates were described as follows:

> The top three industry divisions that employed Mathematical Sciences graduates were Education and Training, Professional, Scientific and Technical Services, and Financial Services (24, 20 and 15 per cent, respectively)…. There were more males compared to females employed in all industries of employment except Health Care and Social Assistance. (Office of the Chief Scientist, 2016, p. 150)

Thus gender differences in participation in more advanced levels of mathematics education continue, with more males than females engaged in courses. Occupational fields in which females were found to outnumber males mirrored those reported for the larger workforce. What those involved in the teaching of pre-university mathematics think about the mathematical demands of selected occupations is described next.

Teachers' beliefs about mathematical pre-requisites for selected occupations

As part of a larger survey, administered to 620 mathematics teaching staff in 85 schools, Li and Koch (2017) collected information for 14 occupations about the level of mathematics thought to be needed: university mathematics, year 12 mathematics, year 10 mathematics, and basic mathematics skills. For six of the occupations at least 70% of both the male and female teachers considered university mathematics to be necessary. For each of these a higher percentage of females than males believed this to be the necessary pre-requisite – see Table 1.

Table 1
Occupations requiring university mathematics – teachers' ratings

Occupation	% males	% females
Biologist	72	81
Computer scientist	89	97
Economist	94	94
Finance advisor	78	83
Pilot	83	89
Secondary school teacher	78	83

Adapted from Li and Koch (2017)

A small number of the occupations listed were thought to require only basic mathematics. Again gender differences were found. As a group, the females identified five such areas: chef (6% thought this); farmer (6%); lawyer (3%); retail sales worker (8%), and health worker (3%). Among the males only one of the occupations was assumed to need only basic mathematics: retail sales worker (11% considered this). It is not easy to determine whose judgements about the level of mathematics required in the different occupations are the more accurate, nor the extent to which the students are aware of, or are influenced, by these views.

Final words

As noted at the outset, mathematics is widely thought to be a gatekeeper to tertiary pathways and career opportunities. Data presented in this paper serve as examples of the persistence and extent of gender linked occupational participation, for the workforce at large and for those in mathematics related areas. Gender differences in post school mathematics courses enrolments, and in teachers' assessment of the mathematical requirement for different occupations have also been presented. Options to counter the flow-on effects of the gender differences highlighted here, as well as those found more broadly, certainly warrant further exploration.

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