GIRLS IN MATHEMATICS: FINAL REPORT

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Table of Contents

List of Tables

List of Figures

List of Terms

Advanced Mathematics	Mathematics Extension 1 and Mathematics Extension 2 – note: interview participants often refer to advanced mathematics as ‘Extension mathematics’
ANZSCO	Australian and New Zealand Standard Classification of Occupations
BOSTES	Board of Studies Teaching and Educational Standards – now NESA
Elementary Mathematics	General Mathematics 1 and 2 or Mathematics Life Skills
High level Mathematics	Mathematics courses containing a calculus component (Mathematics or above)
HSC	Higher School Certificate
ICSEA	Index of Community Socio-Educational Advantage
Intermediate Mathematics	Mathematics – note: From 2019 the intermediate course Mathematics will be renamed Advanced Mathematics, interview participants often refer to the current intermediate mathematics course as ‘Advanced Mathematics’
NAPLAN	National Assessment Program – Literacy and Numeracy
NESA	New South Wales Education Standards Authority D
NSW DoE	New South Wales Department of Education
SES	Socioeconomic status
Standard Mathematics	The new General Mathematics course name from 2019 – note: interview participants often refer to General Mathematics as ‘Standard Mathematics’
STEM	Science, Technology, Engineering and Mathematics
2-Unit Mathematics	Former name for the Mathematics course
3-Unit Mathematics	Former name for the Mathematics Extension 1 course
4-Unit Mathematics	Former name for the Mathematics Extension 2 course

Executive Summary

Project aims

This project, *Girls in Maths,* sought to better understand the decision-making processes surrounding girls' participation in mathematics and to identify any factors that encourage or discourage interested girls from participating in high level mathematics.

The project examined three research questions:

1. Are girls underrepresented compared to boys in studying intermediate or advanced mathematics at high school? If so, how has this situation changed over time?
2. What are the aspirations of NSW high school girls for careers that require a high level of mathematics? Is there any evidence this has changed over time?
3. Are there any systemic forces at work in NSW high schools which might induce girls to prefer to take subjects other than mathematics, even when they profess an interest in mathematics?

Data used in this study were drawn from the NSW Education Standards Authority (NESA) Higher School Certificate (HSC) statistics archive, the Commonwealth Department of Education's Ucube higher education statistics website, the *Aspirations Longitudinal Study,* and interviews focussed on mathematics participation. The specific data utilised were: (1) State-wide HSC subject enrolment data (1991–2016); (2) NSW university enrolments by field of study (2001–2015); (3) *Aspirations Longitudinal Study* surveys, completed between 2012 and 2015 by secondary students from 18 NSW secondary (7–12) or central (K–12) schools and; (4) interviews with secondary school girls, teachers, and parents from 6 of these 18 schools.

Key findings

Major findings of this project were:

1. **Participation in intermediate and advanced mathematics subjects has declined substantially for both boys and girls since 1991**. Overall participation, in Mathematics, Mathematics Extension 1 and Mathematics Extension 2 has declined from 55%, 27% and 8%, of all HSC students respectively in 1991 to 23%, 12% and 5% of all students in 2016. These declining participation rates reflect declining numbers of students undertaking high level mathematics, with some 14,400, 6,400 and 1,200 fewer students enrolled in each subject in 1991 compared to 2016 respectively. While participation in advanced mathematics has stabilised over the last 6 years, there is a continuing decline in the number of students, particularly girls, undertaking intermediate level mathematics each year.

2. **Females are less likely than males to participate in intermediate and advanced HSC mathematics.** In 2016, despite the fact that 51% of all HSC students were female, approximately 46% of all Mathematics, 41% of all Mathematics Extension 1 and 36% of all Mathematics Extension 2 students were female. The relative level of female enrolment in the advanced mathematics subjects has changed little since 1991, whereas the intermediate level mathematics subject has become more male dominated, with the percentage of female Mathematics students decreasing from 51% to 46%, since 1991.

3. **Girls are significantly less likely than boys to aspire to a career requiring high level mathematics.** The career aspirations of girls in our sample aligned with existing patterns of female representation in higher education, which show a consistent underrepresentation of females in fields requiring high level mathematics, particularly in engineering and information technology, over the past 15 years. This indicates that, without significant intervention, gendered patterns of tertiary participation are likely to continue into the future.

4. **Girls' early experiences with mathematics are influential in shaping their future choices and aspirations.** In particular, Year 7 is an important time to develop and maintain girls' interests in mathematics as this is the year which students' transition into learning new abstract concepts such as algebra, and teachers begin to rely more heavily on materials such as textbooks. This transition can have lasting impact on whether a girl will remain interested in mathematics into the future.

5. **A range of issues discourage interested students from undertaking a high level of mathematics, including perceptions of higher workload, inadequate ATAR compensation, usefulness for tertiary preparation only and, competitive university entrance procedures.** These issues disproportionately discourage girls, who are more likely to have lower confidence in their mathematical skills and who are less likely to aspire to a career requiring high level mathematics, from choosing to undertake a high level mathematics subject for their HSC.

6. **Mathematics teachers have the potential to significantly improve girls' confidence in, enjoyment of, and participation in, mathematics within the current NSW education system.** Any interventions designed to increase participation in high level mathematics, particularly for girls, should consider the role of the teacher as central to the experiences students have with mathematics and should focus on building and maintaining girls' mathematical confidence. With gendered perceptions and career aspirations forming in the early years of schooling, such interventions need to begin at an early age and efforts to maintain girls' confidence should continue throughout secondary school.

1. Introduction

This project explores girls' participation in senior secondary mathematics and the aspirations held by girls for careers that require high level mathematics. Drawing on a broad range of NSW data, the project contributes to existing knowledge and provides new insights into the reasons why girls choose to participate, or not, in high level mathematics during the post-compulsory years of schooling.

Current research shows that girls are underrepresented in senior secondary mathematics (Wilson & Mack, 2014). This underrepresentation exists both nationally and internationally (Charles, Harr, Cech, & Hendley, 2014; Watt et al., 2016) and has persisted over time despite numerous equity targets, government initiatives, and research programs designed to understand and increase women's engagement in mathematics and other 'non-traditional' areas of study over the last three decades (Bell, Yates, & May, 2015; Charles, 2017; Watt, 2005). In fact, despite these efforts and targets, recent studies have revealed that girls are still opting out of mathematics, particularly advanced mathematics, at their first opportunity to do so (Watt, 2016; Watt et al., 2012; Wilson & Mack, 2014). This trend, often labelled a 'leaky pipeline', continues into university and beyond, with girls more likely than boys to opt out of non-traditionally female areas of study, including many of those in science, technology, engineering and mathematics (STEM) at each successive education and career level (Office of the Chief Scientist, 2016; Watt, Eccles, & Durik, 2006).

Since 1980, mathematics has been identified as a 'critical filter' to a number of the highest-status, highest-paying careers, in many of which women are underrepresented (Roberts, 2014; Sells, 1980; Watt et al., 2016). In recent years, careers requiring high level mathematics, such as those in STEM (Nicholas, Poladian, Mack, & Wilson, 2015), have become increasingly crucial to Australia and to future innovation and productivity (PricewaterhouseCoopers Australia, 2015). As a result, these fields are experiencing unprecedented job growth with, for example, the Australian Bureau of Statistics (ABS) (2015) estimating that the number of jobs in engineering and information communications technology has grown at 1.5 times the rate of other jobs in recent years. In response to this growth, a new Australian school education strategy has been recently endorsed, calling for increased school focus on the STEM building blocks, particularly mathematics, and increased evidence of what works to increase STEM outcomes, particularly for underrepresented subgroups of the population, such as girls (Education Council, 2015).

It is well-established that the underrepresentation of women and girls in high level mathematics and related careers raises both social justice and economic issues. Economically, it has been argued that women and girls represent untapped talent in many non-traditional career fields (Office of the Chief Scientist, 2016) and that their underrepresentation reduces diversity, reducing the potential for creativity and increasing the potential for bias in the workforce (Roberts, 2014). From a social justice perspective, there is a clear link between participation in high level mathematics and access to many high-status, rapidly growing careers (Watt et al., 2016) which women are not currently accessing in equal numbers. As outlined by Roberts (2014), if men and women are equal then so should be the circumstances that enable them to participate in high level mathematics and in careers that require high level mathematics.

Research reveals, however, that the circumstances that enable boys and girls to participate in high level mathematics are not equal. This inequity is reflected in the many complex and interrelated factors that affect girls' decisions not to study high level mathematics, including: perceptions of ability and self-confidence; occupational interests and preferences; stereotypes; and a lack of appropriate female role models (Roberts, 2014; Wang & Degol, 2017).

Perceptions of ability and self-confidence

The relationship between mathematics ability and gender has been studied for decades (Perez-Felkner, Nix, & Thomas, 2017). Historically, mathematics was regarded as a domain more suited to boys and early research often showed girls to have lower levels of mathematics achievement than boys (Forgasz & Leder, 2017; Leder, 1992). However, large-scale international testing has shown that mathematics ability is not determined biologically by sex, with differences in mathematics performance varying considerably over time and across nations (Office of the Chief Scientist, 2016; Stoet & Geary, 2013; Watt et al., 2006). As outlined by Forgasz and Leder (2017), it is now generally recognised that social influences, rather than innate biological differences (Hyde & Mertz, 2009), perpetuate any observed gender achievement differences in mathematics.

In NSW, recent international standardised testing of students in Year 4 and Year 8 and of students who are 15-years-old (in approximately Year 10), has shown no statistically significant differences in mathematics performance between girls and boys (Thompson, De Bortoli, & Underwood, 2016; Thompson, Wernert, O'Grady, & Rodrigues, 2016). And yet, a large body of both Australian and international research shows that girls hold lower mathematics self-confidence beliefs and report significantly higher levels of mathematics anxiety than boys (Buckley, 2016; Else-Quest & Hyde, 2010; Goetz, Bieg, Lüdtk, Pekrun, & Hall, 2013; Henschel & Thorsten, 2017). In addition, girls are more likely to hold lower beliefs in their mathematical capabilities under challenge, even when compared to boys of the same achievement levels (Perez-Felkner et al., 2017), and are less likely than boys of the same age to report liking or enjoying mathematics (Charles et al., 2014; Frenzel, Goetz, Pekrun, & Watt, 2010). Pivotally, interest in, liking of, and mathematics ability-related beliefs have all been shown to influence adolescents' decisions regarding post-compulsory mathematics participation, more so than prior mathematics achievement (Perez-Felkner et al., 2017; Watt et al., 2006).

Occupational interests and preferences

Young people typically choose their high school courses based on what they would like to do when they leave school and, as a result, girls are more likely to pick advanced maths courses if high level mathematics is relevant to their future career aspirations (Eccles, 2013). Research has shown that girls are less likely than boys to aspire to, and eventually participate in, a large number of the career fields requiring high level mathematics at secondary school (Roberts, 2014). This is particularly the case in fields such as mathematics, physics, engineering, and computing rather than in the 'more social' scientific fields, such as biological or health sciences, in which women are now well represented (Eccles & Wang, 2016; Perez-Felkner et al., 2017; Su & Rounds, 2015).

Women and girls generally place higher value on working with others, making a difference to others and on work-family balance than do males (Diekman, Brown, Johnston, & Clark, 2010; Su & Rounds, 2015). Studies have shown that these differences in interests and occupational preferences, combined with girls holding lower mathematics self-concepts, are predictive of gender differences in STEM participation. For example, Eccles and Wang (2016) found that the underrepresentation of women broadly across STEM could be explained entirely by the fact that men had higher mathematics self-concepts and less significant desires to work with others. Additionally, the fact that the women who did enter STEM were more likely to enter biological and health related fields was significantly predicted by girls placing higher value on working with others and on making a difference than did boys. These findings came from a study of 1200 people who were surveyed in Year 12 to determine their motivational beliefs and aptitudes, and again at age 28/29 to determine their actual occupation. Similarly, Su and Rounds (2015) demonstrated that a key factor for female career choices between STEM and non-STEM, as well as within STEM, was how 'people-oriented' the work environment was. The extent to which the work environment was people-oriented reflected the extent to which women, in general, showed interest in the field.

Stereotypes and role-models

A number of theories have proposed that women's career and academic choices are constrained and shaped by stereotypes surrounding gender as well as by stereotypes surrounding the kind of people who work in, and the values of, various occupations (Archer, DeWitt, & Wong, 2014; Cheryan, Master, & Meltzoff, 2015; Kessels, Heyder, Latsch, & Hannover, 2014; Meyer, Cimpian, & Leslie, 2015). Cultural stereotypes typically depict scientific and technical work as uncreative, solitary, and fundamentally masculine (Charles, 2017). This stereotyping results in reduced uptake of mathematical, scientific and technical work by girls, relative to boys, due to a perceived misalignment of girls' interests and identities with this kind of work. In addition, these stereotypes convey messages that only certain types of, and typically unfeminine, women are suited to scientific and technical work. For example, Kessels (2005) found that girls who pursue physics are perceived as more masculine by their peers than girls who do not. More recently Archer, Moote, Francis, DeWitt, and Yeomans (2017) found that the cultural designation of physics as masculine and hard is carried by both girls who do and girls who do not plan to continue with physics in senior school.

Studies have shown that reducing stereotypes and masculine representations by broadening images of who participates, and the type of work involved, in male-dominated fields can increase female interest and engagement in areas such as engineering and computer science (Cheryan et al., 2015). Access to role-models, whether male or female, who convey communal opportunities within these occupations is one such avenue which has been shown to dispel myths about the solitary, masculine nature of male-dominated fields (Fuesting & Diekman, 2017).

It may not seem problematic if girls and boys choose different career pathways and develop different interests. However,

> when girls' mathematics participation is reduced for negative reasons such as anxiety and lower self-concept, and when those participation choices adversely impact their aspired careers, we need to think carefully about why girls come to hold less positive mathematics motivations than boys. (Watt, 2016, p. 41)

Our project, *Girls in Maths,* explores the participation of girls' in post compulsory mathematics and the aspirations held by girls for careers requiring participation in high level mathematics. Through this exploration we contribute new insights into the mathematics motivations of girls and provide important information on how schools and policy makers can support post-compulsory mathematics participation by girls in secondary school.

1.1. NSW HSC context

This study is situated in NSW, the state that enrols the largest number of secondary students in Australia and has traditionally had the highest overall rates of participation in advanced Year 12 mathematics (Ainley, Kos, & Nicholas, 2008; Barrington & Brown, 2014; Dekkers, De Laeter, & Malone, 1991; Fullarton & Ainley, 2000). In NSW, the *Education Act 1990* mandates that all students study six Key Learning Areas (KLAs), including English and mathematics, from Kindergarten through to Year 10. In contrast, during Years 11 and 12, that is throughout the HSC, students will typically complete five to six subjects, with all except English being elective.

In contextualising this study it is important to note that the HSC landscape has changed greatly over the last few decades. These changes have been a result of the complex interaction between shifting economic conditions, youth transition into the workforce, and policy changes over time (Lyons & Quinn, 2015; Smith, 2004). For example, downturns to the Australian economy since the early 1990s, increasing youth unemployment, and government policy increasing the compulsory school leaving age from 15 to 17 years in 2010, have all resulted in rapid increases in Year 12 student numbers and retention rates over the last few decades (Dekkers & De Laeter, 2001; Dekkers et al., 1991; Dekkers, De Laeter, & Malone, 1986; Reid & Young, 2012). These increased retention rates have created a Year 12 population with wider career aspirations than ever before and increased numbers of students in Year 12 whose interests may not be academic or linked to future university study (Dekkers & Malone, 2000; Reid & Young, 2012; Smith, 2004).

