THE UNIVERSITY OF NEWCASTLE AUSTRALIA

Girls in Maths Research Project

Extension Report

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TEACHERS & TEACHING RESEARCH CENTRE

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ATAR	Australian Tertiary Admissions Rank
Advanced Mathematics	Mathematics Extension 1 and Mathematics Extension 2. Note: interview participants often refer to Advanced Mathematics as 'Extension Mathematics'
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
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
Elementary 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

1. Introduction

1.1. Background

The 2017 *Girls in Maths* Project was a research study designed to investigate the underrepresentation of girls' in Higher School Certificate (HSC) mathematics courses. This project was conducted in three phases involving: (1) analysis of girls' representation in mathematics, using HSC enrolment data; (2) analysis of girls' aspirations for careers requiring high level mathematics, using the existing Aspirations Longitudinal Study dataset; and (3) analysis of any systemic factors that discourage girls from enrolling in high level mathematics, by conducting and analysing interviews.

The project found that girls were less likely than boys to enrol in high level mathematics courses during Years 11 and 12, and less likely to aspire to careers that require participation in high level mathematics during secondary school. Additionally, the project identified several issues that discourage interested girls from undertaking high level mathematics subjects, particularly: higher workload, inadequate ATAR compensation, competitive university entrance procedures, the removal of high level mathematics as a prerequisite for entry to certain degrees, and perceptions of high level mathematics as only necessary for certain career paths.

1.2. Extension project

The research reported here builds upon these results, in an extension to the third phase of the 2017 *Girls in Maths* Project. The aim of this extension was to continue investigating the range of factors that enable or constrain aspirations for, and participation in, mathematics by interviewing an additional 50 participants including secondary students (male and female), their parents, mathematics teachers and careers advisers. This additional research was designed to ensure the credibility and trustworthiness of findings by confirming, expanding, or challenging insights into both the declining participation and the consistent underrepresentation of girls within intermediate and advanced mathematics across NSW.

1.3. NSW Mathematics courses

Table 1 displays the range of mainstream mathematics courses available to NSW students during their Higher School Certificate (HSC).

Table 1: NSW Mathematics courses

Year 11	Year 12
Mathematics General	Mathematics General 1
Mathematics	Mathematics General 2
Mathematics Extension 1	Mathematics
	Mathematics Extension 1
	Mathematics Extension 2

Consistent with current literature (e.g., Barrington & Brown, 2014), and with the 2017 *Girls in Maths* report, the Mathematics General courses can be classified as 'elementary', the Mathematics course as 'intermediate' and the Mathematics Extension courses as 'advanced'. For the *Girls in Maths* project we defined high level mathematics to be those courses which contain a calculus component, i.e. at the intermediate level or above. Further details on these courses can be found in the 2017 *Girls in Maths* final report.

1.4. Sample

In 2017 we visited six NSW secondary and central schools, and interviewed female students in Years 10 and 12, as well as some of their parents and mathematics teachers. These interviews were broadly focused on mathematics and students' mathematics-related aspirations. The total interview sample for the 2017 *Girls in Maths* project consisted of 52 people, including ten teachers, four parents and 38 girls in Years 10 and 12. This sample is displayed in Table 2 below.

Table 2: Number of interview participants: 2017 Girls in Maths Project

Participant Type	**Female**	**Male**
Teachers	8	2
Parents/Carers	4	0
Students (Years 7-9)	0	0
Students (Years 10-12)	38	0
Total Participants	**50**	**2**

In 2018 we extended upon this work by visiting an additional five NSW government secondary or central schools and revisiting a number of the original six schools. In addition to extending the number of schools, we also broadened our sample to include a small number of male students and students in Years 7-9 and 11. This broadening enabled us to explore additional issues that may affect girls participation in mathematics throughout secondary school. As a result of this extension work, the total sample now consists of 115 participants comprised of 68 female students, 17 male students, 23 teachers, including a careers adviser, and 7 parents. The total sample is displayed in Table 3 below.

Table 3: Number of interview participants: 2017 Girls in Maths Project and 2018 Extension

Participant Type	**Female**	**Male**
Teachers	13	10
Parents/Carers	7	0
Students (Years 7-9)	12	11
Students (Years 10-12)	56	6
Total Participants	**88**	**27**

Table 4 details the highest level mathematics course chosen by each student participant in Year 10 to 12. The distribution of courses for those who participated in additional interviews conducted in 2018 was similar to the distribution for participants in the 2017 interviews.

Table 4: Student enrolment in mathematics, highest level		
Participant Type	**Female**	**Male**
No Mathematics	5	1
General Mathematics 1 or 2	28	0
Mathematics	18	5
Mathematics Extension 1	5	0
Mathematics Extension 2	0	0
Total Year 10-12 students	**56**	**6**

In line with the 2017 *Girls in Maths* Study, all students were former Aspirations Longitudinal Study or Locating Aspirations[1] participants and were selected to participate in the interviews on the basis of having mid to high prior National Assessment Program Literacy and Numeracy (NAPLAN) 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. The interview schedules utilised for the second phase of the project are attached as Appendix 1. In order to maintain consistency, these schedules were very similar to those used in the initial interviews.

1.5. Analysis

All interviews were recorded, transcribed and analysed with the assistance of the NVivo software (QSR International, 2014). To ensure anonymity, each participant was assigned a pseudonym. Interviews from the initial phase and the extension phase were then combined into a single project database, so all interviews could be analysed together and common themes and differences could be identified across the phases.

Dominant themes were identified in the data and coded using inductive and deductive logic (Creswell, 2013). A continuous process of reflection and discussion amongst researchers ensured consensus about the themes that were identified (Harry, Sturges, & Klinger, 2005).

[1] A 2017 extension to our work on students' educational and occupational aspirations which included more than 1500 additional surveys.

2. Results

In reporting results of the 2017 *Girls in Maths* interviews we addressed: (1) the reasons students gave for their choice of mathematics (timetabling, influence of others, importance of mathematics, dislike of mathematics, and confidence in mathematics); (2) factors that influenced students' choice of different mathematics courses (workload, confidence, marks and ATAR scaling, as well as need for future career); and (3) the experiences girls reported having with mathematics (the influence of early experiences and the important role of the teacher).

In the extension project all of these factors remained important, and pertained to both girls and boys. Thus, for this report, we have highlighted fresh insights gained through the analysis of all 115 interviews. In particular, we present results on how high level mathematics participation is viewed in schools, the role of the ATAR on students' subject selections, girls' perceptions of careers requiring high level mathematics, and girls' perspectives on how to help them in mathematics.

Whilst we combined all interviews into a single file for the purpose of our analysis, we have included the phase in which each participant was interviewed when reporting results. This inclusion highlights consistencies between the two phases, where: P1 = initial phase and P2 = extension phase. In line with the 2017 *Girls in Maths* report we have also reported the mathematics course chosen by each student in Year 10 (for students in Year 10 or above) as well as an indication of the students' prior performance, using their NAPLAN score at the time of their Aspirations survey. These details provide context in relation to students quoted in the pages below.

2.1. How high level mathematics participation is viewed in schools

Within each of the interviews we asked the participants to describe the kinds of students who enrol in high level mathematics and the reasons they might have for undertaking high level mathematics. This question enabled us to glean important insights into the ways in which high level mathematics students are viewed by their peers. Our analysis of the responses given to this question revealed three broad, yet overlapping, characterisations of the students who chose to undertake high level mathematics, namely: (1) students who want to pursue mathematics-related careers; (2) high achieving students; and (3) students who are interested in mathematics. Reflecting girls' underrepresentation in high level mathematics, participants often associated these student types with boys, rather than girls.

