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ORIGINAL ARTICLE

Does advanced mathematics help students enter university more than basic mathematics? Gender and returns to year 12 mathematics in Australia

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Abstract
Students in many jurisdictions can study Mathematics at different levels in their final 2 years of secondary education. The levels of Mathematics range from standard (not involving calculus), through basic calculus, to more advanced treatments of calculus and algebra. In this context, some students can elect to study Mathematics at a level below their ability. We consider the situation in New South Wales (NSW), Australia, where most Year 12 students who apply to university are awarded a percentile ranking, namely the Australian Tertiary Admission Rank (ATAR). The ATAR reflects students' results in the final 2 years of secondary education and frequently determines what they can study at university. As the study of Mathematics is often segregated by gender, it is of interest to explore how boys' and girls' choices about level of Mathematics study affect their ATAR. We analyze administrative data for 46,000 senior secondary students in NSW who completed their Year 12 in 2011 and the Longitudinal Survey of Australian Youth (LSAY) for the same cohort. Using two-level regressions that control for relevant student and school characteristics, we find that, for a given level of performance in Mathematics in Year 10, girls see greater improvement than boys in Year 12 for all levels of Mathematics except the most advanced course. Girls who study basic Mathematics achieve ATAR increments as high as girls in some advanced courses. We discuss how awareness of these results may influence students' decisions on what level of Mathematics to study in Years 11 and 12.

Keywords Advanced mathematics · Gender · High-stakes testing · Secondary mathematics · Australian tertiary admission rank

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Introduction

Social psychological theories, such as expectancy value theory (EVT) (Eccles 2011), explain why boys and girls choose different levels of Mathematics by pointing to students' expectations regarding their academic ability, enjoyment, self-concept as well as the perceived utilities, and costs[1] of particular choices. The empirical research in this area, however, usually pays more attention to individuals' own personal schemata than the consideration of utilities dependent on context (Eccles and Wang 2015; Guo et al. 2015). Specifically, the expected increases or decreases to the Australian Tertiary Admission Rank (ATAR) which can be derived from the choice of higher or lower-level Mathematics have not been considered through the EVT lens in Australia.

In this paper, we explore the potential costs and benefits of choosing a particular Mathematics study pathway for boys and girls with similar prior academic achievement, family, and school characteristics. We first consider similarities and differences between boys and girls who study Mathematics to obtain an ATAR. Next, we consider whether the returns to study of particular courses (that is the magnitude of the increase to the ATAR relative to Year 10 performance obtained by studying these Mathematics courses) justify the perception held by NSW teachers that many students elect to study Mathematics at a level below their ability, as a strategy to boost their university entry rank (MANSW 2014). We focus on gender, Year 12 completers, and ATAR, because in Australia, as in almost all other OECD countries, gender segregation affects upper secondary and tertiary study (Nagy et al. 2006; OECD 2011, 2015; Van Langen et al. 2006).

We triangulate evidence from full administrative student records with a longitudinal survey and relevant information from secondary sources. We demonstrate, in the case of Australia, that students' Mathematics course selections and returns to these choices have a potential to generate perceptions that the ATAR system rewards specific course-choice strategies that differ between boys and girls.

ATAR and upper secondary schooling in New South Wales

Australia has a comprehensive education system, where students are not sorted into different educational programs until age 16 and the sorting occurs primarily through school and subject choices that students often make with their parents. Of the university applicants who are Year 12 students at the time of application (Commonwealth Department of Education and Training 2017), most are admitted based on their Australian Tertiary Admission Rank (ATAR), which reflects each student's overall achievement relative to their peers in the country (Nicholas et al. 2015). This is the case even though the ATAR is not the only university entry pathway (Pilcher and Torii 2018). In New South Wales, the ATAR is based on obtaining the Higher School Certificate (HSC). To be eligible for an ATAR, a student must complete 10 units of accredited courses which comprise 2 units of English and 8 units from other subjects

[1] Utilities and costs are central concepts in expectancy value theory when it is applied to explain gendered subject choices (Eccles 2011). Utilities are benefits that involve realization of short or long-term goals or obtaining external awards, whereas the costs refer to time, effort, and psychological impacts, i.e., "anticipated anxiety, fear of failure, and fear of the social consequences of success" (Eccles 2011 p.198).