Historically, as reflected in the academic nature of the traditional HSC subjects, the majority of students left school after Year 10 and only the academically inclined remained at school (Smith, 2004). In order to cater for the diversifying HSC cohort, increasing numbers of alternatives to the traditional HSC subjects have been introduced in senior years. These alternatives, which include vocational educational and training (VET) courses, have become remarkably popular, with approximately 30% of all NSW HSC students enrolling in at least one VET course in 2013 (Board of Studies Teaching and Educational Standards, 2013). In addition to this vast change in curriculum offerings a relaxation of HSC requirements has occurred, in order to cater for increasingly diverse student cohorts. Prior to introduction of the 'new' HSC in 2001, when English became the only compulsory subject of study, students were required to undertake English as well as one mathematics, science or technological and applied sciences (TAS) subject, and one Languages, Human Society and its Environment, Personal Development Health and Physical Education (PDHPE) or creative arts subject, to demonstrate their 'breadth' of knowledge (Board of Studies NSW, 2000).

1.1.1. NSW mathematics courses

Whilst the HSC has undergone a variety of changes over time, the structure of course offerings in Mathematics has remained fairly consistent, with most change occurring at the elementary level. Table 1 below outlines the range of mathematics courses offered to students in NSW at the Year 12 level and the various categorisations of these courses prior to 1991 (Dekkers, De Later and Malone; 1986, 1991) and post 1991 (Barrington & Brown, 2014). As illustrated, there are currently six mathematics courses available to students. Of these six courses four are considered 'mainstream' (Gordon & Nicholas, 2013). As outlined by Gordon and Nicholas (2013) the mainstream mathematics courses are: the elementary course Mathematics General 2 (containing no calculus), the intermediate mathematics course (the first of the calculus courses), Mathematics, and the advanced level mathematics courses, Mathematics Extension 1 (which extends Mathematics content) and Mathematics Extension 2.

Table 1. Mathematics subject categorisations in NSW over time

Year	Advanced	Intermediate	Elementary
1976–1985	3 Unit Mathematics 4 Unit Mathematics	2 Unit Mathematics	2 Unit (2A) Mathematics
1986–1990	3 Unit Mathematics 4 Unit Mathematics	2 Unit Mathematics 2 Unit Mathematics in Society	School Assessed Mathematics Subjects*
1991–2000	3 Unit Mathematics 4 Unit Mathematics	2 Unit Mathematics	Mathematics in Society 2 Unit Mathematics in Practice 2 Unit*
2001–2013	Mathematics Extension 1 1/2 Unit** Mathematics Extension 2 2 Unit**	Mathematics 2 Unit**	General Mathematics 2 Unit Mathematics Life Skills 2 Unit*
2013–2018	Mathematics Extension 1 1/2 Unit** Mathematics Extension 2 2 Unit**	Mathematics 2 Unit**	Mathematics General 2 2 Unit Mathematics General 1 2 Unit* (2014 onwards) Mathematics Life Skills 2 Unit*
2019–	Mathematics Extension 1 1/2 Unit Mathematics Extension 2 2 Unit	Mathematics Advanced 2 Unit	Mathematics Standard 2 2 Unit Mathematics Standard 1 2 Unit Mathematics Life Skills 2 Unit*

*School assessed subjects, cannot be used for an ATAR
**No major change to curriculum content[1]

As shown in Table 1, the NSW Education Standards Authority will be implementing new HSC courses across NSW in 2018, examined for the first time in 2019. These courses will continue to maintain the structure of the current course offerings and will integrate the new Australian Mathematics Curriculum. This will be the first major change to intermediate and advanced mathematics course content in over 20 years. In addition, for the first time, five of the six mathematics courses will be eligible to be included in the calculation of an ATAR, with UAC announcing that from 2019 the Mathematics Standard 1 course will, unlike its predecessor Mathematics General 1, be able to be included in the calculation of an ATAR (Universities Admissions Centre, 2017a). It is likely that this will result in five of the different mathematics courses considered ‘mainstream’ into the future.

[1] See http://www.boardofstudies.nsw.edu.au/syllabus_hsc/mathematics-advanced.html for current intermediate and advanced mathematics HSC syllabuses, which were originally published in 1982 and 1989 respectively.

2. Approach

2.1. Research design

The *Girls in Maths* project design is depicted in Figure 1, which broadly outlines the analyses undertaken as well as the range of data utilised for the project and the project's relationship to the existing *Aspirations Longitudinal Study.*

As displayed in Figure 1, the *Girls in Maths* study was undertaken in three complementary phases involving:

1. Collection and analysis of NSW Education Standards Authority (NESA) data on girls' subject choice of intermediate or advanced mathematics over time.
2. Analysis of existing Year 7-12 *Aspirations Longitudinal Study* data and Australian Department of Education and Training NSW Higher Education enrolment statistics to identify the aspirations of girls for careers that require high level mathematics.
3. Interviews with current high school students, mathematics teachers and parents to identify any systemic influences on choice of mathematics by girls in NSW secondary schools.

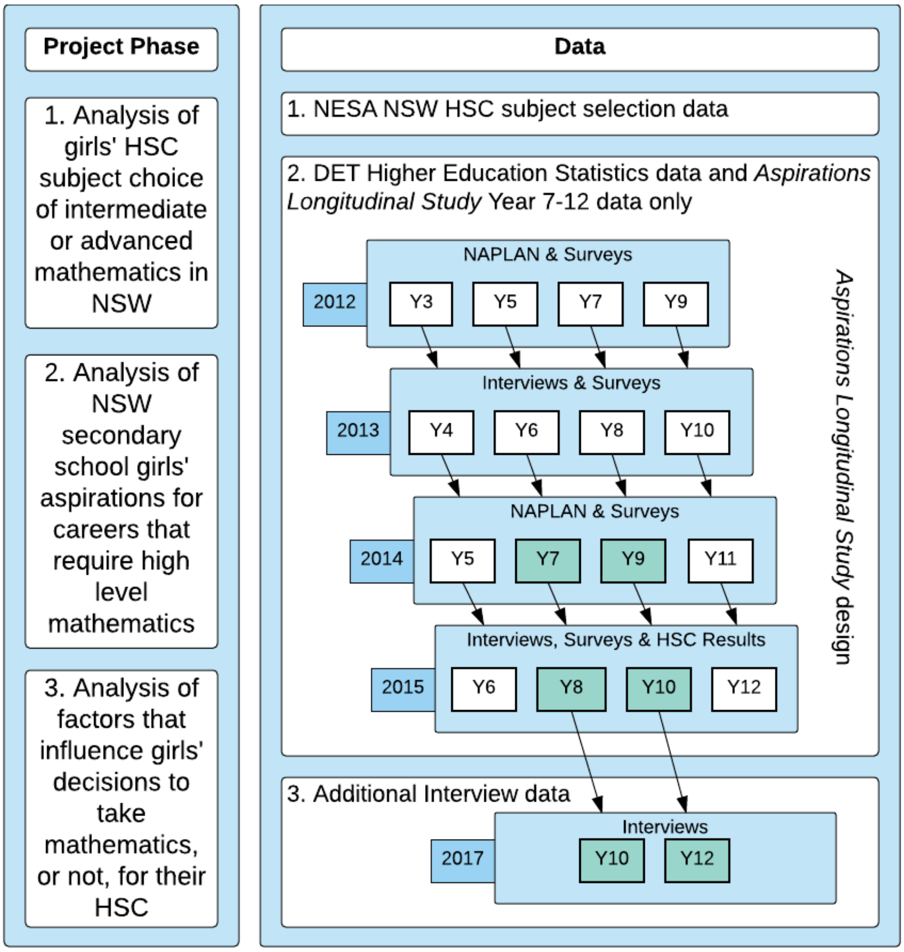

Figure 1. The Girls in Maths *study design*

2.2. Data analysis

2.2.1. Phase 1: Analysis of girls' HSC subject choice of mathematics

To answer the first research question, state-wide HSC subject enrolment data from 1991[2] through to 2016 were collated from NESA. Using these data girls' and boys' participation in the intermediate and advanced mathematics subjects were calculated and compared.

In order to calculate participation rates, the number of males or females in each course was divided by the total number of males or females enrolled in the HSC each year, an approach consistent with Forgasz (2006) and Kennedy, Quinn, and Lyons (2017). As English is compulsory for all students, and has been since 1991, the total number of unique students enrolled in at least one English course was used as the HSC population measure for these analyses. This method is consistent with the approach taken by Cox, Leder, and Forgasz (2004), which details participation in the Victorian HSC equivalent over the period 1994-1999. To conclude this phase, the raw enrolment numbers that underlie the participation trends were analysed and discussed to deepen understanding of any trends in participation.

2.2.2. Phase 2: Analysis of secondary school girls' aspirations

To answer the second research question, existing *Aspirations Longitudinal Study* project data and university enrolment data gathered from the Australian Government Department of Education and Training (2016), were examined to identify the aspirations of girls for careers that require high level mathematics.

As part of the *Aspirations Longitudinal Study,* students were surveyed annually about their occupational and educational aspirations. These surveys were conducted at school during class time and took approximately half an hour to complete. Within the surveys secondary students were asked, "Do you know what kind of work you would like to be doing at 25 years of age?" to determine their occupational aspirations. If a student answered 'yes' to this question they were asked in an open-ended question to name the work they would like to be doing in the future. Students who answered 'no' were given the opportunity to provide up to three future 'career thoughts'. Students' answers to these questions were then coded using the Australian and New Zealand Standard Classification of Occupations (ANZSCO) to the nearest four-digit code (for further details see Gore, Holmes, Smith, Southgate, & Albright, 2015).

For the purpose of this project, a dichotomous variable was created from these ANZSCO codes to determine whether a student aspired to a career requiring high level mathematics or not. Careers requiring high level mathematics were defined as careers that require a university degree (skill level 1) which typically have, at least, the intermediate HSC mathematics course Mathematics (the first of the

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[2] Data pre-1991 is limited in scope, as NESA holds no digital records prior to this time (as confirmed via direct on the 14/12/2016).

calculus courses) listed as assumed knowledge upon entry to the degree in NSW. Degree prerequisites and assumed knowledge requirements were obtained from the University Entry Requirements 2019 Guide for Year 10 students (Universities Admissions Centre, 2016). This definition was seen as particularly useful in the context of the *Girls in Maths* project as it provides a direct link between career interest and HSC subject choice. The ANZSCO codes identified as requiring high level mathematics were then grouped into 6 broad fields to allow for comparison of groups of similar occupations, and are depicted in Table 2. Note that this list of occupations is not an exhaustive list of all careers requiring high levels of mathematics, but is limited to occupational categories named by the students in their open-ended survey responses.

Table 2. Careers requiring high level mathematics

Occupation Grouping	ANZSCO Code	Occupation
Engineering, Surveying, and Architecture	233	Engineering Professionals
	2321	Architects and Landscape Architects
	2322	Surveyors and Spatial Scientists
	2331	Chemical and Materials Engineers
	2332	Civil Engineering Professionals
	2334	Electrical Engineers
	2335	Industrial, Mechanical and Production Engineers
	2633	Telecommunications Engineering Professionals
	2339	Other Engineering Professionals
Natural and Physical Scientists	234	Natural and Physical Science Professionals
	2342	Chemists, and Food and Wine Scientists
	2344	Geologists and Geophysicists
	2341	Agricultural and Forestry Scientists
	2343	Environmental Scientists
	2345	Life Scientists
	2349	Other Natural and Physical Science Professionals
Health, Medical and Veterinary Scientists	2346	Medical Laboratory Scientists
	2512	Medical Imaging Professionals
	2514	Optometrists and Orthoptists
	2515	Pharmacists
	2347	Veterinarians
Information and Communications Technologies	26	ICT Professionals
	263	ICT Network and Support Professionals
	1351	ICT Managers
	2611	ICT Business and Systems Analysts
	2612	Multimedia Specialists and Web Developers
	2613	Software and Applications Programmers
	2631	Computer Network Professionals
Mathematicians, Statisticians, Financial Workers, Economists, and Mathematics Educators	2241	Actuaries, Mathematicians and Statisticians
	2243	Economists
	2414	Secondary Teachers (Mathematics only)
	2223	Financial Investment Advisors and Managers
	1322	Finance Managers
	2222	Financial Dealers

After identifying the careers that require high level mathematics the dataset was examined to identify the popularity of each occupation grouping amongst boys and girls as well as the specific occupations requiring high level mathematics named most often by girls.

In addition, a regression analysis was conducted to determine whether a student's sex was a statistically significant predictor of an aspiration for a career requiring high level mathematics within the sample. This analysis involved the creation of a linear regression model which tested the significance of student's sex, amongst a range of student background and school-related factors, as an influencing factor on aspirations for a career requiring high level mathematics. This regression model was fitted within a Generalized Estimating equation (GEE) framework. The GEE framework, a method robust against violations of normality and missing data assumptions, was fitted to the model to adjust for the correlation of outcomes within students who had completed repeated surveys, due to the longitudinal nature of the data. The GEE model was compared to an equivalent random effects Generalized Linear Model, both of which produced similar estimates and p-values. Results are reported as odds ratios and associated p-values. Analysis was conducted with SAS software version 9.4 and statistical significance was set at 0.05. In accordance with Robinson and Levin (1997), we have used the interpretation of odds ratios provided by Monson (1990) to describe the effects. This interpretation is displayed in the Table 3 below. Details of all variables included in the analysis, as well as the distribution of these variables within the sample, are provided in section 2.2.2.1 below.

Table 3. Interpreting odds ratios

Less likely effect size range	Descriptor	More likely effect size range
0.9 to 1.0	No effect	1.0 to 1.2
0.7 to 0.9	Weak effect	1.2 to 1.5
0.4 to 0.7	Moderate effect	1.5 to 3.0
0.1 to 0.4	Strong effect	3.0 to 10

To determine whether the aspirations held by girls for careers requiring high level mathematics have changed over time, data from the Australian Government Department of Education and Training (2016), detailing enrolments across NSW universities in ten[3] fields of higher education over the years 2001-2015 were examined to determine both the share of girls' enrolments in higher education, and the percentage of girls enrolled in, the fields typically requiring high level mathematics. Five of the ten fields aligned broadly[4] with the occupations requiring high level mathematics identified in the *Aspirations Longitudinal Study*. These fields were: Natural and Physical Sciences, Information Technology, Engineering and Related Technologies, Architecture and Building as well as Agriculture, Environmental and Related Technologies. The five remaining fields were: Health, Education, Management and Commerce, Society and Culture and Creative Arts.

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[3] Mixed Field Programs and Non-Award courses were excluded due to small student numbers.

[4] Note that these fields align broadly with the occupation groupings with, for example, veterinary science falling under the tertiary Health field and finance falling under the field of Management and Commerce.

2.2.2.1. *Aspirations Longitudinal Study* sample and independent variable details

Table 4 outlines the independent variables from the *Aspirations Longitudinal Study* dataset that were used for the logistic regression analysis conducted for Phase 2 of the project and Table 5 displays the distribution of these variables within the sample. As displayed in Table 4, the independent variables were sex, language background, Indigenous status, socioeconomic status (SES), location, cultural capital, cohort, prior achievement (reading and numeracy), relative school socio-educational advantage (ICSEA) and self-rated academic performance. As outlined in section 2.2.2, the dependent variable was student aspiration for a career requiring high level mathematics.