2.1.1. Students who want to pursue mathematics-related careers

The 2017 *Girls in Maths* report found that many students view high level mathematics in utilitarian terms, as useful for gaining access to certain professional pathways only. In line with these findings many participants described the students undertaking high level mathematics as having an aspiration to pursue a career requiring high level mathematics. Sharni and Carrie were two students who shared this perspective:

> I think the people who do Advanced Maths, there's like that aspiration to have a job that actually involves maths, and I think more people just do General Maths because they sort of have to do a maths, even though it's not compulsory, but there's sort of that like… you should probably do maths. Yeah, so I think people who do General maths are doing it more so because it's a need. (Sharni, Year 12, Mid Achievement, General Mathematics, P1)

> Probably because it would have something to do with their future so it might be a prerequisite for their degree but I don't know any degrees that have prerequisites for Advanced Math. But I don't know, if they want to be going [into] construction or [to be an] architect or something they would probably need that Advanced Math. (Carrie, Year 10, High Achievement, Mathematics, P1)

Sharni highlights a belief that mathematical knowledge is important for everybody to possess when she states that "you should probably do maths". However, both girls hold the view that high level mathematics is only undertaken by students who wish to pursue mathematics-related degrees. What is notable here is that Carrie, a high level mathematics student who wishes to pursue a degree in law, does not include herself in her description of students who study high level mathematics. This suggests that those students not aspiring to careers requiring high level mathematics may be in the minority in high level mathematics classrooms.

This perspective on high level mathematics as being for students aspiring to careers requiring high level mathematics was also reiterated by many of the mathematics teachers. Below Mr Chambers and Ms Bauer discuss the types of careers to which they expect their high level mathematics students to aspire:

> Yeah, I guess top level you obviously relate to sort of engineering type courses, high level maths where you need that sort of calculus in those sorts of fields. Then, when you get down to the standard [maths], I guess it can still sort of be related to any sort of mathematics, whether it's building or even accounting, things like that, that relate to maths. (Mr Chambers, Mathematics Teacher, P2)

> The only reason I would see is why students pick a higher level of maths at a school is if they know exactly what they want to do when they finish school, like if they want to do engineering or they want to do mathematics or they want to do something really scientific, or medicine, a lot of them want to do medicine or forensic science […] I remember sitting in my very first university lecture and there was 400 people and maybe like 30 girls and I was like ooh, and then when I graduated [as an engineer] there was me and another girl and that was it out of like 200 [or] so. (Ms Bauer, Mathematics Teacher, P1)

Both Mr Chambers' and Ms Bauer's descriptions are particularly significant in terms of gender. The first career Mr Chambers and Ms Bauer, like many other participants, associated with high level mathematics is engineering, a very male-dominated field. This association is reinforced by Ms Bauer's personal experience, which highlights a significant underrepresentation of girls in engineering degrees. In addition, the majority of the other careers mentioned by Ms Bauer are also male dominated, however to a lesser extent. This indicates that girls may be particularly disadvantaged by the perspective on high level mathematics in secondary school as useful for future career aspirations only.

Many students were also aware that girls are less likely than boys to pursue careers requiring high level mathematics, as conveyed by Lynette:

> I think it is just seen as daunting, like math was—for girls like that, they hate math and I don't know—I think it is just stereotypically men go more into science, math related skills and jobs. I don't know, it's just a lot of stereotyping and sexism and that kind of thing… I'm not going to detail on society. I don't know, at a point females are meant to go into more—not as higher level jobs and stuff, especially around here. They're like, "Boys, if you are looking to go into a trade, or girls, if you are looking to go into hospitality", they usually aim it more at genders and stuff like that rather than people. (Lynnette, Year 10, Mid Achievement, General Maths, P1)

Lynnette highlights that whilst many of the careers associated with high level mathematics are prestigious, they are also stereotypically associated with men. She understands that in most cases this is because these careers are actually male-dominated and that careers education, at her school at least, is gendered to reflect the current workforce. Together these points convey that girls are made aware of gender stereotypes and existing workforce trends from a young age, an awareness that can serve to discourage girls from pursuing certain careers.

2.1.2. High achieving students

The second characterisation of students who undertake high level mathematics was as the highest achieving students. This was a description most often used by teachers and students who were not undertaking a high level mathematics course. Tara and Miriam epitomise this perspective:

> I feel like you have to be really confident in maths to pick Advanced. Just because I feel like you have to know you're going to do well in Advanced otherwise you may as well just pick General and do really well in that. So I'd say its people in the top classes who know they're going to do well […] 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, General Maths, P1)

> I think they would choose it if they're like good at maths and I think that they would do well in it because I don't think people would choose it if they didn't think they were going to do well in it… if they're not getting good marks in maths now or even if they're just getting like average marks or not even necessarily like below average then they might not think that they're capable of doing Advanced Maths. (Miriam, Year 10, High Achievement, General Maths, P1)

Tara and Miriam both refer to the pressure to score highly in the Higher School Certificate (HSC). This is not surprising, given that Year 12 results determine university entry for many students. However, given this pressure, the girls indicate that only the most confident and high achieving students would risk pursuing a more challenging mathematics course.

What is most noteworthy about the association between high level mathematics and high achieving students, is that many of the interviewees perceived boys to be more naturally talented than girls. Jayana and Mr Lawrence were two participants who declared such a perspective:

> From what I've heard the girls seem to be the ones who work harder but the boys seem to get it naturally. I don't know. I think maybe - I really don't know. I know in previous years there's been boys who get it but there's been girls who work hard to get it and end up doing better

> in the end so I don't know. I guess it could just be coincidental, but girls might just have to work harder at it than what boys do. (Jayana, Year 12, Mathematics, P2)
>
> Well, there would be several types, a couple of different types. I'll list a couple, it won't be all of them. You have your, you know, you have your stereotypical, what people usually assume will be male, like that kind of engineering brain, they're interested in computers, they do a bit of programming on the side already, they have a lot of capability with math but they're not always sort of motivated… Anyway, so there's those students. Then, there's those students that are like that and are also motivated in maths, and they excel quite far. Then, there's the deep thinkers and I know if you can appeal to their interest and their curiosity and their inquiry into being, then you can hook them and they'll end up performing quite proficiently in maths. They're not always fast, but they get the concepts, they take the concepts and they run with the concepts. (Mr Lawrence, Mathematics Teacher, P2)

Jayana has the impression that high achieving girls in mathematics have to "work harder" than high achieving boys. Similarly Mr Lawrence states that those who are good at maths either have "what people will usually assume will be [a] *male* engineering brain", or "are not always fast" at maths but "think deeply". These perspectives position girls as likely to require more time to learn mathematics than boys. Given that workload is a significant factor in students' choice of mathematics courses in Years 11 and 12 (*Girls in Maths* report, 2017), the perception that girls need to work harder to understand mathematical concepts is likely to play a significant role in girls' underrepresentation in high level mathematics.

2.1.3. Students who are interested in mathematics as a discipline

The third way in which the students who undertake high level mathematics were characterised was as students who enjoy participating in mathematics. Sharni and Louella, for example, express this view:

> I think it's people… [who] are really passionate about it. (Sharni, Year 12, Mid Achievement, no maths, P1)
>
> Extension kids are die hard maths, like really into it… (Louella, Year 10, High Achievement, Mathematics, P1)

These students were also characterised as having a desire to extend their knowledge of mathematics:

> Well, the students here choose it because they're really keen. Not necessarily that they will need it in any entry courses that they do, but they're keen on extending their maths. (Ms Owens, Mathematics Teacher, P1)
>
> I think they do it because they want to challenge themselves but because they also enjoy it as well. So we only have a small class in the Maths 2 Unit [Mathematics class] so we've got five people and there's two girls and the others are boys but we all get along. We all have a good laugh and we bounce off each other as well. (Elicia, Year 12, High Achievement, Extension Mathematics, P1)

Ms Owens and Elicia both highlight that a student's enjoyment of mathematics is often coupled with the desire to extend or challenge themselves with regards to their mathematics learning. It is this desire, to extend or challenge, that is seen to drive mathematically interested students' choices to enrol in high level mathematics. Elicia further highlights how the students who are undertaking high level mathematics share similar interests, allowing them to "all get along".