(UAC 2015b). The study of Mathematics is optional. The state board (in the case of NSW, the New South Wales Education Standards Authority (NESA 2016), previously known as the Board of Studies, Teaching and Educational Standards, approves courses used to calculate raw HSC marks. These marks are then scaled by the national Universities Admissions Centre (UAC) to moderate the differences between courses, schools, and states. The scaled HSC marks for each student make up an aggregate score out of 500 which is subsequently used to rank that student. It used to be the case that the aggregate score was reported to students. Since 1990, a percentile rank has been reported to students in place of this aggregate score out of 500. This percentile rank, known today as the ATAR, ranges from 0 to 99.95 with increments of 0.05. To illustrate, a student with an ATAR of 85.00 performed better than 85% of their reference cohort. The reference cohort is the students who began secondary education (in Year 7 at around age 12) 6 years prior to the award of the ATAR to completing Year 12 students (UAC 2015a). The ATAR is derived through a complex algorithm which involves multistage grade moderation and alignment (UAC, 2015a). ATARs depend on the level of difficulty of each contributing course indicated by how well students taking this course do in other courses they take. ATARs depend also on students' relative ranks in each contributing course. In NSW, the best 10 units of study (that is those units of study where the student performs best), inclusive of at least 2 units of study of English, are used to determine the ATAR. Students frequently present 12 units of study in Year 12 so 2 units (often equating to one subject) do not need to contribute to the final ATAR. In NSW, over 100 different courses could contribute to the ATAR in 2011 (UAC 2012) but the ATAR system should not disadvantage any student due to their choice of subjects. Short information videos on the Internet advise that "there is no way to game the ATAR system" and taking a specific course gives no guarantee of a higher ATAR (University of Sydney 2016).

Students hold different views about the utility of studying Mathematics to contribute to their ATAR (McPhan et al. 2008). The ATAR system involves high-stakes testing and as such, it is conducive to the emergence of informal strategies that individuals employ to maximize their ranks (for another account see Nicholas et al. 2015). In a recent survey undertaken with over 1000 NSW Mathematics teachers, by the Mathematical Association of New South Wales (MANSW), 51% of respondents reported that many of their students took Mathematics courses below their ability level (MANSW 2014). As many Australian universities relaxed mathematics-related entry prerequisites (Law 2018), some students decided that choosing a less demanding Mathematics course might benefit their ATAR (McPhan et al. 2008). Indirectly, the choice of school can also influence Mathematics course choice as a strategy to secure a better tertiary entry rank. For instance, students who enter elite schools (Forgasz and Hill 2013) typically obtain higher ATARs than their peers in other schools.

School choice and access to mathematics courses

In Australia, two-thirds of secondary students attend government schools, where priority is given to children living in local areas (Campbell et al. 2009). Parents who can pay tuition can opt for a Catholic or Independent school that charges fees which can vary from modest contributions to tens of thousands of dollars per annum. Furthermore, academically oriented children in NSW can sit a test to get into a selective school (mostly in the government sector) that accepts only high achievers. Finally, there are coeducational and single-sex schools, with the latter being mostly elite non-government schools. Most elite schools are in metropolitan areas. This array of choices, including many that come with a price tag, is what makes secondary schooling in Australia a strongly marketized system (Campbell et al. 2009; Perry and Southwell 2014). Secondary schools often compete for future students by advertising in newspapers the information about the ATARs achieved by past graduates (Forgasz and Hill 2013). While basic and advanced Mathematics courses are generally available to students who are enrolled in each of these school types, the highest-level course is sometimes not available in rural areas (McPhan et al. 2008). Therefore, the type and sector of schools are essential inputs to an analysis comparing boys' and girls' study of Mathematics.

Mathematics exams and course choices in NSW

New South Wales is an informative case study of ATAR-related gendered returns to Mathematics based on administrative records, because we can compare boys and girls with similar histories of Mathematics achievement. Until 2011, all NSW Year 10 students sat a series of tests which contributed to the award of their School Certificate (SC). These tests assessed Mathematics, science, and humanities skills (Pitt 2015). We use the information from the Mathematics SC test as an indicator of students' prior ability to examine whether comparable boys and girls benefit equally in terms of ATAR-related gains from their study of specific Mathematics courses.