Table 4. Independent student background and school-related variables

Variable	Source	Description
Sex	School enrolment form	Categorised as male or female
Indigenous status	School enrolment form	Categorised as Indigenous or non-Indigenous
Student year level at baseline	Survey	Four student cohorts: Year 3 cohort, Year 5 cohort, Year 7 cohort, Year 9 cohort
Cultural capital	Survey	Each student's cultural capital was determined and quartiles were calculated for the sample, using a measure created from their responses questions such as: "How often do you do the following activities? (Listen to classical music; talk about music; go to the theatre to see a play, dance or opera performance; go to art galleries or museums; go to the cinema to watch a movie; go to a library; talk about books; play a musical instrument or sing; participate in dancing, gymnastics or yoga; talk about art)"
Language background	School enrolment form	Categorised as English speaking, or language background other than English (LBOTE)
School location	MySchool website (www.myschool.edu.au)	Categorised on a school by school basis as metropolitan or provincial using the Schools Geographic Location Classification Scheme reported on the MySchool website
Socioeconomic status (SES)	School enrolment form	Calculated for each student by combining the highest parental educational and occupation levels into an equally weighted proxy. Data for all NSW government schools were used to separate scores into quartiles
Survey year	Survey	Year the survey was completed
ICSEA national quartile	MySchool website (www.myschool.edu.au)	Categorised into quartiles based on national data on a school by school basis.
Prior achievement – NAPLAN quartile (literacy and numeracy)	NSW Department of Education	The most recent National Assessment Plan for Literacy and Numeracy (NAPLAN) test scores for each student. Data for all NSW government schools within each year level were used to separate scores into quartiles.
Self-rated performance	Survey	Response to the question: "How are your marks this year compared with other students? (Well below average, below average, average, above average, well above average)"

A total of 5,512 surveys were completed by students in secondary school, who identified as either male or female, across the four waves of the *Aspirations Longitudinal Study*. As displayed in Table 5, for both boys and girls the number of surveys completed by secondary school students, over most years, was relatively similar. In addition, the number of Indigenous students and the number of students from language backgrounds other than English were relatively similar for boys and girls. However, a slightly higher proportion of boys' surveys, when compared to girls' surveys, were completed by students from a metropolitan rather than provincial area and, in regards to achievement, girls had a slightly lower average NAPLAN numeracy score and a slightly higher average NAPLAN literacy score. The sample of boys had lower cultural capital compared to the girls, with almost half of all surveys completed by a boy in the bottom cultural capital quartile (42.8%), compared to only 20.7% of all surveys completed by a girl. In addition, the entire secondary school student sample was skewed towards the lower three SES and lower two ICSEA quartiles.

Table 5. Sample distribution

Variable	**Female, *n* (%)** (*n* = 2771)	**Male, *n* (%)** (*n* = 2741)	**Total, *N* (%)** (*N* = 5512)
Survey Year			
2012	559 (20.2)	626 (22.8)	1185 (21.5)
2013	852 (30.1)	856 (31.2)	1708 (31.0)
2014	708 (25.6)	642 (23.4)	1350 (24.5)
2015	652 (23.5)	617 (22.5)	1269 (23.0)
SES			
Quartile 1	676 (25.8)	650 (25.1)	1326 (25.5)
Quartile 2	901 (34.3)	840 (32.5)	1741 (33.4)
Quartile 3	609 (23.2)	601 (23.2)	1210 (23.2)
Quartile 4 (Highest)	437 (16.7)	495 (19.1)	932 (17.9)
Language Spoken at Home			
English	2565 (92.6)	2502 (91.3)	5067 (91.9)
Language other than English	206 (7.4)	239 (8.7)	445 (8.1)
Indigenous Status			
Indigenous	2576 (94.0)	2529 (93.3)	5105 (93.7)
Non-Indigenous	167 (6.0)	182 (6.7)	346 (6.3)
School Location			
Metropolitan	1402 (50.6)	1558 (56.8)	2960 (53.7)
Provincial	1369 (49.4)	1183 (43.2)	2552 (46.3)
NAPLAN Numeracy			
Quartile 1	594 (22.8)	507 (19.6)	1101 (21.2)
Quartile 2	798 (30.7)	660 (25.5)	1458 (28.1)
Quartile 3	775 (29.8)	787 (30.4)	1562 (30.1)
Quartile 4 (Highest)	435 (16.7)	631 (24.4)	1066 (20.6)
NAPLAN Literacy			
Quartile 1	425 (16.0)	573 (21.7)	998 (19.0)
Quartile 2	707 (26.7)	672 (25.8)	1379 (26.2)
Quartile 3	805 (30.4)	710 (27.2)	1515 (28.8)
Quartile 4 (Highest)	711 (26.9)	652 (25.0)	1363 (25.9)

Variable	Female, *n* (%) (*n* = 2771)	Male, *n* (%) (*n* = 2741)	Total, *N* (%) (*N* = 5512)
School ICSEA			
Quartile 1	582 (21.0)	594 (21.7)	1176 (21.3)
Quartile 2	1879 (67.8)	1774 (64.7)	3653 (66.3)
Quartile 3	20 (0.7)	30 (1.1)	50 (0.9)
Quartile 4 (Highest)	290 (10.5)	343 (12.5)	633 (11.5)
Cultural Capital			
Quartile 1	538 (20.7)	1087 (42.8)	1625 (31.6)
Quartile 2	664 (25.5)	676 (26.6)	1340 (26.1)
Quartile 3	731 (28.1)	464 (18.3)	1195 (23.3)
Quartile 4 (Highest)	688 (25.7)	310 (12.2)	978 (19.0)
Self-Rated Performance			
Well below average	57 (2.2)	74 (3.0)	131 (2.6)
Below average	198 (7.8)	202 (8.1)	400 (7.9)
Average	1284 (50.3)	1132 (45.2)	2416 (47.8)
Above	816 (31.9)	798 (31.9)	1614 (31.9)
Well above average (Highest)	199 (7.8)	299 (11.9)	498 (9.8)
Cohort			
Year 5	569 (20.7)	542 (19.9)	1111 (20.3)
Year 7	1327 (48.3)	1399 (51.4)	2726 (49.8)
Year 9	851 (31.0)	781 (28.7)	1632 (29.8)

2.2.3. Phase 3: Analysis of motivations and incentives for HSC subject choice

In order to investigate the third research question, semi-structured interviews were conducted with 52 people, as described in Table 6 and Table 7 below. All students were former *Aspirations Longitudinal Study* participants and were selected to participate in the interviews on the basis of having mid to high prior NAPLAN numeracy achievement and/or an aspiration for a career requiring high level mathematics. All interviews were semi-structured and participants were asked about HSC subject choices, reasons for these choices, advice they had received or given, as well future career aspirations. Interview schedules utilised for these interviews are provided in Appendix 1.

Table 6. Girls in Maths interview participants

Data Source	No. Participants
Year 10 girls	23
Year 12 girls	15
Mathematics teachers	10
Parents	4

Table 7. Highest level of mathematics chosen by student interviewees

	No. Students	
Mathematics Subject	**Year 10**	**Year 12**
No Mathematics	3	2
General Mathematics 1 or 2	14	8
Mathematics	5	3
Mathematics Extension 1	1	2
Mathematics Extension 2	N/A[5]	0

All interviews were recorded, transcribed and analysed using NVivo software (QSR International, 2014). To ensure anonymity, each participant was assigned a pseudonym. Prevalent themes were identified in the data and coded using inductive and deductive logic (Creswell, 2013). A continuous process of reflection and discussion between coders ensured consistency (Harry, Sturges, & Klinger, 2005) over emerging themes. Identified themes were included in a codebook as a reference point for use by all members of the research team (Guest, MacQueen, & Namey, 2011). Key themes that emerged from the interviews in relation to why students choose/don't choose a mathematics subject for their HSC and in relation to student choice of general mathematics versus a high level mathematics subject are presented and discussed to determine whether there are any systemic forces which may induce interested girls to take subjects other than Mathematics for their HSC.

[5] Mathematics Extension 2 is a Year 12 course only. Students who have undertaken Mathematics and Mathematics Extension 1 in Year 11 opt to either: advance into the Mathematics Extension 1 and Mathematics Extension 2 combination, or remain in the Mathematics and Mathematics Extension 1 combination in Year 12.

3. Results

3.1. Phase 1: Girls' HSC participation

Research Question: Are girls underrepresented compared to boys in studying intermediate or advanced mathematics at high school? If so, how has this situation changed over time?

Data Source: NSW state-wide HSC enrolment statistics by subject and sex.

An overview of the total HSC population is displayed in Figure 2 below. The number of students enrolling in the HSC, the number of the enrolled students who successfully completed all HSC requirements, and the percentage of enrolled students who were female are illustrated in this figure for each year over the period 1991–2016.

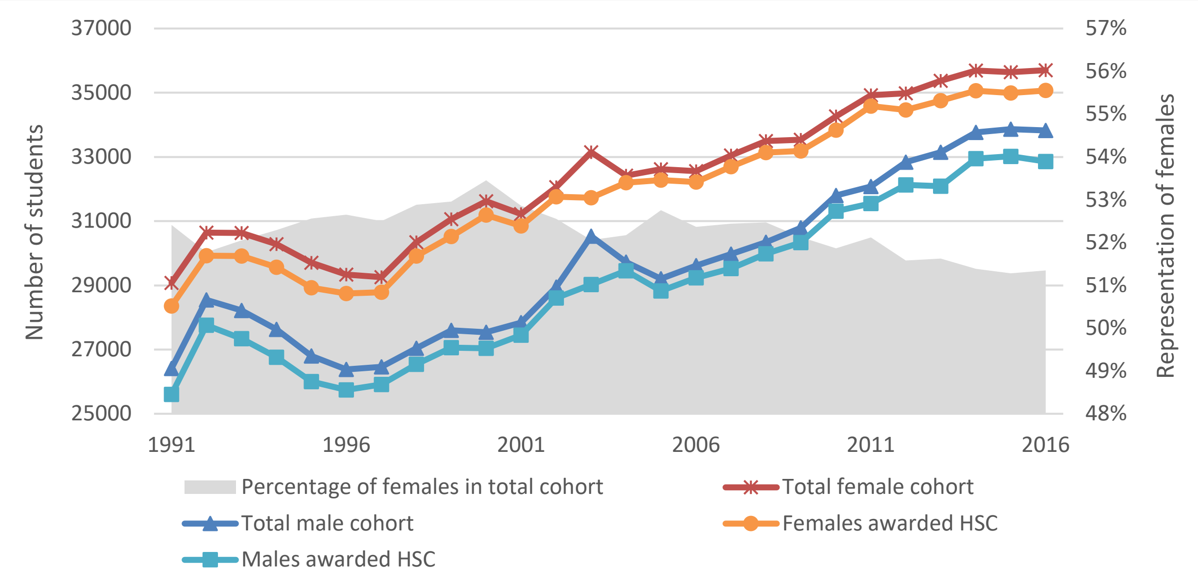

Figure 2. Number of students enrolled in, and awarded, the HSC by sex (left axis) and percentage of students who were female (right axis), 1991–2016

As displayed in Figure 2, the number of male and female students enrolled in the HSC has steadily risen each year (lines, left axis). In 1991, there were approximately 55,000 students enrolled. By 2016 this number had increased to approximately 70,000 students. Each year, just over half of all HSC students have been female (shaded section, right axis), with the representation of girls changing from approximately 52.4% in 1991, to a high of 53.5% in 2000 and to 51.4% of all students in 2016. Each year there has been a small difference between the number of students enrolled in the HSC and the number of students completing all HSC requirements. As illustrated, this difference has been similar for both male and female students and has increased slightly in recent years.

3.1.1. Girls' HSC participation in advanced mathematics

Accounting for rising numbers of students and fluctuations in the overall percentage of girls in the HSC cohort, Figure 3 below presents the state-wide HSC participation rate, by sex, in Mathematics Extension 1 and Mathematics Extension 2. Figure 4 illustrates the amount by which the male participation rate exceeded the female participation rate every five years over the period 1991–2016.

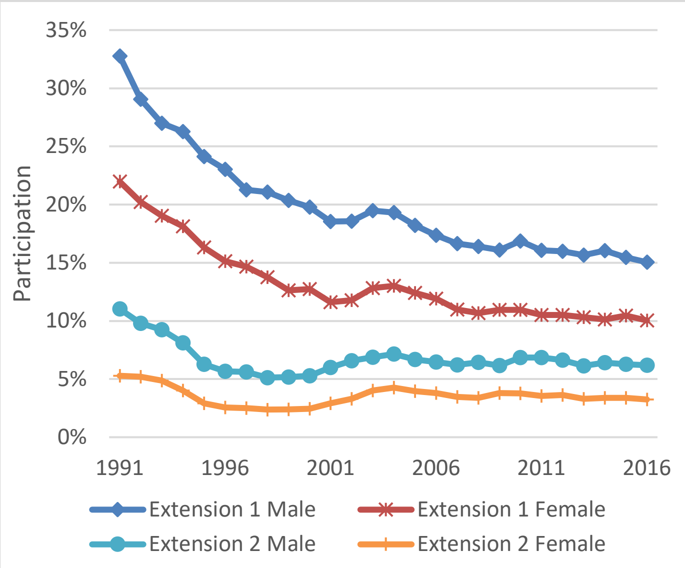

Figure 3. Percentage of students taking each advanced mathematics subject, 1991–2016

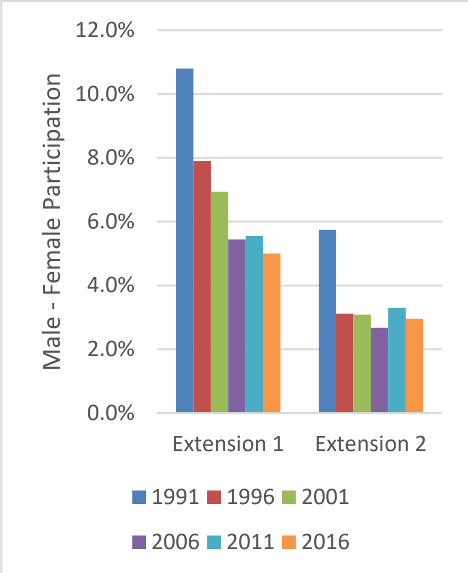

Figure 4. Difference between male and female participation in advanced

As displayed in Figures 3 and 4:

- A higher percentage of male HSC students than female HSC students have enrolled in each of the Mathematics Extension subjects each year since 1991, the starting point for this analysis.
- The male-female participation difference in both subjects has narrowed since 1991 – halving over the period 1991 to 2006, but changing very little since 2006.
  - For Extension 1, the participation difference has changed from approximately 11% in 1991 to just over 5% in 2006, and remains at 5% in 2016.
  - For Extension 2, the participation difference has changed from approximately 6% in 1991 to almost 3% in 2006, and remains at 3% in 2016.
- Overall participation rates, inclusive of both males and females, in Mathematics Extension 1 and 2 have declined by approximately 15% and 3% respectively since 1991.
  - In 2016, the female participation rate in Mathematics Extension 1 was 10%, the male participation rate was 15% and overall participation was 12%.
  - In 2016, the female participation rate in Mathematics Extension 2 was 3%, the male participation rate was 6% and overall participation was 5%.

Figure 5 below displays the enrolment numbers which underlie these participation trends. Given substantial change to advanced mathematics participation over the period 1991 to 2006 and minimal change after 2006, enrolment numbers for the years 1991, 2006 and 2016 only are presented. Figure 6 illustrates the proportion of females enrolled in advanced Mathematics in each of these years.