In regards to gender, many interviewees indicated that girls were less inclined to be interested in mathematics than boys. Ms Taylor and Mr Chambers provide some examples:

> My Extension 1 class is all boys, there's no girls in there at all. In my Mathematics class I've got kind of half/half. So, that kind of makes me think that maybe more boys are interested here. It is different though, because like I notice in my Year 8 class, the girls are much better with writing. They enjoy when it's like, more routine, but the boys just want to get in there and just have a go. It's different, there's definitely a mixed variety. (Ms Taylor, Mathematics Teacher, P2)

> Like, seven years I've been teaching math, and I've definitely had girls that have been, but honestly, majority of the ones that have that *real passion*, that I've come across – I'm not saying – obviously, there are a lot of girls that are – have been boys. I'm just trying to think. Yeah, no, not really, honestly, probably more boys… I don't know if there's any science behind it. I have noticed, obviously, I've come across a lot of girls that are very good mathematicians. I do find that boys generally seem to have the brains – as I said, I don't know the science behind it… (Mr Chambers, Mathematics Teacher, P2)

Ms Taylor, drawing upon her years of teaching, highlights that girls are "better with writing". This positions girls as less interested in mathematics, as a subject based in numbers, than boys. However, it is important to note that Ms Taylor uses the word "here" as well as the words "there's definitely a mixed variety", perhaps indicating that she does not believe these trends, which reflect traditional gender stereotypes, to be universal. Mr Chambers similarly positions girls as less interested in mathematics – less likely to possess the "real passion" for mathematics. However, Mr Chambers positions this alongside apparent differences in achievement to highlight that this may be due to biological differences in male and female brains. It is significant that he holds this opinion despite the fact that he has "come across a lot of girls that are very good mathematicians". This indicates that girls who are interested in, or achieve highly in, mathematics may still be perceived by others as 'exceptional' or different to 'normal' girls.

2.2. Role of the ATAR in students' choice of mathematics course

The role of the ATAR in students' choice of mathematics has gained substantial attention within the Australian media recently (e.g. Koziol, 2018a; Koziol, 2018b), especially since the release of the Education Council (2018) report. Chaired by Australia's Chief Scientist, the report stated:

> Today there are far fewer prerequisites, even in courses where an advanced knowledge of mathematics is essential. Those important signals – to students, that they need to strive; and to schools, that they need to give students the encouragement and resources – are failing. Students select their courses with an eye to a number: the ATAR to enter a particular course. Rightly or wrongly, they absorb the message that the way to boost their ATAR is to drop down a level in mathematics. (Education Council, 2018, p.7)

The conclusion that the ATAR is driving students to "drop down a level in mathematics" stands in contrast with the conclusions drawn from other research studies. For example, the NSW Department of Education's Centre for Statistics and Evaluation (2017) report into mathematics participation reviewed surveys from past HSC students (n=9,040) and found that:

> Despite the evidence of a scaling[2] advantage for HSC General Mathematics, it appears that many students believed that HSC Mathematics had the scaling advantage… Relative to HSC General Mathematics students, the odds of making their course choice in order to maximise ATAR were 1.4 times greater for HSC Mathematics students. In contrast, the odds of being influenced by less homework were 1.9 times greater for HSC General Mathematics students than HSC Mathematics students… it appears that HSC General Mathematics students were more influenced by perceptions of a lower workload rather than a scaling advantage. (Centre for Education Statistics and Evaluation, 2017, p.17)

Given these contrasting findings, that students choose either General Mathematics or high level mathematics to maximise their ATARs, we wanted to explore how influential the ATAR is in shaping students' decisions to enrol in a high-level mathematics courses.

2.2.1. Mathematics boosts the ATAR

The general consensus amongst teachers and students was that mathematics, as a whole, is a subject which benefits students' ATARs. Ms Reeves and Lynette provide examples of this below:

> Well the student who actually came to the door this morning, who was telling us that the [Mathematics] class was full, she said "I want to choose maths because I'm good at it, it's the only thing that's going to boost my ATAR." So there's this concern that maths is a high scaling class and a lot of things that involve writing aren't. So kids are liking maths to boost their marks. (Ms Reeves, Mathematics Teacher, P1)

> I don't really listen to my friends, but like my parents, with my parents, they just said, "It will be good for your ATAR," and "Don't drop it, it's fundamental to your life," like, "Math is everywhere." You need it. (Lynnette, Year 10, Mid Achievement, General Maths, P1)

In addition to making ATAR comparisons between mathematics and essay-based courses, students like Chanee discussed the ATAR and arts-based courses:

> A couple of them suggested that I actually do some more practical subjects like sciences and stuff, because the arts drag your ATAR down a lot. But I didn't want to do that just for the sake of getting a good ATAR when there's no university course that I want to do that needs that. So that's what I based it on I guess. … I don't really know, because it's very confusing, but I've heard that when you do art subjects it sort of gets scaled down or something. I don't really know. It's very confusing. I just got told you generally get a lower ATAR if you do those subjects. (Chanee, Year 12, High Achievement, No Maths, P1)

Chanee's understanding is that arts-based courses disadvantage students through the ATAR scaling process, especially compared to courses like science and maths. Her uncertainty about the ATAR scaling process was common amongst both teachers and students, as will be explored in the next section.

[2] In calculating students' ATARs their raw course marks are 'scaled' to enable comparison of marks between vastly different courses. This can involve increasing or decreasing students' raw marks and is dependent on cohort performance across various courses.

2.2.2. High level mathematics courses boost the ATAR

A number of students stated that the most challenging HSC courses attracted the greatest scaling advantage, as articulated by Lauryn:

> I chose the harder subjects to essentially get a better ATAR with the scaling. (Lauryn, Year 12, High Achievement, Extension Maths, P1)

High level mathematics courses were seen as giving these students an advantage over General Mathematics students. Ms Robins and Ms Reeves provide two different teacher perspectives on this point:

> Yeah, and I know that's happening, and *I wonder* if part of it is because of the marking system for the HSC. I don't know. *I don't know*. Because, *I don't know*, are they not taking a high level of maths because they think you're going to be scaled down? I don't know. I mean, that's something that has been in the media. *I'm not sure.* Because I think something came out in the newspaper a few months ago where it *actually* found that kids who did take two unit maths or higher actually ended up scoring better, I think. Oh look, I can't remember. (Ms Robins, Mathematics Teacher, P2)

> *I don't know* much about scaling. I've had it explained to me once that basically if you're in a high class and you do really well your marks get pushed up. If you're in a hard class and you don't do well you can still get scaled down. *So it sort of depends* which is why we tell the kids to choose stuff they're good at. So General, or Standard as it's now called, *I don't think* that it's necessarily a high scaling one unless you do well. Advanced, yes. If you do alright you can *probably* get scaled. That's how I've always understood it. (Ms Reeves, Mathematics Teacher, P1)

Both teachers express a great deal of uncertainty regarding the ATAR and scaling process as a whole. Nonetheless, both teachers perceive that "if you do alright" in Mathematics you will be probably scaled higher than a student in General Mathematics. However as Ms Reeves understands the system, this 'advantage' only applies to students who do well enough, as those who underperform in high level mathematics "can still get scaled down".

Citing advice from their teachers, several students also stated that there was a scaling advantage given to high level mathematics courses. Elinor, Carrie and Lexi each provided clear articulations of this perceived advantage:

> What we were told was with 2 Units [Mathematics], getting a 60% is the equivalent of getting like 89% in General 2, so it was better to struggle through and get those marks than just go the other one. (Elinor, Year 12, Mid Achievement, Mathematics, P2)

> I'm pretty sure your marks get - say you get 80 per cent in Standard. You'll probably go to a 75 per cent towards your ATAR but if you got 80 per cent in Advanced it would probably get scaled up to 85 per cent. (Carrie, Year 10, High Achievement, Mathematics, P1)

> Personally, I'd like to do that to challenge myself, and hopefully, get better marks. My sister explained it to me. If you get 50% in two unit, you've basically got like 100% in General marks. I don't know how to explain it. (Lexi, Year 9, High Achievement, P2)

Whilst an 'advantage' was associated with the high level mathematics courses, its perceived magnitude differed considerably among students.

Despite the widespread belief that high level mathematics courses attracted ATAR advantages, as noted in the 2017 *Girls in Maths* report, teachers and students also thought that the 'advantage' given to Mathematics students is insufficient. We suspect that this may be a result, at least in part, of the varying magnitude of the perceived 'advantage' for Mathematics. Mr Chambers and Saharah provide examples of this viewpoint:

> Not so much. Yeah, it depends, I know some students strategically choose Standard or General because they think that they can probably get a higher ATAR by getting a higher band in that course. I personally think that it's probably not scaled quite enough, the Mathematics course, as what it should be, but yeah, generally, if I can see they're capable and they're willing to push themselves – that's probably the biggest thing, if they're willing to push themselves, I'll generally, yeah, recommend Mathematics. As I said, it's going to help them at university if they do decide to go down some kind of engineering path or something like that. (Mr Chambers, Mathematics Teacher, P2)

> I would rather sit there and do really well in General than do mediocre in Mathematics, just in the long run it would be more sensible in a way for my ATAR. (Saharah, Year 12, High Achievement, General Maths, P1)

These examples indicate that HSC results and ATAR scores, are important considerations in students' choice of mathematics subject. But this is a complex issue, with some students choosing high level mathematics to boost their ATARs and others avoiding it for the same reason. However, as we argue below, the ATAR is perhaps less influential in driving the declining enrolments in high level mathematics than several other factors.