Since 2001, NSW HSC students have been able to opt out of Mathematics study (Nicholas et al. 2015). For the approximately 78% of HSC students who study some form of Mathematics, the vast majority choose between four HSC Mathematics courses.

HSC General Mathematics (hereafter General Mathematics) is the most basic of the four courses (Board of Studies NSW 2012). It does not involve calculus and emphasizes practical applications of Mathematics in real-life situations. It is suitable for students who do not wish to pursue the study of Mathematics at tertiary level but instead wish to specialize in some area of business that does not involve quantitative analysis, humanities, social sciences, nursing, or paramedical sciences.

HSC Mathematics (hereafter Mathematics), is more demanding than General Mathematics. It involves elements of calculus with an emphasis on applications and is usually described as suitable for those wishing to specialize in science and commerce or other areas in which a minor specialization in Mathematics at tertiary level might be required (Board of Studies NSW 2008).

HSC Mathematics Extension 1 (hereafter ME1) is described as suitable for those interested in physical sciences, computing, or engineering and is studied in combination with Mathematics by students who do well in Mathematics and aspire to careers in these fields. The Mathematics Extension 1 score contributes more to the aggregate score used to derive the ATAR (3 units when studied with Mathematics) than the study of either Mathematics (2 units) or General Mathematics (2 units) (Board of Studies NSW 2008).

Finally, HSC Mathematics Extension 2 (hereafter ME2) is the most challenging of the four courses. It is suitable for students with aptitude for Mathematics and a special interest in it. The course is considered as preparation for the study of mathematically intensive fields at tertiary level. Students who study Mathematics Extension 2 also study Mathematics Extension 1 and for them, the contribution to the ATAR is worth 4 units (Board of Studies NSW 1989).

Obtaining a high ATAR is very competitive. It involves pooling the results from the 10 units of study where the student has performed best (inclusive of 2 units of English for all students) and in at least four subjects. As a result, students who want to study highly regarded programs of study at university often concentrate on subjects at which they excel and opt out of areas in which they struggle. Among those who study Mathematics, students in higher-level courses (Mathematics, ME1 or ME2) usually obtain stronger contributions to ATARs, i.e., they obtain higher HSC scaled Mathematics scores (UAC 2012). However, while studying higher-level courses generally leads to a higher ATAR, there are some anomalies in the process, (Pitt 2015). Nevertheless, students with sufficient ability can choose from a range of courses. Their choice will depend to some extent on their perceived benefit of choosing a level of study in Mathematics.

Theories and prior research on Mathematics and gender

The volume of research on gender differences in secondary Mathematics is considerable (Regan and DeWitt 2015). Much of this research is motivated by the fact that adolescent boys continue to outperform girls by a small but significant margin (OECD 2015). This margin, across the OECD countries, amounted, in 2012, to an average of 11 test score points on a scale with a mean of 500 and a standard deviation of 100. The participation gap in advanced upper secondary Mathematics, however, tends to vary from country to country. Historically in Australia, more boys than girls have taken up higher Mathematics (Ainley et al. 2008; Law 2018), which mirrors the situation in England (Noyes and Adkins 2016) but contrasts with reports from the USA, where higher proportions of girls are found in advanced courses (You and Sharkey 2012). One of the most influential theories used in psychology that explains the gender gap in Mathematics is expectancy value theory (EVT) (Eccles 2011) which posits that students make choices based on prior achievement, expectations of success, self-concept, and subjective task value which comprises interest, enjoyment, attainment value, the value of utility, and perceived costs. These considerations usually vary systematically between boys and girls in the context of different vocational interests (Eccles and Wang 2015) which are motivated by cultural stereotypes (Charles and Bradley 2009). While EVT acknowledges the importance of accounting for specific social and cultural contexts of these choices, measures of socialization (Polavieja and Platt 2014) and school effects (Frehill 1997; Legewie and DiPrete 2014) are usually not central to EVT research (Eccles and Wang 2015; Guo et al. 2015). Nevertheless, EVT shares many hypotheses with sociological and economic research based on rational choice explanations (Griffith 2010). Like EVT, the social cognitive learning theory (Bandura 1986) emphasizes the need to account for the full spectrum of possible choices open to individuals. However, as examining all the possible combinations of choices cannot be achieved in the scope of one paper, we focus here on the choices related only to Mathematics, while making sure we compare boys and girls of similar ability and characteristics.