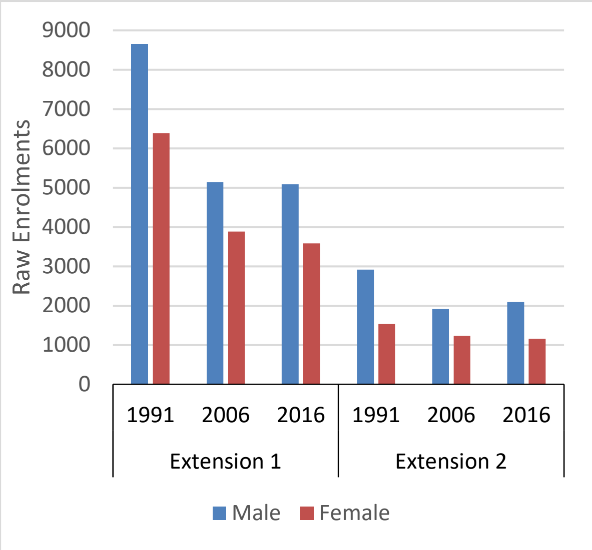

Figure 5. Advanced mathematics enrolments over time

Figure 6. Proportion of males and females in advanced mathematics over time

As displayed in Figures 5 and 6:

- As reflected in the participation rates (Figures 3 and 4), most change to enrolment numbers occurred between 1991 and 2006.
  - In 2016, compared to 2006, there were 350 fewer Extension 1 students and 102 more Extension 2 students.
- As enrolment numbers have decreased, the gap between male and female enrolments has also decreased. This narrowing has been a result of faster decreases in male enrolments than female enrolments, and is reflected in the narrowing participation differences illustrated in Figure 3.
  - In 1991 there were almost 2,300 more males than females enrolled in Mathematics Extension 1; by 2016 this had decreased to 1,500 more males than females.
  - Similarly, in 1991 there were almost 1,400 more males than females enrolled in Mathematics Extension 2; by 2016 this had decreased to 900 more males.
- However, whilst male enrolments declined faster than female enrolments these declines have been proportional to the male overrepresentation in each of these subjects.
  - In 2016, compared to 1991, male enrolments had decreased in Mathematics Extension 1 by 41% (3,600) and female enrolments by 44% (2,800).
  - In 2016, compared to 1991, male enrolments in Mathematics Extension 2 had decreased by 28% (800) and female enrolments by 25% (380).
- As a result, the representation of females in both Extension subjects has changed little over time.
  - In 1991 42% (6,400) of the 15,000 Mathematics Extension 1 students were female, in 2016 a similar proportion, 41% (3,600), of the 8,700 students were female.
  - Similarly, in 1991 approximately 35% (1,500) of the 4,500 Mathematics Extension 2 students were female, in 2016 36% (1,200) of the 3,300 students were female.

3.1.2. Girls' HSC participation in intermediate mathematics

Figure 7 below presents the state-wide HSC participation rate, by sex, in the intermediate level HSC subject, Mathematics. Figure 8 illustrates the amount by which the male participation rate exceeded the female participation rate every five years over the period 1991–2016.

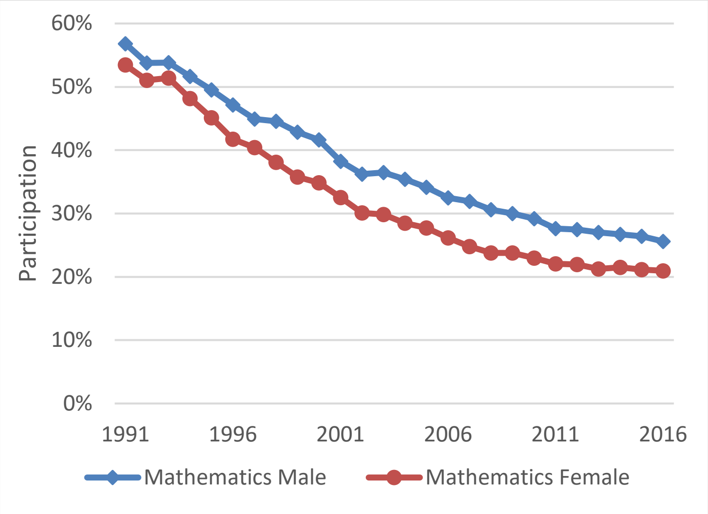

Figure 7. Percentage of students taking intermediate mathematics, 1991–2016

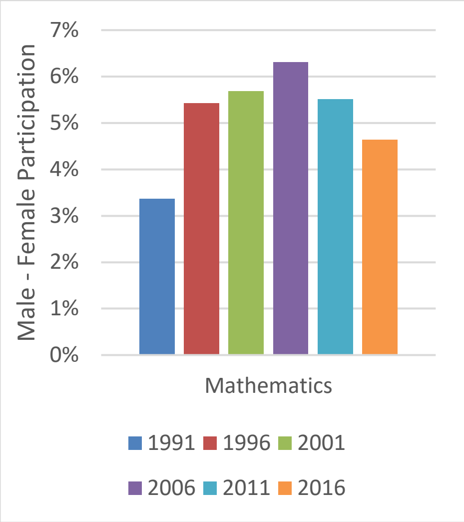

Figure 8. Difference between male and female participation in intermediate mathematics over time

As displayed in Figures 7 and 8:

- A higher percentage of male HSC students than female HSC students has enrolled in Mathematics each year since 1991.
- The male-female participation difference has narrowed in recent years, although it is still higher than it was in 1991.
- The percentage of all HSC students enrolling in intermediate level mathematics, inclusive of both males and females, has declined by 32% since 1991 to 23% in 2016.
  - In 2016, the female participation rate in Mathematics was 21% while, the male participation rate was 26%.
- Unlike in the Extension level subjects this decline has continued at a similar pace since 2006, with a 6% decrease in overall participation in 2016 since 2006.

Figure 9 below displays the enrolment numbers which underlie these participation trends. Figure 10 illustrates the representation of females in the enrolments. The years 1991, 2006 and 2016 have been included in these Figures for comparison to Figures 5 and 6.

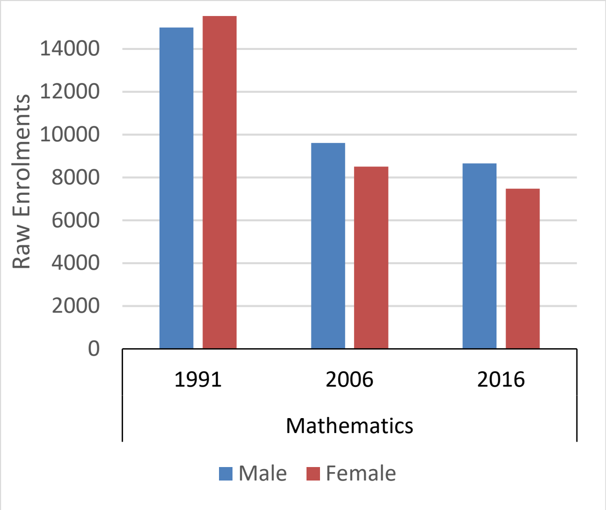

Figure 9. Intermediate mathematics enrolments over time

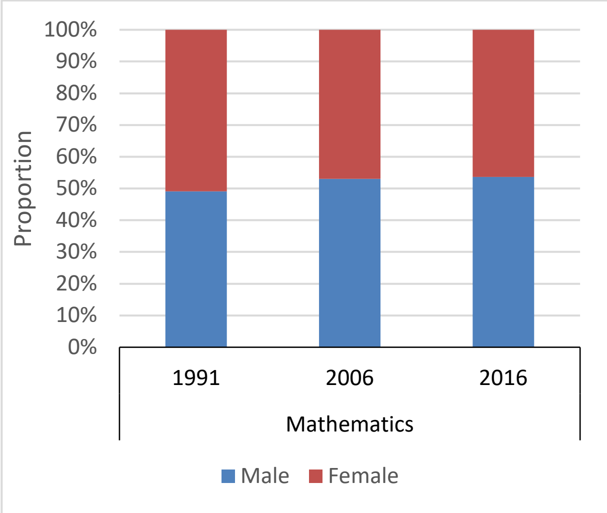

Figure 10. Proportion of males and females in intermediate mathematics over time

As displayed in Figures 9 and 10:

- Unlike raw enrolments in advanced mathematics (Figure 5), enrolments in intermediate mathematics have continued to decline since 2006.
  - There were 2,000 more mathematics students in 2006 compared to 2016.
- In 1991 there were approximately 500 more females than males enrolled in Mathematics. Despite this, girls had a lower participation rate in Mathematics (Figure 7) due to their comparatively greater representation within the total HSC population.
  - As previously outlined just over 52% of HSC students in 1991 were female (Figure 1). This was the equivalent to approximately 110 female enrolments for every 100 male enrolments. However, the representation of girls in Mathematics was just under 51%, the equivalent of 104 female enrolments for every 100 male enrolments.
- By 2016 there were almost 1,200 more males than females enrolled in Mathematics.
  - This was a result of a 42% (6,300) decrease in male enrolments and a 52% decrease (8,000) in female enrolments in 2016 compared to 1991.
- Proportionally faster decreases in female enrolments than male enrolments has resulted in the representation of females decreasing, and enrolment proportions becoming more gendered, changing from 51% female in 1991 to 46% female in 2016.

3.1.3. Phase 1 summary

The following key findings emerged from Phase 1 of the *Girls in Maths* project:

- Girls are underrepresented compared to boys in studying intermediate and advanced mathematics at high school. In each year since 1991 proportionally fewer females have undertaken HSC Mathematics, Mathematics Extension 1 and Mathematics Extension 2.
- The higher the level of mathematics the smaller the percentage of female enrolments compared to male enrolments. Only 35% of enrolments in Mathematics Extension 2, 41% of enrolments in Mathematics Extension 1 and 46% of enrolments in Mathematics were females in 2016, compared to females accounting for 51% of all students undertaking the HSC.
- The proportion of female enrolments, compared to male enrolments, in advanced mathematics subjects has changed little over time (1%), while intermediate level mathematics has attracted proportionally fewer female, than male, enrolments over time, with the female enrolment proportion in intermediate level mathematics decreasing by 5% since 1991.
- Participation in intermediate and advanced mathematics subjects has declined substantially for both males and females since 1991. Overall participation rates, inclusive of males and females, have declined by 32%, 15% and 3% in Mathematics, Mathematics Extension 1, and Mathematics Extension 2 respectively since 1991.
- Declining participation rates have been influenced by both increasing numbers of students undertaking the HSC and by fewer students undertaking high level mathematics, with declines of 14,400, 6,400 and 1,200 student enrolments in Mathematics, Mathematics Extension 1 and Mathematics Extension 2 respectively between 1991 and 2016.
- Participation in advanced mathematics has stabilised over the last 10 years but there is a continuing decline in the number of students, particularly girls, undertaking the intermediate level mathematics each year. This is despite the fact that there are increasing numbers of students completing the HSC each year.

3.2. Phase 2: Girls' aspirations for careers requiring high level mathematics

Research Question: What are the Aspirations of NSW high school girls for careers that require a high level of mathematics? Is there any evidence this has changed over time?

Data Sources: 1. *Aspirations Longitudinal Study* surveys completed by students in secondary school, *n* = 2,771 surveys completed by girls and *n* = 2,741 surveys completed by boys. 2. NSW university enrolment statistics by field of study and sex.

3.2.1. Girls' aspirations for careers requiring high level mathematics

Modelling of the Aspirations Longitudinal Study dataset revealed that females were significantly less likely to aspire to a career requiring high level mathematics than males, even in the presence of a range of student background and school-related variables (Boys OR = 1.53, Moderate Effect). In addition, as shown in Table 8 which displays the results of the GEE regression model, prior mathematics achievement, cultural capital and age were significant, with students who had high NAPLAN numeracy scores (Q3 OR = 1.87, Moderate Effect; Q4 OR = 3.20, Strong Effect), higher cultural capital (Q3 OR = 1.31, Weak Effect) and/or were younger (oldest cohort OR = 0.74, Weak Effect) significantly more likely to aspire to a career requiring high level mathematics than students with comparatively lower levels of prior numeracy achievement, lower cultural capital and/or who were in an older school year. Markedly, out of all variables explored, sex had the second strongest effect size, with males having 1.5 times the odds of females to hold an aspiration for a career requiring high level mathematics.

Table 8. GEE regression results

	Named a Career Requiring High Level Mathematics			
Variable	**Yes**	**No**	**Odds Ratio**	**Monson (1990) odds interpretation**
Survey Year				
2012 R	262 (21.7%)	946 (78.3%)		
2013	379 (20.0%)	1516 (80.0%)		
2014	282 (20.9%)	1070 (79.1%)		
2015	240 (18.4%)	1064 (81.6%)		
SES				
Quartile 1 R	255 (18.3%)	1136 (81.7%)		
Quartile 2	331 (18.4%)	1464 (81.6%)		
Quartile 3	255 (20.2%)	1005 (79.8%)		
Quartile 4	246 (26.4%)	685 (73.6%)		
Language Spoken at Home				
Language other than English R	114 (25.6%)	332 (74.4%)		
English	994 (19.6%)	4068 (80.4%)		
Indigenous Status				
Indigenous R	49 (14.2%)	297 (85.8%)		
Non-Indigenous	1053 (20.6%)	4048 (79.4%)		

Variable	Named a Career Requiring High Level Mathematics Yes	No	Odds Ratio	Monson (1990) odds interpretation
Sex				
Female [R]	**462 (16.7%)**	**2306 (83.3%)**		
Male	**646 (23.6%)**	**2094 (76.4%)**	**1.53*** **	**Moderate Effect**
School Location				
Metropolitan [R]	651 (21.6%)	2367 (78.4%)		
Provincial	512 (18.7%)	2229 (81.3%)		
NAPLAN Numeracy				
Quartile 1 [R]	109 (10.6%)	918 (89.4%)		
Quartile 2	224 (14.4%)	1327 (85.6%)		
Quartile 3	368 (23.2%)	1221 (76.8%)	1.87***	Moderate Effect
Quartile 4	364 (33.4%)	727 (66.6%)	3.20***	Strong Effect
NAPLAN Literacy				
Quartile 1 [R]	132 (13.1%)	878 (86.9%)		
Quartile 2	207 (14.9%)	1184 (85.1%)		
Quartile 3	354 (23.0%)	1183 (77.0%)		
Quartile 4	384 (27.7%)	1003 (72.3%)		
School ICSEA				
Quartile 1 [R]	258 (21.3%)	955 (78.7%)		
Quartile 2	681 (18.3%)	3031 (81.7%)		
Quartile 3	43 (25.0%)	129 (75.0%)		
Quartile 4	181 (27.3%)	481 (72.7%)		
Cultural Capital				
Quartile 1 [R]	311 (18.5%)	1371 (81.5%)		
Quartile 2	303 (21.7%)	1096 (78.3%)		
Quartile 3	295 (23.4%)	964 (76.6%)	1.31*	Weak Effect
Quartile 4	200 (19.6%)	819 (80.4%)		
Self-Rated Performance				
Below or well below [R] average	81 (14.3%)	486 (85.7%)		
Average	414 (16.5%)	2095 (83.5%)		
Above	459 (27.2%)	1226 (72.8%)		
Well above average	151 (29.2%)	366 (70.8%)		
Cohort				
Year 5 [R]	234 (20.8%)	890 (79.2%)		
Year 7	608 (21.2%)	2264 (78.8%)		
Year 9	321 (18.2%)	1442 (81.8%)	0.74*	Weak Effect

[R] denotes reference category.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

In addition to females being significantly less likely to aspire to a career requiring high level mathematics, females' aspirations compared to males' aspirations within the occupations identified as requiring high level mathematics were less varied. Almost 50% of all females who aspired to careers requiring high level mathematics wanted to be veterinarians. In comparison, males' aspirations were spread across a broader range of careers.

Table 9. The most popular occupations requiring high level mathematics for males and females

Girls	**Boys**
Veterinarians	Other Engineering Professionals
Life Scientists	Life Scientists
Architects	Architects
Other Natural and Physical Scientists	Other Natural and Physical Scientists
Other Engineering Professionals	Computer Network Professionals

Figure 11 displays the percentage of aspirations named by females or males within each occupation grouping, as categorised in Table 2, as well as across all occupations requiring high level mathematics.