2.2.3. Beyond the ATAR – 'Pipeline' issues

A key theme emerging from our analysis of the interview data, is the influence of students' experiences with mathematics throughout the schooling years, or the schooling 'pipeline'. As Mr Mills and Mr Fletcher explain, for some of their students the struggle with maths begins in primary school:

> I almost cry in my Weetbix in the morning when I get a new intake of Year 7s. You look at some of the skills that they're coming with and... So I think, and this is not a shot at primary teachers at all, but I think getting primary teachers to have a passion and a skill and a desire to promote maths as something that is important and worthy for the kids to study is, I think, where it starts. (Mr Mills, Mathematics Teacher, P2)

> You've got to be careful about how much you give away here. I think we struggle with some of the primary school coming through and I can't be critical, I'm not a primary teacher - put me into a geography classroom it's difficult. I did hear one time there was talk about getting primary school maths teachers to be able to teach up to Year 10 maths... I don't want to be critical but I think it's been a known fact for a while that maths is struggling. (Mr Fletcher, Mathematics Teacher, P1)

Mr Mills and Mr Fletcher highlight that a number of their students enter Year 7 already behind in their mathematical skills. Using the terms "almost cry" and "struggle" in response to Year 7 students'

mathematics skills, these teachers convey that helping students catch up to the syllabus is a significant challenge. Other teachers also provide examples of this challenge:

> I know in terms of maths in Year 7 I had – I could set tasks and when I was setting them I was setting them at a variety of levels for the modified curriculum, so some were Stage Two [Years 3-4] and some were Stage Three [Years 5-6], some Stage Four [Years 7-8]. (Ms Reynolds, Mathematics Teacher, P1)

> The kids that come from our feeder schools who have not got the Stage Three, which is like Year 5 and Year 6 concepts, they really struggle in Year 7 with, because maths is, out of all the curriculums, maths moves the quickest because we have so much to cover. So I find that if the kids don't really have, aren't equipped with the skills in Year 5 and 6 for Stage Three, then Stage Four it's such a big jump. (Ms Bauer, Mathematics Teacher, P1)

> Some [Year 7 students] are between Stage 2 and - Stage 1 and Stage - the stage would be Stage 4, if they're lucky. Yes. I worked in a primary school last year and it was wonderful. I had the opportunity to kind of, "You guys are going to be in my school next year, learn your tables"… They don't get it. It's got a lot to do with that whole thing of let's change the curriculum for the primary school by putting in all of this stuff and this stuff and they just keep adding stuff in. So those teachers aren't getting time to do the basic skills. (Mr Murray, Mathematics Teacher, P2)

These teachers highlight that, in their experience, students can enter Year 7 several schooling years behind in their mathematics knowledge. Ms Bauer further highlights that, with a relatively fast paced curriculum, there is little time to catch these students up and, as a result, many students will "really struggle in Year 7". However, Mr Murray indicates that a fast, or crowded, curriculum also exists in primary school, limiting the time teachers can devote to maths. Later in her interview Ms Bauer highlights that funding and a lack of resources in public schools can exacerbate these problems. He describes that with "about 30 students" who can be working up to five or more curriculum year levels apart, teachers are "running a marathon every lesson because it's just, I need an aide in there, it's too hard". As explored in the 2017 *Girls in Maths* report, these challenges struggle may be compounded by the fact that less concrete concepts, such as algebra, are introduced in the Year 7 curriculum.

In addition to noting issues stemming from primary schooling, participants raised many aspects of secondary schooling that exacerbate the challenge of attracting students to high level mathematics. One of these issues, streaming, is highlighted by Gabby below:

> Ever since Year 7 they've always been pushed to go to like Year 9 grade of maths where we are just started to get out of Year 6 to Year 7. Where like, yeah, pretty much… with all my maths I've had the exact same people in my class. They do push us, but you just see average stay average and the smarts go higher. (Gabby, Year 10, Mid Achievement, General Maths, P1)

Gabby recognises that her placement in a mid-ability class, as a result of 'ability' streaming, may have limited her opportunities. Being in the same class since Year 7 may result in students who enter Year 7 behind in mathematics remaining behind their peers for the rest of their schooling. It is important to note that streaming practices in Australia are higher than in other nations, with 98 per cent of secondary school principals approving some form of streaming in their mathematics departments compared to an average of 75 per cent across the Organisation for Economic Cooperation and Development (OECD) nations (OECD, 2013). In our sample many of the 11 schools had some form of mathematics streaming in place during Year 7 and almost all had streaming in place by Year 8.

Our data indicate that issues surrounding streaming are particularly exaggerated in Years 9 and 10 due to the effect of the NSW streamed mathematics curriculum in these school years[3]. Ms Bauer and Mr Chambers explain:

> We have stage 5.1, 5.2, 5.3 so the top class gets taught not really 5.1 but 5.2, 5.3 and then the second class which is my class we teach 5.1, 5.2 so I'm just tailoring my class just to the General [Mathematics course]. It's a massive disadvantage if you want to do 2 Unit [Mathematics], you just like, you've got to get out of my class, you've got to get up [if you want to do Mathematics or above in Years 11 and 12]. (Ms Bauer, Mathematics Teacher, P1)

> Well, we sort of divide the [Years 9 and 10] classes into streams, so we sort of have three to four classes. Usually, it's only the top class that will do the 5.3, so I guess a third or a quarter of the kids. Then, majority, the middle ones, usually the middle ones are – because bottom end of that 5.3 class aren't even probably 5.3, they're probably more like a 5.2 slash 5.3, so the next class is just straight out 5.2 and then, it almost goes into a 5.1. It's probably, yeah, it's even hard to get a full 5.3 class now. (Mr Chambers, Mathematics Teacher, P2)

Ms Bauer and Mr Chambers indicate that, as a result of streaming, only a small number of students at their schools are actually taught a maths curriculum which provides a suitable level of background knowledge for the Year 11 and 12 calculus courses. This means that many students, regardless of their interests, future career aspirations, or perceptions of ATAR scaling, are not actually in a position to undertake high level mathematics.

A third set of issues which relate to the declining enrolment in high level mathematics is retention in Year 11 and 12, as highlighted by Lauryn:

> At the beginning, we had a [Mathematics] class of 25 and they all picked it because of the scaling. But those who are left now, we either enjoy it or we are good at it so that's why we kept it and stayed in Advanced. The ones who picked it as well, they definitely need it for their ATAR or it's a requirement to get into uni.

> I have talked to some of the guys who are coming in top of the class in General and they find it easier and more enjoyable. The gap level between the two subjects is insane and that's why a lot of people struggled with it, because they said "in General it's just doing Year 10 Maths". I actually heard a lot of people saying, even a few of the teachers, that it would be better to have a course in between the two because yeah, now that I think about it, a lot of people have said that the knowledge difference is too big and that's why a lot of people dropped, because if people didn't pay attention in Maths in earlier years, they don't have the understanding for Advanced and that's why a lot of them dropped down, because it's similar to what they knew before. (Lauryn, Year 12, High Achievement, Extension Maths, P1)

Lauryn highlights several salient points in her discussion of Year 11 and 12 high level mathematics retention. Consistent with our findings in section 2.2.2 she indicates that many students choose to enrol in a high level of mathematics in an attempt to 'boost' their ATARs, however issues in the 'pipeline' and the difficult nature of high level mathematics courses result in large dropout rates. She observes that even students who have been taught the 5.3 curriculum may not have had the required background to undertake high level mathematics in Year 11 and 12 if they did not "pay attention" in Years 9 and 10.