All the theories above point out that students in comprehensive education systems have considerable control over, and responsibility for, their educational careers. Students face quite complex choice making in a situation of uncertainty about utilities and costs. Given that, these arguments point out that in meritocratic and rational systems, prior academic performance should be the strongest factor shaping subsequent educational pathway choices, but in reality students' self-concept and vocational interest, which vary strongly by gender, can lead boys and girls to select different pathways in Mathematics even if their prior performance is identical (OECD 2015). These theories require us to take into account school types and environments, which can also be indicators of social class (Forgasz and Hill 2013; Legewie and DiPrete 2014). Finally, they suggest that peer influences are gendered because girls and boys tend to follow models of the same rather than the opposite sex (for a comprehensive review see: Eccles 2011) which may be relevant in utility considerations.

Our analysis comprises two steps: first, we compare three groups of factors that might affect Mathematics uptake and course level choices made by boys and girls. In the second step, we compare ATAR returns to course choices made by boys and girls of comparable ability. The factors we compare in the first step are, first, the overall propensity to study Mathematics by gender as well as gender differences in the level of Mathematics by school type, namely private versus public and coeducational versus single-sex schools as well as academically selective versus non-selective. Second, we consider individual predictors of Mathematics course choices made by boys and girls which have been highlighted by EVT and prior research. They are prior academic ability, vocational expectations of students, their Mathematics self-concept, parental influences, and the context of other subject choices. Third, we examine how much comparable boys and girls gain in terms of ATAR when they study particular Mathematics courses. In the second step we consider how the patterns of ATAR returns, which students partially understand (MANSW 2014), may influence their perceptions of utility and costs involved in studying Mathematics.

Data, method, and measurement

To conduct the analysis, we used the Stata software and de-identified administrative records held by the Board of Studies, Teaching and Educational Standards (BOSTES) in New South Wales for over 46,000 students who sat their Year 10 SC tests in 2009 and then obtained their Higher School Certificate in 2011. These records provide full information about students' Year 10 SC achievement in Mathematics, school type, Mathematics courses, and the standardized score obtained on HSC Mathematics in the student's chosen course of study. The second data source is the nationally representative 2009 Australian Programme for International Student Assessment (PISA) sample of 15 year olds who have been re-surveyed every year since 2009 (NCVER 2012) in the Longitudinal Survey of Australian Youth (LSAY). The analyses are based on the second wave of the Y09 LSAY only for those NSW students who were in Year 11 in 2010, and Year 12 in 2011. We have 1138 NSW students with valid data.

Dependent variables and modeling techniques

We model the choice of Mathematics course for boys and girls where there are four different Mathematics courses available to the students. General Mathematics is coded as 1, Mathematics is coded as 2, ME1 is coded as 3, and ME2 is coded as 4. By contrast, the LSAY data classifies the level of Mathematics course of study into just three levels where ME1 and ME2 are collapsed into a single most advanced level of

Mathematics study (see Table 1). To account for between-school variation in access to these courses, we use two-level ordered logit random intercept models (Rabe-Hesketh and Skrondal 2012b) which are appropriate for nested data, where students share more common characteristics within schools than across schools and where Mathematics courses have an inherent order denoting their degree of difficulty.

To model ATAR returns to course choices, we use the HSC scaled Mathematics score, which is a variable ranging from 0 to 100. This is the input of Mathematics study to a student's ATAR. The BOSTES data contain HSC Mathematics marks; however, HSC scaled scores for individual students are not available due to privacy concerns. To derive them, we use published thresholds (i.e., select actual scores) and a linear interpolation procedure described by Pitt (2015). We note that the estimated scaled scores used in this analysis will be very close to the true scaled scores as explained by Pitt (2015). As a result, the output and conclusions from this analysis are not affected in