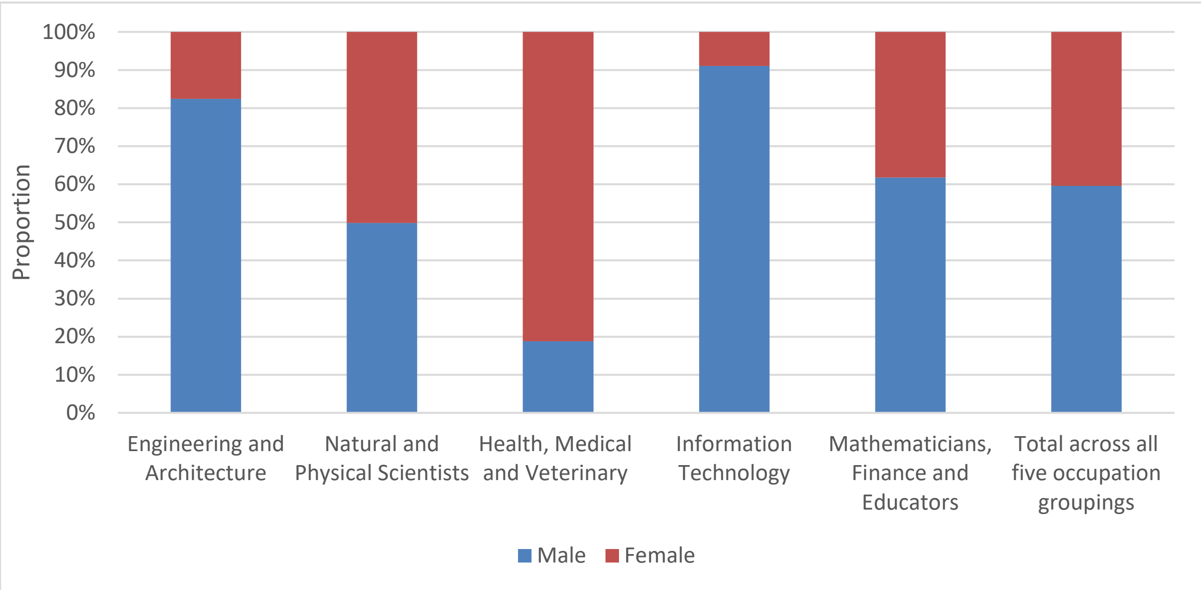

Figure 11. Proportion of males and females aspiring to each occupation grouping

As displayed in Figure 11:

- Approximately 60% of all aspirations for careers requiring high level mathematics were named by males.
- Three out of the five occupation groupings were more likely to be named by males.
- Engineering and Information Technology, were the occupational aspiration groupings in which females showed the least interest compared to males. Less than 20% of interest in these occupation groupings was expressed by females.
- Health, Medical and Veterinary sciences was the only occupation grouping more likely to be named by girls and Natural and Physical Sciences had approximately equal levels of interest between girls and boys.

Figure 12 illustrates, by sex, the percentage of students surveyed in each year of secondary school who named one or more of the careers in each of the five occupation groupings.

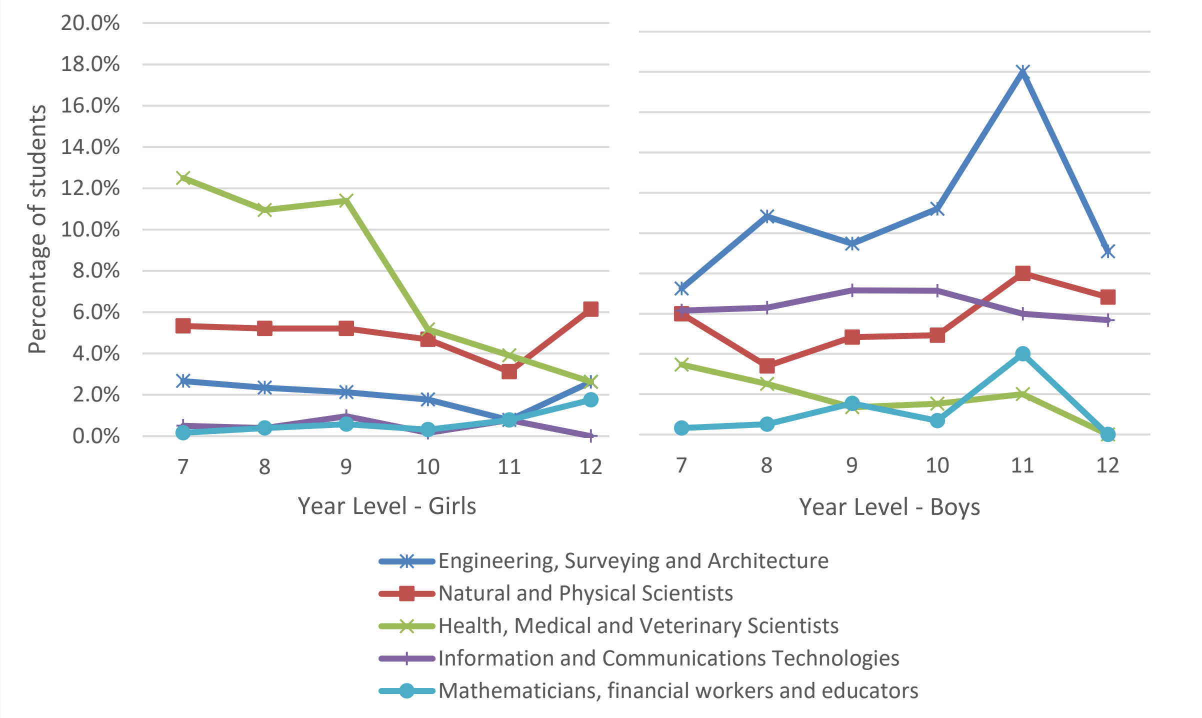

Figure 12. Percentage of students in each year aspiring to at least one career within each occupation grouping

As illustrated in Figure 12:

- Differential patterns of occupational interest between males and females were evident within our sample from as early as Year 7 and continued throughout secondary school.
- In each year of secondary school boys had higher levels of interest in engineering and information technology. However, interest in engineering dramatically decreased in Year 12 for boys.
- Girls had higher levels of interest in Health, Medical and Veterinary science, primarily due to aspirations for veterinary science (Table 9). However, interest in this career decreased dramatically as girls entered senior high school.

3.2.2. Girls' career interests over time

Figure 13 illustrates the percentage of domestic students, by sex, entering university in each of the broad fields of study that typically require high level mathematics.

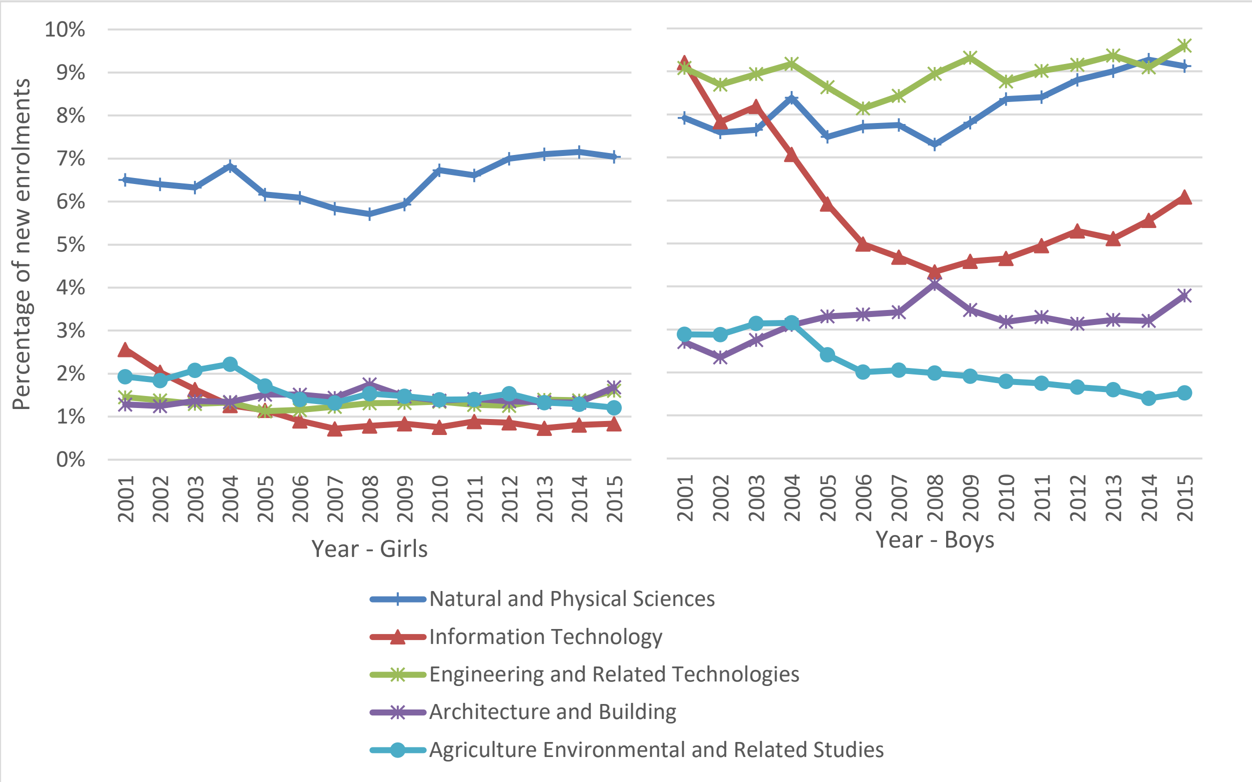

Figure 13. Percentage of commencing higher education student enrolments in fields typically requiring high level mathematics, 2001–2015

As illustrated in Figure 13:

- Girls have been less likely to enter into each of the university fields typically requiring high level mathematics since at least 2001.
- Four of these fields each attracted less than 2% of all female enrolments, compared to just one of these fields for boys, in 2015.
- The relative popularity of all five fields combined has decreased slightly over time for both males and females:
  - In 2001 32% of the commencing male students and 14% of the commencing female students enrolled in a field requiring high level mathematics.
  - In 2015 30% of the commencing males and 12% of the commencing females enrolled in a field requiring high level mathematics
- Mirroring the aspirations of secondary students, the underrepresentation of girls is particularly evident in engineering and technology, with almost 10% of all new male enrolments in NSW universities being in Engineering and Related Technologies and just over 6% being in Information Technology, compared to just below 2% and 1% for girls respectively.

Whilst not depicted, it is worth noting that the five fields displayed in Figure 13 are the least popular fields of study for girls, with Society and Culture, Health, Management and Commerce, Education, and

Creative arts each attracting more female enrolments than any of the fields typically requiring high level mathematics. In contrast, for boys, Engineering and Related Technologies was the third most popular field of study and Natural and Physical Sciences the fifth most popular field of study.

Figure 14 displays the representation of females in each of the five fields requiring high level mathematics in 2001 compared to 2015.

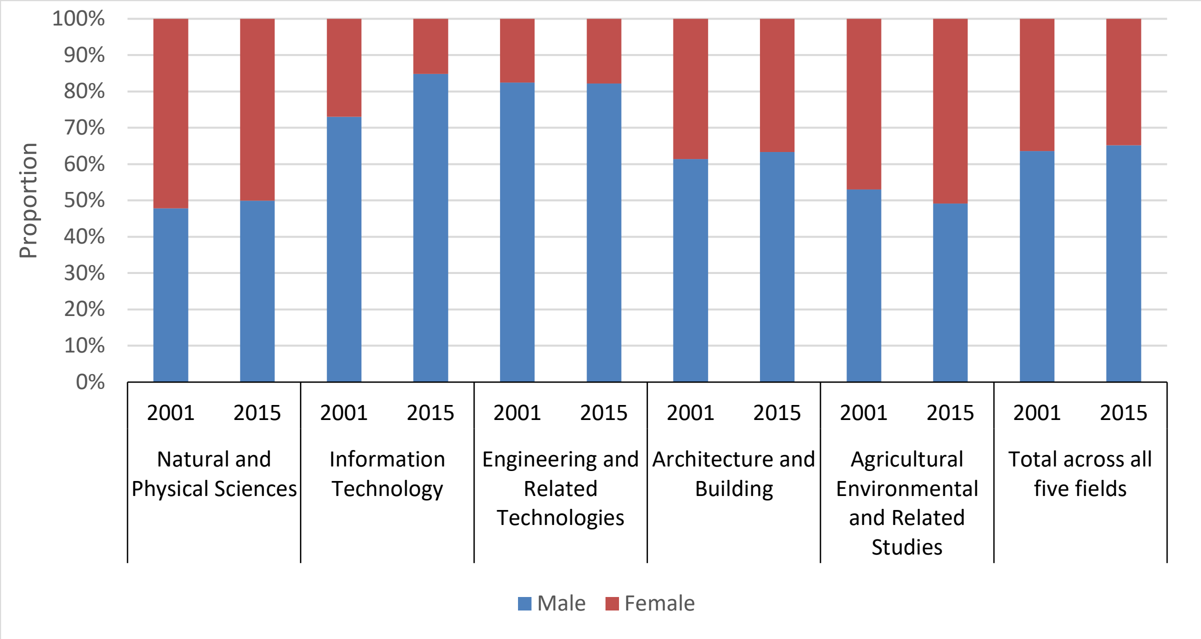

Figure 14. Proportion of male and female enrolments in higher education fields that require high level mathematics over time

As displayed in Figure 14:

- Little change to the gender composition across all of the tertiary field requiring high level mathematics has been evident over the last 15 years. In 2001 approximately 36% of enrolments in all five fields combined were female, in 2016 approximately 35% of enrolments were female.
- Similarly, little change to the gender composition in each of the tertiary fields requiring high level mathematics has been evident over the last 15 years, except in Information Technology which has become more gendered with the percentage of male enrolments increasing more than 10% to 85%.
- Between 2001 and 2015 there were substantially more boys than girls enrolled in the Information Technology, Engineering and Related Technologies and, Architecture and Building fields of tertiary education.
- Approximately equal numbers of boys and girls were enrolled in the Natural and Physical sciences and in the Agricultural Environmental and Related Studies fields.

3.2.3. Phase 2 summary

The following key findings emerged from Phase 2 of the *Girls in Maths* project:

- Girls were significantly less likely to aspire to a career requiring high level mathematics than boys (Boys OR = 1.53). A student's sex had the second strongest effect, behind NAPLAN numeracy score, on aspirations for a career requiring high level mathematics within our sample.
- Differential patterns of occupational interest between males and females were evident within our sample from as early as Year 7 and continued throughout secondary school.
- Girls' aspirations for careers requiring high level mathematics were particularly narrow. Veterinarian accounted for almost 50% of all the occupations requiring high level mathematics named by girls.
- Overall, the aspirations for careers requiring high level mathematics were highly male dominated and broadly mirrored the existing patterns of participation in higher education, with a particular lack of interest shown by females, compared to males, in engineering and information technology.
- Little change to the representation of males compared to females in the tertiary fields requiring high level mathematics has been evident over at least the last 15 years except in Information Technology, which has become more male dominated.

3.3. Phase 3: Systemic forces that influence girls' choice of mathematics

Research Question 3: Are there any systemic forces at work in NSW high schools which might induce girls to prefer to take subjects other than mathematics, even when they profess an interest in mathematics?

Data Source: Semi-structured interviews with 52 participants: 23 Year 10 girls, 15 Year 12 girls, 10 mathematics teachers, and 4 parents.

3.3.1. Why girls choose/don't choose a mathematics subject for their HSC

Thematic analyses of the interviews revealed four key themes which related to girls' choice of a mathematics subject for the HSC. These themes were: subject selection and timetabling; the influence of others; the importance of mathematics; and student dislike of, or lack of confidence in, mathematics. These themes are discussed in turn below.

Subject selection and timetabling

Despite the fact that the number of students undertaking no mathematics for the HSC has been increasing for some time now (Wilson & Mack, 2014), mathematics is still the most popular elective HSC subject (Board of Studies Teaching and Educational Standards, 2016). Girls and teachers indicated that, in regards to subject selection and timetabling, this popularity benefits mathematics in comparison to other elective subjects.