[3] In Year 9 and 10 the NSW syllabus splits into 3 different pathways, 5.1, 5.2 and 5.3. Many of the outcomes of the 5.3 pathway are assumed knowledge for all of the calculus-based mathematics courses in Year 11 and 12.

Retention is a significant problem across the state. Figures 1 and 2 on Pages 18 and 19 illustrate the proportion of students, by sex, enrolled in each level of mathematics during Year 11 and Year 12 over the last decade with the highest level mathematics course enrolled displayed for each student. These Figures reveal that the number of students entering high level mathematics courses in Year 11, compared to the number that remain in these courses until the end of Year 12, differs by thousands. For example, in the 2017 HSC there were more than 3500 fewer calculus based students than in the 2016 preliminary year.[4]

In particular, data in these figures show that students who undertake General Maths in Year 11 then go onto General 1, General 2 or no maths in Year 12, students who undertake Mathematics choose to either remain in Mathematics or drop to a lower level in Year 12, and students who take Mathematics and Mathematics Extension 1 in Year 11 choose to either extend into Extension 2 Mathematics (sitting examinations in Extension 1 and Extension 2 mathematics), remain in Extension 1 and Mathematics or drop to a lower level of mathematics.

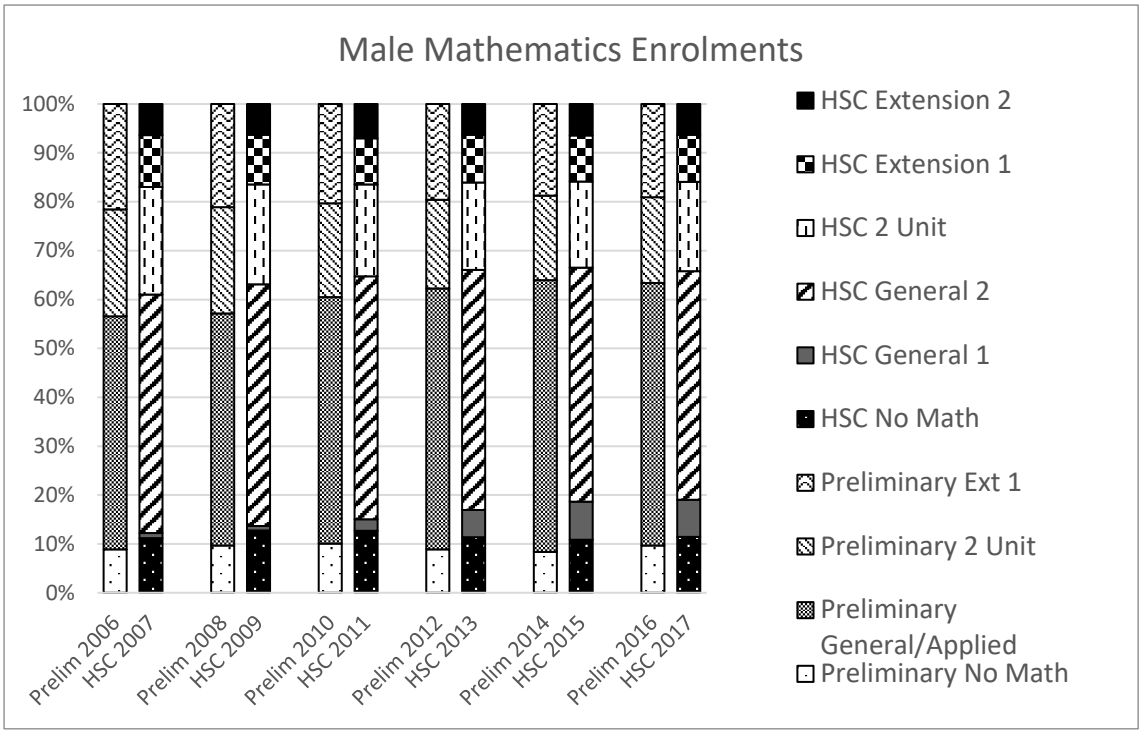

Figure 1: Male preliminary and HSC mathematics course enrolments

[4] Note: The data for the graphs which follow was obtained from the *Girls in Maths* project database, containing raw statistics obtained from the New South Wales Education Standards Authority (NESA). Additional Year 11 data was also sourced from NESA.

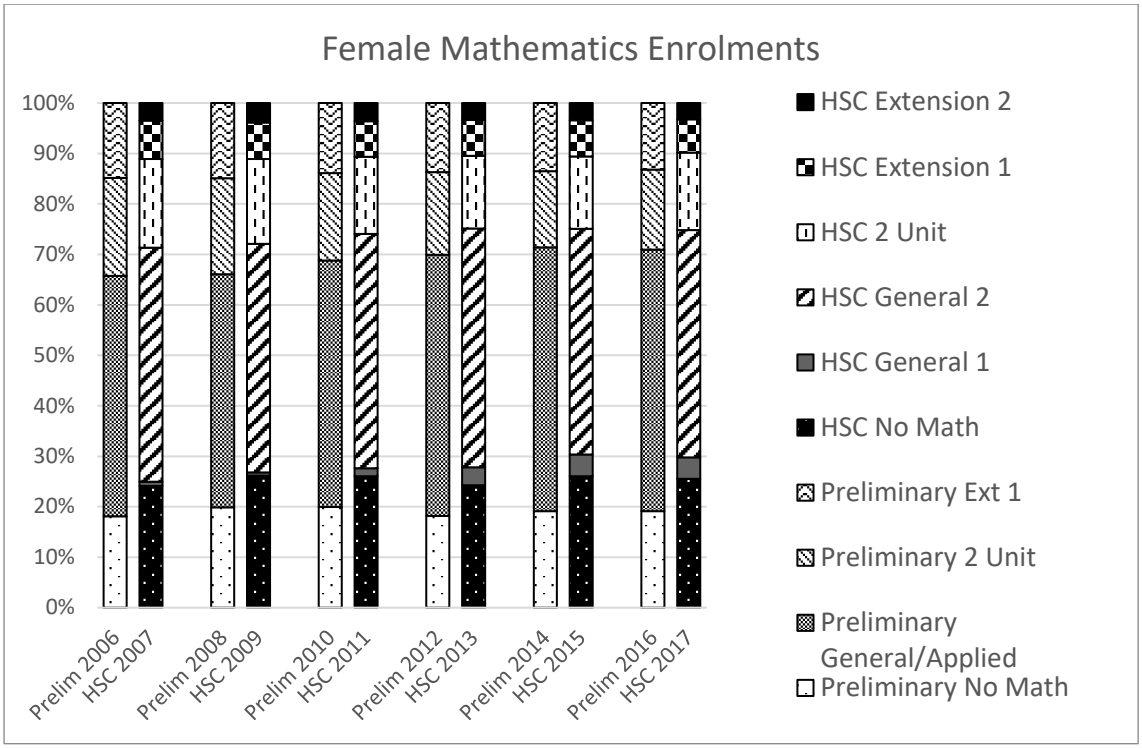

Figure 2: Female preliminary and HSC mathematics course enrolments

2.3. What do girls think about careers that require high level mathematics?

The 2017 *Girls in Maths* final report revealed that girls are significantly less likely to aspire to careers that require participation in high level mathematics in secondary school. Our extension interviews revealed that aspirations for a career requiring high level mathematics is a characteristic of students who undertake high level mathematics in Years 11 and 12 (section 2.1). Wanting to find out why girls were less likely than boys to aspire to these careers, we asked students to describe a number of mathematics related careers. We found that many students were uncertain about the nature of careers that require high level mathematics, perceived mathematics as a barrier to pursuing such careers, perceived these careers as too isolating, and/or felt that these careers were 'for boys'.