Table 1 Dependent and independent variables in LSAY data

	How it was measured (numerical codes in parentheses)
Dependent variable	
Mathematics course in Year 11	General Mathematics (1), Mathematics (2) ME1 or ME2 (3)
Independent variables	
Year 10 student's expectation to work, at age 30, in a mathematically intensive science occupation	Professional occupations in mathematical and physical sciences, information and communication technology and engineering[a] were coded as (1). Other occupations were coded as (0).
Father works in a mathematically intensive science occupation	Mathematically intensive science-related occupations were coded in the same manner as students' expected occupations.
Mother works in a mathematically intensive science occupation	Mathematically intensive science-related occupations were coded in the same manner as students' expected occupations.
Economic Social and Cultural Status (ESCS) (OECD 2009)	An OECD-derived variable which indicates socio-economic status of student family, measured in standard deviations above or below the mean with higher scores denoting higher status.
Year 10 mathematical literacy—PISA plausible value (OECD 2009)	An OECD-derived variable which is a mathematics literacy test score with a mean of 500 and a standard deviation of 100.
Physical science subject	Students who studied any of the following subjects: Physics, Chemistry, and Earth and Environmental Science were coded (1) and other students were coded (0). Subjects were coded on curriculum content, not on label.
Year 10 self-concept of own mathematical ability: a single question in which students assessed how well they did in Mathematics	The answer options were: very poorly (0), not very well (25), about average (50), better than average (75), very well (100).

[a] Verbatim reported occupational titles were coded to numerical codes of the Australian and New Zealand Standard Classification of Occupations ANZSCO (ABS 2006). Occupations treated as mathematically intensive comprised the following ANZSCO groups: 135, 23 (except for 234, 2323, 2324, 2325) and 26

any material way by the use of estimated scaled scores. To model the HSC scaled score gains, we use a two-level random intercept model for continuous outcomes which corrects for clustering of students within schools (Rabe-Hesketh and Skrondal 2012a).

Independent variables

In the administrative data, we have information on gender[2] coded as 0 for males and 1 for females, Year 10 performance in the Mathematics School Certificate test on a scale from 0 to 100 with school type and sector as control variables. We distinguish between government schools, Catholic schools, Independent schools, and selective schools. Selective schools in New South Wales admit only high-achieving students based on an entrance exam. Most selective schools are government schools and our data include government selective schools only. In each of the school sectors, we also distinguish between coeducational schools, boys-only schools, and girls-only schools. In the survey data analysis, we use the individual predictors shown in Table 1 as well as school type and sector distinctions that match those in the administrative data.

Results

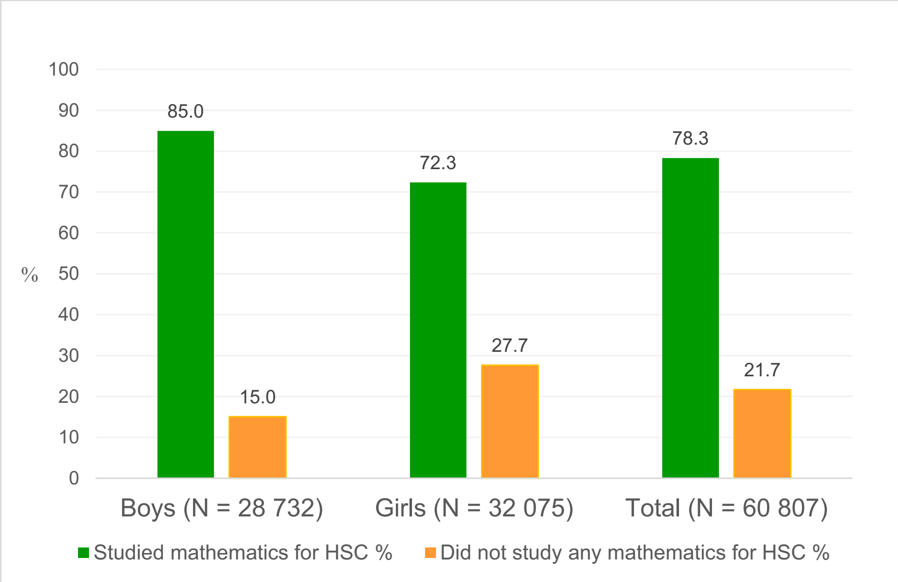
Students in NSW have considerable freedom when choosing subjects to build their study programs in Years 11 and 12. This includes, since 2001 (Nicholas et al. 2015), the option of discontinuing the study of Mathematics. Figure 1 shows how the rate of Mathematics course uptake varies significantly by gender. In 2011, 21.7% of NSW students decided not to study any Mathematics as part of their HSC program, but these students included 27.7% of girls in contrast to only 15% of boys.