Sansa and Miriam, describe the general process for electing subjects as follows:

> We had to choose six subjects and two back-ups in case they overlap and we sent them in, in like week five. (Sansa, Year 10, High Achievement, Mathematics)
>
> For our subject selection we had to write down our subjects in order of what we most wanted and then down to our back-ups. We had to bring that to school and get teachers to sign it off, sign off each subject. (Miriam, Year 10, High Achievement, General Mathematics)

As Sansa and Miriam outline, students will typically make subject nominations, in order of preference, before any timetabling occurs. Across all six schools it was after students had made their nominations that classes were formed and timetabled by school staff. As the girls discuss, this process sometimes results in missing out on first choices:

> Well, we put our subjects in and they picked… like whichever ones didn't overlap, so I missed out on chemistry. (Sansa, Year 10, High Achievement, Mathematics)
>
> I was interested in doing a science, but then everything ran on lines of stuff that I wanted to do more importantly. Like biology ran at the same time as textiles I think, which was one [textiles] that I really knew I should do, so that's why I didn't do that one. Then something else ran on another line, so yeah. (Chanee, Year 10, High Achievement, No Maths)

> So the actual subjects that I wanted, some didn't run so - because what I want to do in the future is be a photojournalist and have my own business and stuff or be an English teacher. But photography didn't run or geography didn't run so they were the ones that I really wanted because they're sort of based for photography and journalism… I think it's a number of 10 in a class for it to run and there were only four. (Valerie, Year 10, Mid Achievement, General Mathematics)

These statements highlight how issues of timetabling and student quotas for subjects influence, and limit, the availability of subjects for students. However, the girls highlighted that these issues typically have little effect on mathematics as “normally maths and English, but that’s compulsory, normally for maths you always get it” (Leia, Year 10, High Achievement, General Mathematics). With more than 80% of students electing to undertake a mathematics subject as part of their HSC last year (Board of Studies Teaching and Educational Standards, 2016), we argue that students are unlikely to miss out on mathematics because it does not “run” and it is likely to be timetabled at the same time as few, if any, other classes.

In addition, throughout the interviews advanced and intermediate level mathematics students discussed being in classes of as few as one or two students:

> I don't know. I don't know because I know my friend Bailey he's chosen Extension and advanced with me. It's only us two in Extension. But there's only a handful of people doing advanced. (Elkie, Year 10, High Achievement, Extension Mathematics)

> So it's me and then another boy that's in the two unit [Mathematics]. (Elisha, Year 12, High Achievement, Extension Mathematics)

Unlike other subjects, we found no evidence of student quotas being required for intermediate and advanced mathematics to run. However, this may mean attending class before or after school:

> So we do extension in the morning so on Monday mornings and Friday mornings. (Elisha, Year 12, High Achievement, Extension Mathematics)

As Elisha describes, classes for advanced mathematics are often run before or after school and, as such, require substantial commitment and dedication from both the teacher and the students. Elisha reinforces this special effort made when she later discusses that she is “just not a morning person” but, nevertheless, still continues with the subject.

It is notable, however, that whilst we interviewed a range of girls, we were unable to interview any girls who were undertaking, or who had even considered undertaking Mathematics Extension 2 for their HSC. This is not surprising given that only 3% of all girls across NSW studied Mathematics Extension 2 for their HSC last year. Of the six schools at which we conducted interviews, only one school currently had students undertaking Mathematics Extension 2 and, as Bella states, at some schools such as her own, “Extension 2 never gets mentioned… like if you do it, it’s off campus.” (Bella, Year 12, High Achievement, Mathematics). This implies that whilst students have little trouble accessing General Mathematics, Mathematics or Mathematics Extension 1 there may be some restrictions for students who wish to study Mathematics Extension 2. On the other hand, given the small number of students across the state who undertake Mathematics Extension 2, and given that there were no girls in our study who expressed interest in Mathematics Extension 2, we expect that this is rare.

The influence of others

The girls indicated that a variety of resources were available to them to help with their HSC subject selections. For example, Clara, a mathematics teacher, as well as students Miriam and Elkie describe the various processes available at their schools:

> We actually run career nights for the kids to come to and we will give them information and an interview going into subject selection. Whilst they're able to choose the type of maths that's available to them, we are then explaining to them what the different maths looks like in Years 11 and 12 and we make sure that we've got most teachers on board, at least three or four of them, talking to the kids "all right tell me what you want to do, all right let's have a look at that, here's your options." (Clara, Mathematics Teacher)

> [There was a] subject expo and they had all little stalls set up for each subject and you would walk around and find out information about the subjects and they would give you like pamphlets and stuff so you could take it home and read about it. (Miriam, Year 10, High Achievement, General Mathematics)

> I had a subject selection interview and she suggested physics to me but yes it's not running... She just sort of asked about my interests and stuff like that and then because I said I was interested in maths and I wasn't too sure she said that physics has a lot to do with maths and do I reckon I'd do well in it. (Elkie, Year 10, High Achievement, Extension Mathematics)

As the girls describe, schools generally provide a range of opportunities to help students make informed choices regarding their HSC subjects.

Students and teachers indicated that general advice was given for students to choose subjects that they like, were good at or would need in the future. In addition, there was open encouragement for all students to choose a mathematics subject. Chanee and mathematics teachers Brodie and Kurt each discuss this advice:

> I just remember sort of them telling us that we shouldn't choose, you know, based on - like we should make educated decisions. We should choose based on what uni courses [we are interested in]. We should look into that sort of stuff and we should not choose just because we don't like the teacher or just because we don't like - because our friends are in there or just because we find it like easier or anything like that. So yeah, all sorts of standard things. (Chanee, Year 12, High Achievement, No Maths)

> The way that I put it to them is - I don't ever want to discourage them from choosing maths because I love maths and I want everyone else to love maths. So if they're asking me about maths I say if you're good at it, if you like it, or if you need it, choose it. (Brodie, Mathematics Teacher)

> To not worry about what their friends are doing or what teacher they'll have and to look at what career or direction they want to go in. (Kurt, Mathematics Teacher)

Brodie and Kurt convey that there is broad encouragement from mathematics teachers for all students to take a mathematics subject for their HSC, although there is some concern that students may choose subjects based on what their friends are doing rather than what is best for them. However, the girls overwhelmingly stated that their peers had little influence on their choices:

> The girls [my friends] are supportive too, like, we all have different ambitions and we all just support each other for what we want to do I guess. (Brianna, Year 10, Mid Achievement, Mathematics)
>
> My friends were just sort of, like, do what you want. Don't go off what other people are doing. (Gloria, Year 12, Mid Achievement, General Mathematics)
>
> I haven't really spoken to my friends about my choices, but my parents are happy with my choices. (Sansa, Year 10, High Achievement, Mathematics)

These statements highlight that, despite teacher concern, the students are not typically influenced by their friends' subject choices. Each of the girls above recognises that they shouldn't choose "what other people are doing" because they each have their own "ambitions".

Although there was general recognition that friends had little influence on subject choices, the girls often mentioned speaking to their parents/guardians about their choices. This is reflected in each of Carrie, Sadia and Kurt's statements below:

> Because of my Dad. My Dad made me. I had to pick maths no matter what but I'd rather choose the higher scale math and then have the option [to drop back]. (Carrie, Year 10, High Achievement, Mathematics)
>
> It's just always I guess my family and stuff have always told me it's really important, so that's just how I've come to feel about it [mathematics]. (Sadia, Year 12, Mid-Achievement, General Mathematics)
>
> [The two girls] have thought about dropping out quite a few times but I think one of them has got grandparents that want them to keep doing it [Mathematics Extension 1] and so it's pressure from the guardians. (Kurt, Mathematics Teacher)

As described, mathematics is generally recognised as important and this recognition often results in expectations from parents or guardians to elect to undertake, or to keep taking, a mathematics subject. We argue that much of this expectation arises from the important link between mathematics and many future career opportunities.

The importance of mathematics

Among the Australian public, mathematics is seen as an important subject for everyone to study and an important subject for employment opportunities (Forgasz & Leder, 2017). As Gloria, Sadia and Marion each state, there is a perception of mathematics as useful for developing life skills, for future job prospects and/or for future studies:

> I figured it [mathematics] was kind of essential as well for afterwards, especially with the finance section in general maths that we do; helping with bills and things like that. (Gloria, Year 12, Mid-Achievement, General Mathematics)
>
> Just from what I've seen and like entering universities and stuff, there's always, you know, you need maths to do this and that and, I don't know. (Sadia, Year 12, Mid-Achievement, General Mathematics)
>
> I did say to her, "I dropped the subject [mathematics] in school when I could because of the teacher. Don't do the same thing. Try and stick it out." And especially with the way jobs are,

> like, what jobs are going to be on offer, you know, I was concerned that it would be a really important subject to stick out. (Marion, Parent)

These statements highlight that the status of mathematics, as an important subject linked to many future opportunities, plays an important role in encouraging students to select a mathematics subject for their HSC.

Another student, Tara, discusses how the status of mathematics influenced her choices:

> Well, I don't know what I want to do, so I just picked those subjects because I was interested in a lot of them… I was actually going to pick maths, but when I got there I decided to change it just because I found I was only putting it there because it looks better to have it on your ATAR because a lot of jobs require you to – well like a lot of Unis and stuff like that would rather if you had maths on there and that's why I was going to do it. (Tara, Year 10, Mid-Achievement, No Mathematics)

As Tara illustrates, there is often a struggle between the importance of mathematics and disinterest, or lack of confidence to achieve, in the subject. For Tara the concerns of it 'looking better' to take mathematics resulted in a long deliberation, before a last-minute decision to choose what interests her, and what she feels she would do well at, instead of what 'looks good'.

For others, as Nancy, a mathematics teacher, discusses, the recognition of mathematics as important for the future outweighs their interests:

> They either just have no interest in maths whatsoever, which I think is just the general view that they've brought through the entire way through. Kids that say that they're not good at maths still generally do maths in Year 11 and 12, they just pick General 1 [non-ATAR mathematics], or they move towards General 1 in Year 12, because it's still also a view that maths is very important, maths is everywhere and you need to know how to do maths. So they still want to do it, but they don't want to do much of it. Yeah, which is interesting for the kind of contrast with the 'you're either good at it or not good at it', but people still understand that it is needed. The ones that don't [pick maths at all] are just, they're kind of, they don't see that they need it for what they want to do, like I had one girl that wanted to be a journalist, and she said "I don't need maths, I really don't need maths for it". And I said "Alright, like you can definitely learn reasoning skills from it and everything", but her list of subjects that she chose were all directly towards journalism. And so it was all society and culture kind of things, world things, and so she did the highest level of English, stuff like that. Yeah. (Nancy, Mathematics Teacher)

As Nancy conveys, most students will choose to undertake a mathematics subject for their HSC as students "still understand that it is needed". However those with little interest in the subject are likely to choose the easiest option available to them and, as such, it is only common for students who perceive mathematics as entirely not useful to them, or who really have "no interest in maths whatsoever" to choose no mathematics for their HSC.

Dislike of and confidence in mathematics

A key theme amongst the students who chose to undertake no mathematics for the HSC was a dislike for, or lack of confidence in, the subject. For example, Stacie describes her decision not to study mathematics for the HSC:

> I don't know, I just never really… I've always sort of just… not liked math at all, and so when the opportunity arises to never have to do it again as a school subject… I was just like, "Yes, I'm definitely not going to do that." From like Year 7 when I found out you could drop math…I was like, "I'm not going to do math in 11 and 12." So that was sort of just set in my mind since then. And I don't know, just the whole process of maths has always just made me frustrated and… I don't know, I just felt like I couldn't do it. Yeah. It's just hard. (Stacie, Year 10, High Achievement, No Maths)

Stacie's decision not to study mathematics was made long before Year 10. For Stacie, it appears that her lack of confidence in mathematics shaped her negative relationship with the subject. Stacie's experiences illustrate the importance of helping girls develop confidence in their mathematical capabilities. Even though she has previously demonstrated that she is a capable student, evidenced through her high NAPLAN numeracy results, she declares "I just felt like I couldn't do it."

The effect of confidence in mathematics is also illuminated by Tara who, early in her interview, outlines that not choosing mathematics was a last minute decision:

> I think it's a shame that everyone's not super confident to like at least do maths standard. I don't know, as it does look good on your thing [HSC], but I know, I guess everyone's different and you're only good at what you're good at. (Tara, Year 10, Mid-Achievement, No Mathematics)

For Tara, despite the fact that she sees clear value in undertaking mathematics, as 'it looks good on your thing', her confidence to get good marks in the subject motivates her choice, at least in part, not to undertake mathematics for her HSC.

For other girls, confidence plays a smaller role in their decision not to study mathematics, with factors such as interest, enjoyment and future use most influential. For example, Chanee and Marissa each describe their decisions not to study mathematics:

> I just didn't really enjoy maths that much and I didn't really need to do it for any course, so I felt, like, doing something that I didn't enjoy for no reason, there wasn't really much point in doing that. (Chanee, Year 12, High Achievement, No Maths)

> I'm not that interested in maths. It's something that confuses me, and I just don't like. It just isn't something that really clicks with me. (Marissa, Year 12, Mid Achievement, No Maths)

It is noteworthy that we did not interview any girls who professed an interest in mathematics but did not choose a mathematics subject for their HSC. All girls who did not choose mathematics, like Chanee and Marissa above, generally labelled dislike of and/or confidence in mathematics as their reason for not selecting a mathematics subject.

3.3.2. Why students choose General Mathematics vs. intermediate or advanced mathematics

Thematic analysis of the interviews revealed three key themes which related to student choice of General Mathematics vs. a high level mathematics subject for the HSC. These themes were: workload; confidence in relation to marks and ATAR scaling; as well as need for future career. These themes are discussed in turn below.

Workload

A key difference between General and high level mathematics is student workload. As Cassie, a mathematics teacher, describes, students are required to work hard to succeed in the calculus-based mathematics courses:

> What's involved in, you know, succeeding… and that is to… work consistently, practice, revise. (Cassie, Mathematics Teacher)

In contrast to the consistent practice and revision required to succeed in the high level mathematics courses, Sahara describes the workload of the General Mathematics course:

> Well because a lot of the kids that are in the [General Mathematics] class have always been in the top classes of math we all sit there and say that General is the easy math because it's very much for the most part just expanding on what you already know. It's just the old topics just added onto almost, and we just find it really really simple and that's why we decided yeah we'll call it, like, that's the easy math and then you've got the actual math being Mathematics because a lot of us all sit there and say we could have taken Mathematics if we wanted but that just wasn't a sensible idea with the other classes we take and how we've seen everyone else react to the Mathematics course. (Sahara, Year 12, High Achievement, General Mathematics)

Sahara discusses a considerable difference in complexity as well as time and effort required between the General and Mathematics courses. As such, many high achieving mathematics students, like Sahara, decide to undertake the "easy math" for their HSC because it brings less stress and a very light mathematics workload, which therefore gives students more time to work on their other subjects.

Similarly Miriam, a current Year 10 student, discusses how the workload of the intermediate mathematics course discouraged her from selecting a high level of mathematics:

> They [our teachers] told us that we are all capable of doing advanced [Mathematics] in our class… [But] I think that would be like a lot of workload especially because I'm doing biology, PDHPE and advanced English. I just think it [Mathematics] would be too overwhelming for me with all that work and stuff. (Miriam, Year 10, High Achievement, General Mathematics)

As Miriam outlines, the workload involved in undertaking a high level mathematics course, particularly when combined with the workload of other courses such as Advanced English, can be overwhelming for students. Indeed this is the case even for students like Miriam who are told that they are capable of "doing advanced". Sadia describes why this may be problematic:

> A couple of people started off with advanced [Mathematics] and went back to standard [General Mathematics]. I think that's the only way that you could do it. You can't move up. You can only move down. (Sadia, Year 12, Mid Achievement, General Mathematics)

As Sadia describes, the fact that capable students like Miriam are deterred from even trying a high level mathematics course can be problematic as students can't usually choose to "move up" later if they find the non-calculus General Mathematics course to be "really really easy". However, as indicated by Cassie, movement from Mathematics into General Mathematics is common:

> We have had girls - girls particularly, but not just all girls, who have started the higher [intermediate] level and they've found that it's just too much for them and for them to succeed would involve far too much time and effort. So… they've changed levels and gone for the less complex [General] maths. (Cassie, Mathematics Teacher)

Cassie's statement highlights that the workload of the calculus-based courses is a challenge students must overcome, both in their selection of the course and in studying the course through to the end of the HSC.