2.3.1. Uncertainty about the nature of careers requiring high level mathematics

Many students, both female and male, expressed uncertainty about what was involved in a range of mathematically intensive careers. For example, when asked to describe who might be interested in an engineering career, Aida and Raine provided the following responses:

> People who love cars and are really into it. People who are good at [the] maths and science side of it. (Aida, Year 9, Mid Achievement, P2)

> Okay, engineer. I actually don't know what they do in the job. I've heard of an engineer but I can't sit here and tell you specific stuff that they do. I wouldn't be an engineer but I just know a student who's finished school last year that's actually studying engineering at [name of

university] Uni and yes he did subjects of chemistry, physics, maths. I do know that he is needing all of those subjects at the moment to do engineering. So yes, I wouldn't do it but I feel like a hard driven person, not necessarily smart but a person who wants to work and learn needs to go into that field of engineering. (Raine, Year 12, Mid Achievement, Mathematics, P2)

Aida, like a number of the girls in the sample, displays a limited understanding of engineering by describing engineers as mechanics who are good at mathematics. Raine, more overtly, indicates that she has no idea about what engineers do. Despite this lack of knowledge Raine expresses no desire to find out more about engineering and dismisses it as a career that is not for people like her.

Many girls also expressed uncertainty about careers in mathematics or statistics:

> I think I could be interested in that because I enjoy maths but I don't know. I don't even really know much about what the stats people do. I don't know enough to have an input I think. (Elicia, Year 12, High Achievement, Extension Maths, P1)

> No idea what that is. (Kaye, Year 12, Mid Achievement, Mathematics, P2)

Computer science was another career about which many girls admitted to having both little knowledge of and little interest in. Sansa, when asked if she might consider a career in this field, articulated:

> Sansa: No, because I don't get coding.
>
> Facilitator: Have you had much experience with coding?
>
> Sansa: No, like in science the other day my teacher was talking about it for like 10 minutes or something. (Sansa, Year 10, High Achievement, Mathematics, P1)

Despite having little experience with coding Sansa declares that she does not have the required skills to pursue computer science, she doesn't "get it". Like Raine, she dismisses a career in this field as 'not for her'. If students are to consider careers in these fields as appropriate options to pursue, our data suggest a clear need to expose students to a wide range of mathematically-intensive careers.

2.3.2. Mathematics as a barrier to these careers

Many students described careers such as engineering, computer science, mathematics teaching and statistics as being for "really smart" people only:

> I think you would have to be really smart to be an engineer. Is that where you design bridges and stuff? No, I couldn't do that. My babysitter's son she - my old babysitter's son - I'm not babysat anymore – but he was an engineer and he did really well at school. In maths - I mean. My mum taught him and I remember her saying he was one of her best students ever and he went on to be an engineer so I'm guessing you have to be really smart for that. I don't think I could be an engineer. I think you'd have to love maths as well and I don't love maths. I love it sometimes like I said but… (Jayana, Year 12, High Achievement, Mathematics, P2)

> Stereotypically it would be someone a bit nerdy and like obviously smart, you'd have to be smart [to pursue computer science]. You would have to be smart to do all of that. I just keep saying smart, but you know, it's what you need. (Lynnette, Year 10, Mid Achievement, General Maths, P1)

Jayana highlights that the perception of needing to be "really smart", can come from a wide range of sources, including parents, which Lynnette indicates it is a widely held stereotypical perception.

Our data also revealed how a view that only the best mathematics students pursue high level mathematics careers often combines with stereotypical notions of 'mathematical talent', to discourage girls from pursuing these careers. Three girls highlight this perspective below:

> Well because I'm not naturally brainy at maths I don't feel like I would - at university I don't think I would like to do that. I feel like someone who does Advanced and Extension would be more suited to teach someone maths. (Gina, Year 10, Mid Achievement, General Maths, P1)

> Yeah. I think you have to have a really good understanding of maths to be those things. I don't think I am that good at maths. (Martine, Year 10, Mid Achievement, Mathematics, P2)

> Mathematician, I was, when I was younger, interested in doing, but then again, as I said, as I got older I became more passionate about history and English. I moved away from the math. Then mathematician, it's more, I think—the kids that can sit there and almost without an issue go through and look at the math question and just instantly know exactly where the answers are. It's almost—it plays out in front of them and that's just not me. I have got to sit there and look at it for a while and go, "Okay, so that would be that, that would be that." It's not as simple for me as it is for some of the other kids. They sit there and are like, "Yeah, I know exactly what you want to do when you leave school then." (Saharah, Year 12, High Achievement, General Mathematics, P1)

Given that girls are more likely to be positioned as less mathematically talented than boys (section 2.1.2), these statements highlight the importance of disrupting the myth of finite 'talent' and broadening images who of pursues mathematically intensive careers as vitally important if more girls are to pursue careers requiring high level mathematics.

2.3.3. Isolated nature of these careers

A number of the girls who were interviewed stated that they would not pursue careers requiring high level mathematics because they perceived them to be too isolated:

> I'd probably do more physics. But I probably wouldn't be any of those scientists, because I don't really like working in a lab. I like being out with people. I don't really like being in labs and doing all that sort of stuff all the time. I just want to be outside. (Eliza, Year 9, High Achievement, P2)

> Yeah. I don't think I could work in… I know you'd probably have to work in a lab. I don't think I could work in a lab. I couldn't be inside all day. (Nieve, Year 10, Mid Achievement, Mathematics, P2)

Eliza and Nieve perceive careers in science as restricted to laboratory work and hence as undesirable given their interest in working in more 'connected' or "outside" environments.

Technology careers, like the science careers that involve lab work, were also perceived to be undesirable by many girls, in part because of the isolated nature of such work:

> I definitely wouldn't do it. I'm not the sort of person to sit in front of a computer all day. I don't really like computers. They tend to frustrate me. (Lacey, Year 8, Mid Achievement, P2)

Lacey's perceptions of computers and isolation is enough to make her "definitely" sure that it isn't the right job for her.

Many girls also expressed a desire to work in environments in which they could make a difference to others. Eliza provides a clear example:

> I could probably help them if I went STEM, but in STEM jobs, they sort of work more as a team, and it's like, "This company did it", where, as a nurse, if they come to the hospital, then they're like, "This person helped me." I would individually help them. Work with one person at a time. (Eliza, Year 9, High Achievement, P2)

Eliza reveals her aspiration to both help people and have "individual" contact and recognition for her work. Whilst acknowledging that STEM offers connection to a team, she also sees it as too "company" driven and therefore unable to fulfil her individual aspirations.

2.3.4. Gendered perceptions surrounding these careers

In addition to perceiving careers requiring high level mathematics as 'isolated', many girls stated that these careers were 'for boys'. This is evident in Arrielle's statement below:

> I guess for girls there seems to be a tendency to just say that it's more of a male based, I don't know, I wouldn't even be able to say why that is a tendency, but just out of my female peers I don't see any of them going, "Oh I really want to do maths to go and do this," or "I really want to go and do maths to go and do this." They just see it as like - I wouldn't even be able to single out, you know, apart from the mathematician, I wouldn't even really be able to single out specific pathways, but it's kind of like the big black hole of you just don't go there, because, well I don't know, if they don't enjoy maths they just go, "Well maths is just maths and I don't want to do it anymore." (Arrielle, Year 10, High Achievement, General Mathematics, P1)

Arrielle reveals that more boys than girls wish to pursue mathematically-intensive degrees and she attributes this difference in part to the fact that many girls, including herself, are unaware of the degrees they might pursue with a background in high level mathematics. However, using the "black hole" simile, Arrielle explains that such degrees are seen as a place for boys, where girls "just don't go there". This view highlights the intransigence of gender stereotypes about suitable careers.

For some girls, the perception of careers requiring high level mathematics as being 'for boys' was a result of direct negative experiences with these careers:

> It's all over social media, like just women in engineering. There's like pages – you know, like Facebook pages where people doing particular courses will have a Facebook group page and they'll post memes, as they call them, on there saying women in engineering – and they have a sexual saying underneath it or whatever, or like that's rare and all the men try to chase – like, it's all on social media. (Ellinor, Year 12, High Achievement, Mathematics, P1)

Ellinor highlights how girls in high school can be aware of the male dominated environments they will encounter if they choose to pursue a career that requires high level mathematics. For Ellinor, who earlier in her interview stated that she used to aspire to engineering, the experience of reading about engineering degrees on social media, and the environment she is likely to encounter in these degrees, was enough to dissuade her from this career path.

Even without negative experiences, students such as Emilee were aware that careers requiring high level mathematics are populated by males:

> I guess more male populated jobs are contributed (sic) to maths, like you know what I mean, so they all kind of think "I have to do maths to get a good job", so they actually kind of work better in maths. But I don't know. (Emilee, Year 10, High Achievement, Mathematics, P1)

As a Year 10 student, Emilee highlights that the gender differences in the careers to which mathematics leads, can drive gender differences in student engagement and performance in mathematics even before Year 11 and 12 subject choices are made.