It is evident that a lower proportion of girls than boys study Mathematics in Year 12, which can reinforce any existing notions held by students that studying Mathematics is culturally more appropriate for boys. Apart from gender differences, Mathematics study has become less popular among all students over time. Hodgen et al. (2010) compiled corresponding data for HSC students in NSW between 2001 and 2009 and appending our figures to their report shows a steady decrease in the proportion of secondary students who study any Mathematics in their final years of schooling. In 2001, 90.5% of HSC students took some Mathematics course, but in 2008 this proportion was only 79.2% (Hodgen et al. 2010), falling to 78.3% by 2011 (Fig. 1).

Most students study basic Mathematics only, but this varies by gender and school type

Most adolescents in NSW study Mathematics to gain a tertiary entrance rank, at the lowest of our four levels, that is, by taking General Mathematics which, in 2011 attracted 62% of all Mathematics-taking boys and 67% of girls (Table 2).

[2] We acknowledge the distinction between the cultural gender and the biological sex. However, in our data, no distinctions between gender diverse students are possible so we must assume that students are cis-gendered, i.e., their gender corresponds to their sex.



Data source: BOSTES

Fig. 1 Proportions of NSW students who did and did not study Mathematics as part of their Higher School Certificate program in 2011 by gender

The next level up, Mathematics, which involves elements of calculus, attracted 21% of boys and 20% of girls, with ME1 accounting for 10% of boys versus 9% of girls. The highest-level Mathematics course, ME2, attracted 7% of all boys but only 4% of all girls. The widest differences by gender are, therefore, in the lowest and highest-level courses.

The uptake of the four levels of Mathematics courses identified in the "Mathematics exams and course choices in NSW" section varies in single-sex and coeducational schools and across school sectors (see Table 2). Some 2% of students study Mathematics for the HSC at a level lower than General Mathematics. This explains the difference between the number of boys and girls who study Mathematics for their HSC in Fig. 1 and in the section for all schools in Table 2. In regular coeducational schools, only 2% of girls and 6% of boys study ME2. This contrasts with single-sex schools, where the proportions of students in ME2 are 10% of boys and 9% of girls. Many single-sex schools are Independent schools. The higher proportion of students at these schools studying the highest levels of Mathematics is consistent with their more elite status and associated intake of students of higher ability.

By sector, the highest uptake of advanced Mathematics courses occurs in Independent schools, followed by government schools and, as previously shown in Victoria (Forgasz and Hill 2013), in Catholic schools, where students are least likely to opt for higher-level Mathematics. Not surprisingly, selective schools have the largest proportions of students studying the highest-level Mathematics. In these schools, 33% of girls studied ME1 while 28% of girls completed ME2, while for boys, the corresponding proportions were 33% and 35%, respectively.

Table 2 Year 12 NSW Mathematics Course Enrolments in 2011 by Gender and School Type

	General Mathematics	Mathematics	ME1	ME2	Total	N
All schools						
Boys	62%	21%	10%	7%	100%	23,638
Girls	67%	20%	9%	4%	100%	22,717
Coeducational schools						
Boys	65%	20%	10%	6%	100%	18,368
Girls	73%	18%	7%	2%	100%	16,699
Single-sex schools						
Boys	54%	23%	14%	10%	100%	5,270
Girls	50%	25%	15%	9%	100%	6,018
Independent schools						
Boys	56%	24%	13%	7%	100%	5,822
Girls	59%	26%	11%	4%	100%	5,157
Catholic schools						
Boys	70%	20%	8%	3%	100%	4,181
Girls	74%	19%	6%	1%	100%	4,207
Government schools, except for selective schools						
Boys	69%	19%	8%	4%	100%	12,211
Girls	74%	17%	6%	2%	100%	12,033
Selective government schools						
Boys	8%	24%	33%	35%	100%	1,424
Girls	13%	26%	33%	28%	100%	1,320

Data source: BOSTES

The most advanced course in Mathematics is studied by one in three students at selective schools, while only 3% of boys and 1% of girls at Catholic schools study this course.