As Sahara outlines, sometimes this transition from Mathematics to General mathematics is not smooth:

> They either get halfway through the course and they drop down and I've also seen a fair few of my friends just have mental breakdowns because of the amount of work that's gotta go into the course and how hard it eventually gets. We just look at it and we're like "nope, okay, good thing we picked general. I couldn't handle that." (Sahara, Year 12, High Achievement, General Mathematics)

While it may be problematic that high achieving students are discouraged from attempting the intermediate mathematics course due to its high workload, as Sahara describes, the warnings given to students about the workload are not unfounded. Schools must therefore carefully balance warnings about workload with encouragement and support for students who show an interest in high level mathematics.

Nancy and Kurt explain that the transition from intermediate to the first advanced mathematics course is somewhat smaller than the transition between General and intermediate mathematics:

> I can get most of my mathematics kids to do Extension 1, because it's just little bits tagged on the end, and it really helps their Mathematics. I explained that it's like you have 10 questions, and the Mathematics kids can get up to question eight, so question eight is the hardest question there [that] they can do, while the extension kids can do question 10. (Nancy, Mathematics Teacher)
>
> Well what I find is if they do Extension 1 their Two Unit [Mathematics] marks also rise, so even if they bomb out at Extension 1 because of the influence that it has on their Two Unit [Mathematics], you know, who cares if they don't get the one unit. (Kurt, Mathematics Teacher)

As both Nancy and Kurt outline, due to the similar nature of the course content, with Extension 1 Mathematics building on Mathematics content, students who undertake the 1-unit Extension 1 course in conjunction with the 2-unit intermediate Mathematics course will generally benefit from increased Mathematics grades.

Reinforcing this benefit Elicia, an Extension 1 Mathematics student, reflects on her experiences:

> You've really got to draw out every aspect of the question. In two unit you just find a keyword and you're like, "Okay, so I have to do this," but in extension you've got to show something

> from something else so you've got to have quite abstract thinking. (Elicia, Year 12, High Achievement, Extension Maths)

While Elicia describes Extension Mathematics as requiring “abstract thinking”, she later describes the intermediate mathematics course as “quite easy” in comparison.

However, similar to the large gap in complexity, effort, and time required between General Mathematics and Mathematics, the teachers identified that there is a large difference between Mathematics Extension 1 and Mathematics Extension 2.

> Extension 2, it definitely does pull from their other subjects, because it’s a lot of work and not much time to do it. And it’s very different to anything else that they have really studied. There’s quite a big jump between Extension 1 and Extension 2. (Nancy, Mathematics Teacher)

This ‘jump’ and ‘pull from other subjects,’ given the amount of time and effort required to be successful in Extension 2, is a determining factor for student participation, according to Nancy:

> Definitely one of the girls that I want to do Extension 2 probably won’t. But that’s just because she’s a very all round kid, and she’s working hard at all her subjects, and so Extension 2 is a lot of work for her to put on top of all the work she’s already doing. (Nancy, Mathematics Teacher)

Confidence, \marks and ATAR scaling

In addition to higher workload, students identified pressure to score high marks in order to maximise their ATARs and HSC scores as key influences in their choices surrounding the appropriate level of mathematics to undertake. Marion, a parent, outlines the effects of the focus on marks on her daughter’s subject choices:

> I don't think it's so much whether it's an interest or not. It's she wants to do nursing so - and she was told from the school to do whatever you're going to get a great mark, do because that's what you need to get into uni. So her course selection has been more guided by what can you go really great in to get the marks for uni. So, yeah, that's where that's at. (Marion, Parent)

As Marion outlines, both teachers and students are aware of the competitive nature of university entrance and this plays a significant role in subject choice.

However, whilst students were aware of the competitive nature of university entrance there was some confusion about how the ATAR calculations work. In general the girls were of the opinion that the intermediate course Mathematics scales slightly higher in the ATAR calculations than General Mathematics. For example, Carrie outlines her knowledge of ATAR scaling:

> I'm pretty sure your marks get – say you get 80 per cent in Standard [General Mathematics]. You'll probably go to a 75 per cent towards your ATAR but if you got 80 per cent in Advanced [Mathematics] it would probably get scaled up to 85 per cent. (Carrie, Year 10, High Achievement, General Mathematics)

Similarly Gina outlines how the ‘low scale’ of General Mathematics affects the ATAR score:

> They always say – the same with Standard English. To go good, you have to get a band five or a band six to be scaled well because I think the majority get - I don't know. That's what they say. Whether they're just saying that... (Gina, Year 10, Mid Achievement, General Mathematics)

However, despite the fact that students noted that high level mathematics gets "scaled up" there was a general notion that this was not enough incentive to undertake the course:

> I'd rather sit there and do really well in General than do mediocre in Mathematics, just in the long run, in general, it would be more sensible for my ATAR. (Sahara, Year 12, High Achievement, Mathematics)

Sahara's clear understanding is that it is less of a challenge for a high achieving student to do really well in General Mathematics and, doing well in General Mathematics is perceived as being more beneficial than receiving a small scaling advantage on top of a mediocre Mathematics score.

Tara and Lizzie further explore the effects of the focus on marks and poor ATAR incentives:

> I don't know if many people did pick maths Advanced because I know my friend group is mainly people who are in top class. I know a lot of them were doubting picking Advanced because even though they know they're capable of it, just in case they would rather do General and do very well rather than slip up and then just do average in Advanced. (Tara, Year 10, Mid Achievement, No Maths)

> I was doing really well at the start of the preliminary Advanced course because I wasn't as busy. But as the year went on, I was getting involved with a lot more things at school and out of school and I found it hard to keep up with some things. I'd try to but I just couldn't remember anything and during prelim I kind of bombed out and didn't do as well as I wanted to. Then my teacher said, "Oh, you should consider going down to General because you might get a good mark there." So I did. (Lizzie, Year 12, Mid Achievement, Mathematics to General Mathematics)

As Tara and Lizzie discuss, the pressure of getting good marks can discourage interested students from both selecting a high level of mathematics and from continuing with a high level of mathematics until the end of the HSC.

Need for future career

With intermediate and advanced mathematics courses generating a higher workload, and perceived to attract only small ATAR advantages to compensate for this, the majority of girls who chose to undertake intermediate or advanced mathematics were either very confident in their mathematical capabilities to achieve more than a "mediocre score" or, more often, required a high level of mathematics for their future study plans.

For example, Clara and Elkie describe the types of student who chooses to undertake a high level of mathematics:

> We've got kids that want to be architects, we've got kids that want to be engineers, there's quite a few that want to be a vet, not sure if we've got any doctors in the current year but there's a few vets in there, so they are choosing it to have that high level. (Clara, Mathematics Teacher)

> Obviously if they're confident with themselves in it and if they want to do further study in maths. (Elkie, Year 10, High Achievement, Extension Mathematics)

As a further example, Sahara shares her own experiences of choosing General Mathematics as a high achieving student:

> I wanted to continue on with math because I do enjoy math but with my career pathway I am aiming towards [humanities teaching], math is not completely vital so I went for a lower level math. (Sahara, Year 12, High Achievement, General Mathematics)

Sahara's personal experience highlights that students who enjoy mathematics, but do not need a high level for their future career or study, will often choose General Mathematics. For Sahara, who "could have taken Mathematics if she wanted to" the higher workload and small ATAR scaling advantage is not worth it when, intermediate mathematics is not needed for her future and, she can "sit there and do really well in General" with little effort.

For many of the girls, it was a teacher who provided the advice to only choose to undertake high level mathematics if it is relevant to their career. For example, two girls share their personal experiences of the advice they received from their teachers:

> I talked to one of my teachers and she was like "do Standard [General Mathematics], you'll breeze through it and there'll be less stress on you with all the other subjects." But I did really consider doing the Advanced [the intermediate course, Mathematics]… She asked me what I wanted to do and then she was like "you don't particularly need all the stuff that's in advanced" so she told me to do Standard and that I'd do really good at it." (Lena, Year 10, Mid Achieving, General Mathematics)
>
> Well the only one I wasn't really sure about was the Extension Math because the head teacher did say if I didn't want to do a job that involves math there would be no point but I had no idea what I wanted to do, so he just sort of wasn't really much help. But I talked to my teacher and he said the best option would be Extension then I can just always drop it if it's too hard. (Elkie, Year 10, High Achieving, Extension Mathematics)

Both Elkie's and Lena's experiences demonstrate that while mathematics, as a whole, is viewed as important for developing life skills, for future job prospects and for future university studies, the higher levels of mathematics are often viewed as relevant for tertiary preparation only.

However Clara, a mathematics teacher, explains why the advice to align the mathematics choice with your future career and study goals is given to students:

> The universities love you to do the higher level maths. The universities want you to do the highest level maths that you can do. The disadvantage would be if it really was above your ability and you were choosing it and that could cause a lot of stress and you're not necessarily going to get the marks and it's not going to count. Yes, it will be on your HSC, which is great, but if it's not needed, and you're not up to it, go choose something that is going to be of value to you that you stay engaged with. (Clara, Mathematics Teacher)

As Clara explains the high level mathematics courses are challenging and, as a result, students can become disengaged if the level of maths is not immediately needed for their future study plans. Clara also mentions the effects of the courses being "above a student's ability". Throughout the interviews we noted that, in some cases, students were encouraged to drop out of the intermediate calculus course, because it was perceived to be 'above a student's ability' or not appropriate for the student's grades, regardless of their career aspirations.

As many universities no longer have firm prerequisites for entry into a degree requiring high level mathematics, students are able to enter into degrees, such as engineering, having undertaken elementary, or even no, mathematics for their HSC (King & Cattlin, 2015). This means that teachers and students often focus on marks and minimising student workload, rather than adequate mathematics preparation.

For example, Hope discusses her friend who was told to drop down into the General Mathematics course in order to achieve better results:

> Yeah, and he wasn't really getting good marks and I think the teacher said "if you move down you'll get better marks", I know he just got 93% in trials." (Hope, Year 12, Mid Achievement, General Mathematics)

As is later discussed in the interview, Hope's friend wishes to "go to uni" and do "engineering and all that stuff".

Similarly Bella describes her personal experiences:

> I've had a lot of teachers just like "nup, you should drop, like why are you even doing this subject [Mathematics]?", and I'm like "why not? Like it's good to have that subject behind me because I want to do a bachelor of science"… there's always that component of problem solving in science. (Bella, Year 12, High Achievement, Mathematics)

Bella's experiences highlight the complex interaction between the need for high level mathematics for future study and the need to score good marks to be able to enter into the degree. Bella later says that she has struggled in the Mathematics course, but is determined to see it through because it is of great interest to her and her imagined future.

3.3.3. The experiences of girls in mathematics

Two additional themes emerged from the data as important to the experiences girls have, and the relationships girls develop, with mathematics. These themes, the influence of early mathematics experiences and the important role of the teacher, are explored below.

The influence of early mathematics experiences

As Clara states, the early experiences girls have with mathematics are vital:

> I think by the time we've got them into Year 11 and 12 their life choices or their life experiences are sort of forming before we get to them. (Clara, Mathematics Teacher)

Clara's statement highlights that many students' future life goals and occupational aspirations have formed long before senior school. This demonstrates the importance of improving the early experiences girls have with mathematics and with non-traditional career fields.

In particular, a critical period for teachers to develop and maintain a positive attitude of girls to mathematics is Year 7. As Brodie discusses, Year 7 is a time of incredible change for students:

> I teach a top Year 7 class. Generally speaking they're pretty engaged and they've come from primary school and a lot of them have come with a love of maths because of that which is really great at the start of the year but they've slowly some of them have weaned off loving maths and they – I'm thinking of a group of girls in particular. They've decided they don't like it anymore. In my other classes we have a small pocket of kids who like maths as a subject. Some kids just like being in my classroom because I do things a little differently sometimes but more kids than not probably have a bit of a stigma. I just had an argument with a student before because they didn't like maths.
>
> When they're in Year 6 one of the girls described it to me – she said, "Our teacher would get us to sit on the carpet at the start of every lesson. We'd have concentrated instruction and then we'd go to our tables." They were used to that routine. High school's a change and aside from it being a change they're also developmentally changing and social structure is changing. There are more kids. There are more - it's uncool to be good at maths. That's what I'm finding the kids – they just think it's lame to be smart. (Brodie, Mathematics Teacher)

Brodie's statement demonstrates that the changes students go through in Year 7 can, and often do, result in students developing negative perceptions of mathematics. This makes Year 7 a critical time to prevent students "weaning off" mathematics.

As Cassie explains part of the changes that happen in Year 7 relate to the ways in which students are taught mathematics:

> That's a hard one. Interest versus confidence, I think there'd probably be a lot of students that turn up here from primary school and they're quite, you know, keen for their maths. In the last, say, 6 to 10 years they've come from primary school having played lots of games in maths. Then they get to high school and there tends to be a lot more theory, book work, that sort of thing. So a lot of them do tend to lose interest. But also I think that a lot of the lack of interest is the lack of success. A lot of them, I feel anyway, is that they don't have that resilience to keep trying. If they get it wrong or they don't understand it, they don't actually push themselves to keep going until they do actually understand. (Cassie, Mathematics Teacher)

Cassie's discussion of the difference between primary school and Year 7 highlights the difficult, and often very fast, transition students must navigate between learning concrete mathematics in primary school, often through interactive class activities and games, and having to learn more abstract mathematical ideas with a higher reliance on teaching methods such as textbooks. Cassie also highlights that the teaching strategies and assessments employed in high school often do not provide students with enough opportunity to be successful and to feel that they are capable of learning these new abstract ideas.

Students also noted the difference between primary and secondary school mathematics. Stacie describes her experiences:

> Yeah, well… most of the time… in primary school, I was better at it, probably, because it was easier, and I could manage it. And then suddenly when I got to high school, it seemed like everybody else had learned all this stuff in primary school that we hadn't, and so I sort of dropped back a bit. (Stacie, Year 10, High Achievement, No Mathematics)

For Stacie, comparing her achievements with other students and not being given enough opportunities to feel successful in her own mathematics learning led her to lose her confidence in mathematics ability. This had a lasting effect on her, as demonstrated by her decision not to undertake any mathematics for her HSC. Stacie decided this in “like Year 7” as soon as she found out she “could drop math” in Year 11 and 12.

For other students, algebra was identified as the critical obstacle in their mathematics journey. For example Allie and Stacie detail their experiences of algebra:

> Yes. I'm okay at the basic maths but as soon as they start putting letters and the stuff into it I'm just gone. (Allie, Year 10, Mid Achievement, General Mathematics)

> Just like the whole learning process – like trying to grasp a new thing that’s like… totally not related to anything else you’ve ever done; or you’re just wondering, “Where am I ever going to use this in my life?” Like, we did algebra for a year, and I was like, “When am I ever going to use this?” So then I decided to get this attitude that was like, “Oh, math is pointless; I don’t need math.” (Stacie, Year 10, High Achievement, No Mathematics)

Stacie highlights that teachers, and the way mathematics is taught, play an important role in helping students understand and engage with topics such as algebra and that making real-world connections is an important teaching strategy. Cassie, a mathematics teacher extends this notion:

> Because I think a lot of students think maths is arithmetic and, you know, they think that's all they need to - their numeracy skills. So they don't want to make - a lot of them find algebra particularly difficult and obviously it depends on how it's presented of course. But in the end it is a thinking thing in that a lot of them, they find it too complicated. They can't get their - too many symbols, that sort of thing, getting their head around it; different language. (Cassie, Mathematics Teacher)

Cassie’s statement highlights that the way algebra is presented to students can improve their understanding of the topic. However, in general, many students find algebra difficult. As the concept that pronumerals (letters) can be used to represent numbers is first introduced to students in Year 7 (Board of Studies NSW, 2012), this is one of the first abstract concepts students encounter and is further evidence of the critical role teachers of Year 7 students play in developing and maintaining students’ relationships with mathematics through the transition into higher level mathematical thinking.