2.4. What could help girls with maths?

At the end of each interview we asked the girls what could be done to help them, or girls in general, with mathematics. They raised a wide range of important ideas, outlined below.

A number of girls spoke about confidence in mathematics and stereotypes surrounding "brainiacs" as issues which need to be addressed in order to increase the participation of girls in mathematics:

> I think girls have really low self-confidence. They really need to boost their self-confidence. So telling them that they can do that, they're just as good as the boys, if not better, will really help them apply themselves in class. A lot of people at our school are just like, "I don't want to do it, because I'll get picked on. I'll get laughed at." But they need to know that being smart is not something to laugh about; it's good. It's good to be competitive. It's good to be smart. But they really don't, but they just need the self-confidence boost. (Eliza, Year 9, High Achievement, P2)

> A lot of girls would think that like doing maths and lots of study is for like weirdos sort of thing, but like I would just say like breaking down that stereotype and making it known that it's not only boys that can be super smart. Like the major scientists in years before has been like Newton, Einstein, like everyone thinks that it's only men that can be brainiacs, but obviously it's not. (Kristina, Year 10, High Achievement, Extension Mathematics, P2)

Both Eliza and Kristina reveal that the cultural positioning of mathematics often excludes girls. This is particularly evident in Kristina's reference to the history of female exclusion from mathematically intensive professions, resulting in a lack of current role models for girls. For these girls, the key to increasing girls' participation in mathematics is in "breaking down" negative stereotypes to strengthen the message that girls are "just as good as the boys" at mathematics.

Many girls also noted that breaking down barriers to girls' aspirations for mathematically-intensive careers could help increase their participation in mathematics:

> Probably being taught about more careers that involve a lot of maths that typically females pick, whereas engineering is normally [for] males. (Kaye, Year 12, Mid Achievement, Mathematics, P2)

> There's a day where people come and talk about maths and do skills stuff in our hall and that but I'm not sure what that's called. Probably more days like that. But students get the option of doing it and they don't bring their note back in - just say their friends aren't doing it so

> they don't do it but it could really help them. (Kasha, Year 11, Mid Achievement, Mathematics, P2)
>
> I don't want to be stereotypical but a lot of those careers that mathematics leads to is very male based, like I remember doing Bachelor of Science and they said it's a very – like, becoming a teacher, a science teacher, it's a very male faculty based area. Then that has kind of driven me to be well I'm a female, maybe I can do something else. So, maybe showing that yeah, what makes women less capable than men? Like, women can just do as much – the same level as math as men and there should be an even playing ground for males and females to be in maths... But I don't know, just having something there, whatever that something is, to say that the careers mathematics can lead to isn't just very – isn't just for a male and it's easy for everyone to do really, so both parties, males and females and all in-betweens if you want to go that in-depth. (Ellenor, Year 12, High Achievement, Mathematics, P1)

Kaye and Ellenor highlight that girls don't "typically pick" careers that "mathematics leads to". Whilst Kaye expresses a desire to find out the mathematics-related careers that "females pick", Ellenor argues that removing the division between careers which are 'for boys' and 'for girls' is needed to increase girls' participation in high level mathematics. Kasha suggests that careers days focused on mathematics could be one avenue for conveying less gendered perceptions of careers requiring high level mathematics.

Finally, many of the girls also indicated that a lack of role models in the high level mathematics courses within their schools is a factor that needs changing:

> I think the main reason that so many girls aren't going towards the harder levels of maths is because there aren't so many role models in the harder levels of maths. It is more—you sit there and hear all about the males. If there was more information and more role models there for the girls, I think they would be more willing to go into it, instead of feeling like the minority. (Saharah, Year 12, High Achievement, General Mathematics, P1)
>
> I really see more, tend[ency for] the boys to be in the higher math, I don't know, I just seen it. There's a few girls that are in our Advanced [class], but I've always just seen boys and when I think of that, I think of boys doing it. Because we've got all boy teachers as well, we don't have any girl math teachers or anything like that... we don't have that role model there to be like, "Oh, she can do it." Because it's always... yeah, I've always seen it like a boy thing to do it. There's always boy teachers doing it. I don't know. I don't mind. Most of the teachers here are fine, and they're really nice and they're really helpful. So I don't mind what gender they are, but maybe for other people. (Neshelle, Year 11, Mid Achievement, General Mathematics, P2)

Saharah explains that girls in high level mathematics may feel like a minority group because of their underrepresentation. In some instances, as Neshelle indicates, this can be compounded by all-male mathematics teaching staff. Together these accounts indicate that without female role models in high level mathematics courses, the stereotype that mathematics is a "boy thing to do" is likely to both persist and hinder girls' interest in mathematics.

2.5. Summary

Our analysis of the 115 interviews conducted for the *Girls in Maths* project revealed the following key insights:

- Students who undertake high level mathematics are described by others as: needing maths for their career aspirations, high achieving in mathematics, and/or interested in mathematics. However, precluding female participation in mathematics, many teachers and students associated these descriptions with boys, who were seen as dominating mathematically-intensive careers, more likely than girls to be 'naturally talented' at mathematics and more likely to demonstrate interest in mathematics.
- There is a great deal of confusion surrounding the ATAR scaling process, yet the majority of teachers and students in our sample believed that undertaking high level mathematics courses gives students an advantage in the scaling process. Reflecting confusion about the ATAR process, the perceived magnitude of any scaling 'advantage' varied considerably amongst participants.
- Whilst the ATAR and associated scaling were important considerations for some students in the choice of mathematics at senior level, our data suggests that many more students are likely to be affected by aspects of the schooling 'pipeline' such as: falling behind the syllabus in primary school, the transition to secondary school, fast paced curriculum, ability streaming and the differentiated curriculum in Years 9 and 10. As a result, only a small number of students in our sample schools were sufficiently prepared with the assumed pre-requisite knowledge to undertake a high level mathematics course in Years 11 and 12.
- Underpinning the gender differences in aspirations for careers requiring high level mathematics is girls' perceptions of the careers requiring high level mathematics as isolated, male-dominated, and only for the most talented mathematics students. This was often complicated by limited understanding of what is actually involved in such careers.
- Girls suggested that disrupting career stereotypes, providing female role models in high level mathematics courses and beyond, and boosting girls' mathematical confidence might be important steps in increasing girls' representation in high level mathematics courses.

3. Discussion and conclusion

This report has detailed findings for the 2018 extension of the 2017 *Girls in Maths* project. Through our analysis of the 115 interviews, conducted in 2017 and 2018, we have gained fresh insights into girls' underrepresentation in mathematics in relation to: (1) how high level mathematics participation is viewed in schools; (2) the role of the ATAR on students' subject selections; (3) girls' perceptions about careers requiring high level mathematics; and (4) girls' perspectives on how to help them pursue high level mathematics.

We found that students who undertake high level mathematics are generally perceived by their peers and teachers as aspiring to a career requiring high level mathematics, achieving highly in mathematics and/or enjoying mathematics. However, precluding girls' legitimate participation in mathematics, these characteristics were often associated with boys. Despite a number of participants invoking biological differences to explain these trends, research has shown that mathematics ability, and mathematical interest, are *not* determined biologically by sex. In fact, differences in mathematics interest and performance vary considerably over time, across nations and across cultures indicating no consistent sex patterns (Stoet & Geary, 2013; Watt et al., 2006). Nevertheless, the myths that mathematical giftedness is biologically determined, mathematically talented students are Asian or White males, and mathematics is not a creative endeavour, are some of the most pervasive, longstanding and damaging cultural misconceptions to the development of student interest and engagement in mathematics (Sheffield, 2017). Our analysis highlights the need to continue working towards dispelling these myths.