Given that more girls than boys opt out of HSC Mathematics study (Fig. 1), it may appear that, if students abandon Mathematics primarily because of prior performance, girls who continue in Mathematics should outstrip their male peers due to being in the top 72% rather than the top 85% of the Year 10 cohort. However, panel 1 in Table 3 reveals that girls who go on to study Mathematics do not do better than boys in their Year 10 examinations. We see that the average mark of girls who go on to study General Mathematics in their Year 10 SC Mathematics test was about 1% lower than for boys (69.78 versus 70.98). A similar difference was also observed for girls and boys who go on to study the Mathematics course (80.90 versus 82.38). It is of interest to consider not only means but also percentiles given in Table 3. Percentile values show that gender differences are very small and mostly insignificant for students in the upper and lower tails of Year 10 test score distributions in General Mathematics and Mathematics and for students who take up higher-level Mathematics courses, namely ME1 and ME2. Mean values suggest that boys and girls choose Mathematics courses based on their ability rather than cultural gender stereotypes. The gender gaps in Year 10 performance within Year 12 courses are small (Panel 1).

Table 3 Information about Distribution of SC Test Scores and HSC Scaled Mathematics Marks by Gender and Mathematics Subject

Panel 1: School Certificate Mathematics in Year 10, 2009									
	Mean			Percentiles					
		p1	p10	p25	p50	p75	p90	p99	N
General Mathematics [A]									
Boys	*70.98*	52	61	*65*	*71*	*77*	*81*	88	14,748
Girls	*69.78*	52	60	*64*	*70*	*75*	*80*	88	15,225
Mathematics [A]									
Boys	*82.38*	65	*74*	*78*	*83*	*87*	*90*	96	4,867
Girls	*80.90*	65	*72*	*77*	*81*	*86*	*89*	94	4,557
Mathematics Extension 1 [A]									
Boys	87.98	72	81	85	88	92	94	98	2,458
Girls	87.05	73	80	84	87	91	94	98	2,034
Mathematics Extension 2 [A]									
Boys	91.60	75	85	89	92	96	97	99	1,565
Girls	91.03	75	84	88	92	95	97	99	901
Panel 2: HSC scaled Mathematics scores in Year 12, 2011									
	Mean			Percentiles					
		p1	p10	p25	p50	p75	p90	p99	N
General Mathematics									
Boys	*41.63*	*0*	*19*	*26*	*39*	*57*	*69*	83	14,748
Girls	*43.55*	*3*	*20*	*27*	*42*	*59*	*71*	83	15,225
Mathematics									
Boys	*53.18*	*0*	*29*	*44*	*55*	*66*	*75*	86	4,867
Girls	*55.75*	*0*	*36*	*47*	*57*	*68*	*76*	86	4,557
Mathematics Extension 1									
Boys	*74.36*	31	*57*	*68*	77	84	89	96	2,458
Girls	*75.80*	39	*60*	*70*	78	84	89	95	2,034
Mathematics Extension 2									
Boys	86.29	48	75	84	88	92	95	99	1,565
Girls	86.33	49	77	83	88	92	94	98	901

Data source: BOSTES, estimates in italics are statistically different between boys and girls at the 1% significance level

[A] Year 10 information grouped by Year 12 course

In terms of ATAR-related returns to the study of Mathematics, which are measured by the HSC scaled Mathematics scores (Panel 2 in Table 3), girls do marginally better than boys in all courses except for ME2 where the scores are very similar for boys and girls. On average, boys in General Mathematics get 41.63 points while girls receive 43.55 points. In Mathematics, girls' marks are slightly larger with an average of 55.75 compared to 53.18 for boys. However, in ME2, boys and girls perform at a very similar level. The summary statistics in Table 3 do not show substantial differences in prior ability of boys and girls who select particular courses for HSC Mathematics. Girls get marginally higher returns to the study of lower-level courses and do as well as boys in ME2.