The important role of the teacher

Central to almost every experience girls have with mathematics is their teacher. As such, most girls were very quick, in the interviews, to discuss their mathematics teachers and the important role of those teachers. Mathematics teachers were identified as important to both choice of mathematics and choice within mathematics.

As Kurt and Arielle explain, the teacher plays an important role in student subject selection:

> Yesterday we had a meeting for the Year 10 students choosing the subjects, and it was about the ATAR, and some students want to know which teacher is the teacher in which maths course because they want to choose their subjects based on who the teacher is. (Kurt, Mathematics Teacher)

> I haven't talked to Miss, but because I originally went to this school, then I moved away and then I came back, I do know her and I get along really well with her, which is part of the reason that I chose to do maths. Because when I have a good teacher for a subject I tend to excel in it more than, you know, if I didn't… (Arielle, Year 10, High Achievement, General Maths)

Similarly, mathematics teachers play an important role in the choice students make within mathematics. This is shown in the contrasting experiences that Brianna and Gloria relay surrounding their subject selections:

> Well, originally I was finding the top class hard and I was just sitting there one time and he asked me to come out. He was, like - I was, like, I would like to move down and he thought I was doing well up in the top and he's, like, that he would like me to do advanced in the next year. That's that I got approached next year to do advanced [intermediate level mathematics] and Extension 1 so I'll just give it [intermediate level mathematics] a go and you can always, like, go down. You can never move up. (Brianna, Year 10, Mid Achievement, Mathematics)

> I kind of regret not taking up advanced [intermediate level mathematics] in year 11… I had my maths teacher say to me - he kept fluctuating between saying, "You should do General, you should do advanced." Then mum just went - I think it was me maybe. I was sort of, like, "Oh, yeah, I'll just do advanced and I can drop down later on." Then I went, "Actually, no, I don't think I want to do that because of my final exam" - because we had topic tests every couple of weeks in Year 10 and my last one wasn't the best, but the one before it was really good, which was when I was sort of, like, tossing up between General and advanced. Then I went with General when I should have done Advanced because I could have just dropped down if I wanted to." (Gloria, Year 12, Mid Achievement, General Mathematics)

For both girls, confidence in their potential to successfully complete a high level of mathematics for their HSC was relatively low. Both girls were in similar situations being in the top classes of their school (Gloria also identifies this in her interview) and achieving at a mid-level. However, Brianna's mathematics teacher approached her with the advice to attempt a high level mathematics subject, instilling within her the confidence to attempt the intermediate mathematics subject. In contrast, Gloria's mathematics teacher "kept fluctuating" in his advice, which let Gloria's lack of confidence in her mathematical capabilities lead the decision to not attempt a high level mathematics course, a decision which Gloria admits she regrets. Importantly, Gloria was locked into her decision, with the option for Brianna to "drop down" to the General Mathematics course available if needed, but no option for Gloria to increase into the intermediate level later on.

Similarly to Gloria and Brianna, Bella discusses the influence of confidence and her mathematics teachers:

> I think the teachers need to be promoting, like yeah it's Extension 1, but we'll be there to support you. It never crossed my mind to try it because of that fear [of the course] really. (Bella, Year 12, High Achievement, Mathematics)

Bella's statement highlights that advanced mathematics is seen to be a challenging subject amongst students. However Bella believes that it can be overcome with the support of a teacher.

Mathematics teachers were also identified by the girls as highly influential in regards to their overall experiences of mathematics. Gina demonstrates an important example of this:

> Well in my junior years I didn't really pay attention to math or anything. I didn't really like it and everything. It wasn't until I got into Year 11 and 12 where I actually started to enjoy math. I don't know if that's just because of the teacher I have now as well. I really enjoy the way he teaches and stuff.
>
> I never had him until Year 11 either so maybe if I did have him it would have been my interest in math would have started a lot earlier I guess. I don't know. (Gina, Year 12, Mid Achievement, General Mathematics)

Gina’s experiences demonstrate how a mathematics teacher can positively influence the relationship students have with mathematics. Gina’s mathematics teacher has helped her transform from an individual who ”really didn’t like” mathematics to a very interested motivated mathematics student who states that maths is now ”one of my favourite [subjects]”.

Arielle also elaborates on this topic stating that:

> I think having a good teacher and having - I think that was actually the main - that’s the kind of main factor in how well I do in maths really, is the teacher’s ability to just kind of work at a pace that you’re comfortable with and just be able to thoroughly explain things and therefore, I guess, that’s reflected in the work that you do and the things that you achieve. (Arielle, Year 10, High Achievement, General Maths)

For Arielle the teacher is the main variable in her enjoyment of, and achievement in, mathematics.

Finally, Sadia describes how important her mathematics teacher was to her:

> Well, she was very important because she was obviously the one that when I didn’t understand something, she would be the one that actually knew how to explain it and I wouldn’t have got as far in maths without her. (Sadia, Year 12, Mid Achievement, General Mathematics)

As Sadia describes, no student would go ”as far in maths” without their mathematics teacher. This makes mathematics teachers, the way mathematics is taught, the relationship mathematics teachers have with their students and the advice mathematics teachers give to students some of the most important variables in a student’s mathematics education.

3.3.4. Phase 3 summary

The following key findings emerged from Phase 3 of the *Girls in Maths* project:

- Teachers indicated that students who are interested in mathematics typically elect to undertake at least one mathematics subject for their HSC. No girls were interviewed who expressed an interest in mathematics but did not choose to undertake a mathematics subject. The girls who chose not to undertake mathematics expressed a perception of mathematics as entirely not useful to their future career or study goals and articulated dislike, disinterest, and/or lack of confidence in mathematics.
- Students who elect to take a mathematics subject for their HSC usually have few issues with timetabling of mathematics given mathematics' popularity as an elective subject. Unlike other subjects we found no evidence of student quotas required for high level mathematics courses to run. However, Mathematics Extension 2 is rarely, and possibly never, undertaken at some schools and students undertaking Extension 1 Mathematics, in small classes, may have to attend these classes before or after school.
- Mathematics is widely recognised as important for a wide range of future opportunities, including both university entrance and non-university job prospects. This leads to a wide range of students choosing to undertake a mathematics subject for their HSC. However, high level mathematics is typically only recognised as important for tertiary preparation. This discourages interested mathematics students who do not wish to pursue, or who are unsure whether they will pursue, a degree requiring high level mathematics from enrolling in high level mathematics courses.
- A range of additional issues were identified to influence girls' choice within mathematics including: perceived and actual high workload, pressure to score high marks due to competitive university entrance procedures, inadequate ATAR scaling compensation for students who choose to undertake high level mathematics, and the removal of university prerequisites.
- Girls' early experiences with mathematics are influential in shaping their future choices. In particular, Year 7 was found to be an important year for developing and maintaining students' interest in mathematics. The ways in which teachers transition students into learning new abstract concepts, such as algebra, can have lasting impact on whether a student will remain interested in mathematics into the future.
- Teachers were also identified as playing an important role in instilling mathematical confidence in girls, which was identified as a barrier to girls' choices of and within mathematics. Additionally, our results demonstrated that mathematics teachers, the way mathematics is taught, the relationship mathematics teachers have with their students and the advice mathematics teachers give to students are some of the most important variables in a student's mathematics education.

4. Discussion

> Divergent attitudes formed by girls and boys in childhood—such as confidence in their abilities to apply mathematics to problem solving—have far reaching implications for the opportunities available to them in adulthood. (Office of the Chief Scientist, 2016, p. 4)

This project drew upon state-wide HSC and university enrolment data, *Aspirations Longitudinal Study* survey data, and semi-structured interviews with students, teachers and parents to investigate the decision-making process surrounding girls' participation in high level mathematics. Through our investigation we provided a detailed account of: (1) girls' and boys' participation in high level HSC mathematics; (2) the aspirations of girls in secondary school for careers requiring high level mathematics; and, (3) factors that influence students' decisions to/not to participate in high level mathematics.

Our analysis revealed that high level mathematics remains a male dominated domain with girls still far less likely than boys to participate in intermediate and advanced mathematics in 2016. We found that whilst the balance of males and females in advanced mathematics subjects has remained stable since 1991, the intermediate level mathematics subject has become slightly more male-dominated over time, with proportionally fewer girls than boys electing the subject over time. Given increasing need for qualified graduates in fields requiring high level mathematics (Nicholas et al., 2015; PricewaterhouseCoopers Australia, 2015), these trends are concerning in economic and social justice terms.

Moreover, our analysis highlighted broad issues across senior secondary mathematics as a whole, with participation in high level mathematics subjects declining substantially for both boys and girls over the last few decades. With increasing diversification of the HSC student cohort and, as such, increasing numbers of students with diverse aspirations completing Year 12 (Dekkers & Malone, 2000; Reid & Young, 2012; Smith, 2004), it is not surprising to find some decline in participation in high level mathematics over time. However, our findings showed that these declines in participation reflect real declines in the number of students undertaking high level mathematics. These findings align with well-established trends with, for example, the Mathematics Association of NSW (MANSW) reporting in 2013 that:

> The NSW education system produces approximately 3,000 fewer calculus trained students per year than it did in 2001. This represents a drop of 13% over 12 years. The majority of the decline in calculus trained students is in the [intermediate] Mathematics (2 Unit) only cohort, with a decline of 18% since 2001. Student enrolment[s] in Extension 1 and Extension 2 have been more stable over the period. (Mathematical Association of New South Wales, 2013, pg. 10)

In addition to declining participation in, and lower levels of female engagement with, high level mathematics in secondary school, our analysis revealed lower levels of female interest, compared to males, in careers requiring high level mathematics, both in aspiration and in current tertiary level participation. Of particular note, the aspirations of secondary school girls, from as early as Year 7, aligned with existing female representation in higher education, with higher education enrolment trends showing that girls have been less likely to enter into fields requiring high level mathematics in NSW since at least 2001. Whilst our analyses of enrolments in higher education in NSW were restricted to 2001–2015, past research has shown that the underrepresentation of females in tertiary fields associated with high level mathematics is a deeply embedded trend, which has persisted internationally and has changed little over time (Bradley, 2000). In particular, we noted that there was a real dearth of interest shown by females in engineering and information technology. Given that these are two of the fastest growing fields in Australia (Australian Bureau of Statistics, 2015), there is a clear need for targeted intervention programs that address the gendered nature of these fields if girls are to be attracted in greater numbers.

The fact that girls were less likely to aspire to a career requiring high level mathematics was a relevant factor in girls' underrepresentation in high level mathematics at secondary school. Our analysis of interview data revealed that the need for future career was an important influence on whether girls chose to undertake high level mathematics for their HSC. Whilst mathematics, in general, is seen to have high relevance to university preparation as well as non-university job prospects and life skills (Forgasz & Leder, 2017), our analysis showed that high level mathematics in NSW was predominately viewed by teachers to be useful for tertiary preparation only. This perception results in active discouragement for students to undertake a high level of mathematics unless it is relevant to their future career goals. Given that secondary school girls are less likely to aspire to a career requiring high level mathematics we argue that this disproportionately discourages girls from participating in high level mathematics, which in turn prematurely closes a range of careers to girls by restricting the ease with which they can later pursue a career requiring high level mathematics if they choose to do so.

In addition to the need for future career, issues surrounding workload, focus on marks due to the competitive university entrance system, and ATAR scaling were all identified to interact in multiple complex ways to discourage interested, and/or high achieving, girls from participating in high level mathematics. Our results showed that students and teachers believed, in regards to ATAR scores, it was better for a high achieving student to undertake the General Mathematics course and score highly than to undertake the intermediate mathematics course and potentially achieve a lower score. Although BOSTES (2016), now NESA, states that this advantage is a 'perceived' advantage only, recent research has found that these perceptions are, in fact, true. The Centre for Education Statistics and Evaluation (2017) demonstrated that in 2013 the average scaling advantage for students choosing General Mathematics over Mathematics was 5.3, the equivalent to 1.3 ATAR points. This is partly due to the fact that Mathematics only students are competing with 3 Unit Mathematics Extension 1 students for high exam marks, and so are unlikely to score marks as comparatively high as they could in General Mathematics (Mathematical Association of New South Wales, 2013). Workload also plays a role in this scaling advantage, with the smaller workload associated with undertaking the non-calculus course, General Mathematics, giving students the opportunity to spread more time and effort across other subjects and, hence, improve their grades all round. Again, we argue that these systemic factors disproportionately discourage girls, who are more likely to have lower confidence in their mathematical skills (Perez-Felkner et al., 2017), and hence are more likely to have lower confidence in their ability to manage the higher workload and to score well in the higher levels of mathematics.

It is important to note that changes are forthcoming in relation to ATAR scaling. At the end of 2016, NESA announced that, as part of a suite of reforms which will be introduced with the new HSC mathematics courses in 2019, mathematics courses will soon be marked on a common scale:

> English is already marked and reported on a common scale, allowing a reliable comparison and guarding against any perceived advantage for academically able students sitting a less-demanding English course. Placing the mathematics courses on a common scale will similarly

> discourage students from taking courses for a perceived ATAR advantage. (Board of Studies Teaching and Educational Standards, 2016, pg. 18)

However, this change alone is unlikely to improve participation in high level mathematics, particularly for girls, as it does little to address confidence to achieve in the high level courses, substantial workload differences, and all round HSC performance benefits when undertaking a mathematics subject with a lighter workload. In addition, preliminary analyses of English enrolments (Appendix 2) show that enrolments in intermediate and advanced English courses, whilst experiencing rapid growth post-2001, have also begun to decline over the last ten years, despite being marked on a common scale during this time.

Another change on the horizon involves some NSW universities, namely the Australian Catholic University and the University of Sydney (Universities Admissions Centre, 2017b) announcing the re-introduction of high level mathematics, typically at the intermediate level, as a prerequisite for entry into degrees requiring high level mathematics from the year 2019. Given our findings have shown that students are often encouraged to complete General Mathematics to increase their grades regardless of career aspiration, the re-introduction of university prerequisites should serve to increase higher level HSC mathematics participation. However, with at least nine NSW universities still yet to re-introduce mathematics prerequisites, and girls less likely to enter into many of the degrees requiring high level mathematics, we suggest that these changes will likely have a small impact on HSC mathematics participation at this stage, particularly for girls.

More positively we found that mathematics teachers have the potential to significantly improve girls' confidence, participation in, and enjoyment of mathematics within the current NSW education system. Throughout our interviews we found mathematics teachers, the way mathematics is taught, the relationship mathematics teachers have with their students and the advice mathematics teachers give to students to be some of the most important and influential variables in a student's mathematics education. As Easy and Gleeson (2016) conclude mathematics teachers, through their advice and encouragement or discouragement, are the 'gatekeepers' to high level mathematics.

Ultimately this study, *Girls in Maths*, has shown that girls are currently, and have historically been, underrepresented in both high level mathematics and in careers requiring high level mathematics. In addition our analyses have revealed that, on current trends, we are likely to see little change to this underrepresentation without significant intervention and/or policy change. We argue that aside from policy and curricular changes, that directly address the systemic issues that discourage girls and boys from undertaking high level mathematics, mathematics teachers have the greatest power to impact on the participation of students in high level mathematics. As such, any interventions designed to increase participation in high level mathematics, particularly for girls, should consider the role of the teacher as central to the experiences students have with mathematics. With gendered perceptions and career aspirations forming in the early years of schooling, any such interventions need to begin at an early age and should include efforts to increase girls' confidence in mathematics throughout secondary school.

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