Whilst current policy and debate in mathematics focused on the ATAR and lack of university prerequisites as driving declining enrolments for both boys and girls, our data suggests that these issues apply in only a relatively small number of student cases. Instead we found numerous 'pipeline' issues throughout students' schooling lives that result in only a small pool of students to be adequately prepared to undertake high level mathematics by Years 11 and 12. These findings align with well-established national trends, which have played a peripheral role in the ATAR debate. For example, Australia's international mathematics performance is currently declining (Thompson, De Bortoli, & Underwood, 2016; Thompson, Wernert, O'Grady, & Rodrigues, 2016) and, in the most recent round of testing, more than 30% of Year 4 students achieved at or below the lowest international Trends in International Mathematics and Science Study (TIMSS) benchmark for performance, whilst only 9% achieved the Advanced Benchmark. This compares poorly to countries like Singapore in which 50% of students achieved the Advanced Benchmark. It also places us behind countries like the USA and Russia in the proportion students with high mathematics performance (Thompson, Wernert, et al., 2016). Relatedly, the number of students who enjoy mathematics continues to be small, at fewer than 20% by Year 8 (Office of the Chief Scientist, 2016). Furthermore, Australian schools have continued to have greater trouble sourcing qualified mathematics teachers than school in many other countries around the world (Office of the Chief Scientist, 2016). These critical factors indicate that NSW mathematics, to quote our interviewee Mr Fletcher, "is struggling" for both boys and girls, and long before Years 11 and 12.

This report also built upon our understandings of why girls in secondary school are less likely than boys to aspire to careers that require high level mathematics. Our analysis demonstrates that many girls perceive high level mathematics careers to be isolated, male-dominated and/or only for the most mathematically talented students. These perceptions were accompanied by uncertainty surrounding

exactly what is involved in many of these careers. Our findings align with current literature which has shown that a key factor in girls' career choices between STEM and non-STEM, as well as within STEM, is how 'people-oriented' a work environment is perceived to be (Su & Rounds, 2015). Researchers have argued that these trends are exacerbated by cultural stereotypes that depict scientific and technical work as uncreative, solitary, and fundamentally masculine (Charles, 2017). These stereotypes have also been shown to have undesirable consequences for girls who do show interest in mathematically-intensive careers. For example, Kessels (2005) found that girls who pursue physics are perceived as more masculine by their peers than girls who do not. However, studies have shown that reducing stereotypes and masculine representations by broadening images of who participates in male-dominated fields, and the type of work involved, can increase female interest and engagement in areas such as engineering and computer science (Cheryan, Master, & Meltzoff, 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). Of note, dispelling stereotypes about mathematically intensive occupations was offered by many girls as a suggestion for increasing their desire to pursue high level mathematics.

Adding the findings of this extension work – biological myths, stereotypes, 'pipeline issues', and male-dominated, 'isolated', careers – to those of the original project findings – HSC workload, inadequate ATAR compensation, competitive university entrance procedures, and the removal of high level mathematics as a prerequisite for entry to certain degrees – reveals a wide range of complex factors associated with girls' underrepresentation in mathematics. The sheer range of factors indicates that there is no simple solution to increasing girls' participation in mathematics. However, working with primary teachers and high school mathematics teachers, who are central to girls' experiences in maths, as well as with careers advisors, in order to begin breaking down stereotypes from an early age will be essential to achieving greater representation of girls in mathematics.

4. Publications and Presentations

We have begun to disseminate findings from the *Girls in Maths* project. Dissemination will accelerate over the next 12 months or so, now that we have completed the extension of data collection and analysis.

The first journal article from the project, discussing Year 12 enrolment data, was published in April 2018. Key findings from this paper were included in an article in the *Sydney Morning Herald* ,written by Education journalist Pallavi Singhal and also featured on television on *7 News Sydney*.

We anticipate submitting two additional journal articles by early next year, and several other articles are planned, many of which will be included within Felicia's PhD thesis work.

In addition to publications, we have presented findings from the project at both national and international conferences and we have presented the findings at teacher and careers advisor professional development meetings locally and nationally.

Below is a list of all dissemination activity currently associated with the project.

4.1. Publications

Jaremus, F., Gore, J., Fray, L., & Prieto-Rodriguez, E. (2018). Senior secondary student participation in STEM: Beyond national statistics. *Mathematics Education Research Journal*. doi:10.1007/s13394-018-0247-5
Downoaded 281 times from the journal website to date. Altmetric score of 13

4.2. Papers in preparation

Jaremus, F., Gore, J., Fray, L., & Prieto-Rodriguez, E. (forthcoming). "It's been a known fact for a while that maths is struggling": An analysis of factors beyond the ATAR that influence students' choice of high level mathematics

Jaremus, F., Gore, J., Fray, L., & Prieto-Rodriguez, E. (forthcoming). An analysis of girls' and mathematics teachers' perceptions of who participates in high level mathematics.

Jaremus, F., Gore, J., Fray, L., & Prieto-Rodriguez, E. (forthcoming). Why do girls enrol in high level mathematics? A qualitative analysis.

Jaremus, F., Gore, J., Fray, L., & Prieto-Rodriguez, E. (forthcoming). The aspirations of girls for careers requiring high level mathematics: Implications for girls' participation in secondary mathematics

4.3. Presentations

Jaremus, F., Gore, J., Fray, L., & Prieto, E. (2018, August) *"As bad as it sounds, they are the nerds": Girls' perceptions of who participates in STEM*. Paper presented at the Network Gender and STEM Conference, Eugene, OR.

Jaremus, F., Gore, J., Fray, L., & Prieto, E. (2018, August) Aspirations of Australian secondary students for careers requiring high level mathematics. Poster presented at the Network Gender and STEM Conference, Eugene, OR.

Fray, L., Patfield, S., & Jaremus, F. (2018, June) The educational and occupational aspirations of Australian school students: Understanding complexity for greater equity. Presentation at the Career and Transition Network Meeting for school careers advisors, Maitland, NSW.

Fray, L., Patfield, S., & Jaremus, F. (2018, May) The educational and occupational aspirations of Australian school students: Understanding complexity for greater equity. Presentation at an Aspirations Longitudinal Study teacher professional development evening, Newcastle, NSW.

Gore, J. (2018, May) The educational and occupational aspirations of Australian school students: Understanding complexity for greater equity. Presentation Career Development Association of Australia National Conference, Hobart, TAS.

Jaremus, F., Gore, J., Fray, L., & Prieto, E. (2018, April) The gendered future of STEM? Challenges revealed by girls' aspirations for careers requiring calculus. Paper presented at the American Educational Research Association Conference, New York, NY.

Jaremus, F., Gore, J., Fray, L., Lloyd, A. & Prieto, E. (2017, December) Aspirations of NSW high school girls for careers that require high level mathematics: A fine-grained analysis with alarming results. Poster presented at the Australian Association for Research in Education Conference, Canberra, ACT.

Jaremus, F., Gore, J., Fray, L., Lloyd, A. & Prieto, E. (2017, December) What enrolment trends reveal about male and female participation in mathematics: A nuanced analysis of NSW HSC data. Paper presented at the Australian Association for Research in Education Conference, Canberra, ACT.

4.4. Forthcoming presentations

Jaremus, F., Gore, J., Fray, L., & Prieto, E. (2018, November). *"It's been a known fact for a while that maths is struggling": A qualitative account of factors influencing students' enrolment in high level mathematics*. Paper to be presented at the Australian Association for Research in Education Conference, Sydney, NSW.

Jaremus, F., Gore, J., Fray, L., & Prieto, E. (2018, November). *The best, brightest and most advantaged; particularly if you're a girl: Aspirations of students in Years 3 to 12 for core-mathematics careers*. Paper to be presented at the Australian Association for Research in Education Conference, Sydney, NSW.

4.5. Media articles

Easier subjects making tertiary study harder (2018, September 25) The Coffs Advocate. Retrieved from: www.pressreader.com

High school students are selecting 'easier' subjects to get higher scores. (2018, September, 14) news.com.au. Retrieved from: https://www.news.com.au/

Singhal, P. (2018, September 12). 'Easy' HSC subjects growing, one in four girls no longer doing maths. *The Sydney Morning Herald.* Retrieved from: https://www.smh.com.au/

7 News Sydney. (2018, September 13). Maths out of fashion [Live Broadcast, Online Video]. Retrieved from https://www.facebook.com/7newssydney/videos/2125980484390302/

Of note, the Sydney Morning Herald article was shared from the Sydney Morning Herald Facebook page (https://www.facebook.com/pg/sydneymorningherald/) 41 times. It also generated 109 comments from the public.

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