It is important to note that students with a very wide range of ability in Mathematics in Year 10 (as measured by their SC Mathematics test score) go on to study General Mathematics for their HSC. A similar phenomenon is evident for students who study ME2. As an example, students who scored about 80 on their SC Mathematics test go on to study HSC General Mathematics but also study ME1 or ME2. Although stronger performers in Year 10 tend to go on to higher-level courses, there is a considerable overlap in SC Mathematics test scores. This indicates that students look beyond their own ability when choosing the level of Mathematics to study in their final 2 years of school.

Table 4 shows how important prior Mathematics performance is for course choice compared to gender when school sector, type, and the variation across schools are taken into account. It reports the proportional odds ratios from a two-level ordered logit regression which predicts the odds of taking a higher-level course divided by the odds of taking any of the lower-level courses. The odds of an event is the probability of the event occurring divided by the probability of the event not occurring. The higher the odds of an event, therefore, the more likely the event will occur. Odds ratios greater than one, therefore, denote positive effects whereby a higher-level course of study in Mathematics is more likely as the predictor variable increases. The odds ratio of 1.315,

Table 4 Odds ratios of upper secondary Mathematics course choices in the BOSTES data. Two-level ordered logit regression (students nested in schools)

	General Mathematics (1) Mathematics (2) ME 1 (3) or ME2 (4)	
	Odds ratio	(SE)
Year 10 School Certificate (SC) Mathematics test score (0 - 100)	1.315***	(0.005)
Female	1.096*	(0.050)
Female x Year 10 School (SC) Certificate Mathematics test score	0.978***	(0.004)
Government school = reference category		
Catholic school	0.698***	(0.061)
Independent school	1.039	(0.084)
Selective school	1.275	(0.167)
Coeducational school = reference category		
Boys only school	1.285	(0.167)
Girls only school	2.058***	(0.177)
School level variance	0.543	(0.042)
Wald Chi-Square	7560.90	
p-value for Wald Chi-Square	0.000	
Number of schools	757	
Number of students	46,355	

Data source: BOSTES

*p<0.05

**p<0.01

***p<0.001

seen in Table 4, means that each extra SC Mathematics test point received by a student in Year 10 increases the predicted odds of a student studying a higher-level Mathematics course. The gender effect is depicted by a positive main effects term (1.096) and a negative interaction of SC Mathematics test score with gender (0.978). A useful way to summarize the impact of factors on choice of Mathematics course for the HSC is to compute expected probabilities or average partial effects (Mood 2010; Williams 2012) for boys and girls who obtained specific SC Mathematics test scores.

These predicted probabilities, based on Table 4, but not shown in it, indicate that for boys who received 85 points on their SC Mathematics test, the probability of subsequently taking General Mathematics was 21%, the probability of taking Mathematics was 47%, with 24% probability of taking ME1 and 7% chance of taking ME2. For girls with an SC Mathematics test score of 85, the corresponding probabilities were similar although higher for lower-level courses, namely 24%, 48%, 23%, and 4% respectively.

For boys who performed better on the SC Mathematics test, scoring 90 out of 100, these probabilities change considerably. They were 32% for General Mathematics, 7% for Mathematics, 39% for ME1, and 22% for ME2. Girls with an SC Mathematics test score of 90 had the corresponding probabilities of 9%, 36%, 37%, and 18% of taking one of the four Mathematics courses, ordered by difficulty. So, this 5-point difference in the SC score, which captures students' prior mathematics ability, matters much more than gender when predicting Mathematics course choices. Gender affects course choice only marginally.

Schools matter as a context for course choices yet only two school effects remain significant after gender and prior ability have been taken into account in Table 4. In Catholic schools, students take advanced Mathematics less often than students in the government sector. In contrast, girls in single-sex schools are more likely to take up advanced courses than their comparable peers in coeducational settings. Readers interested in the discussion of possible reasons for these differences across school sectors are referred to Marks (2010) and across single-sex and coeducational schools to Pahlke et al. (2014).

Analogous results also hold in the LSAY survey data when we model Mathematics course choice as a function of even more predictors, as suggested by EVT, in Table 5. The positive female coefficient of 1.543 does not reach statistical significance as a predictor of course choice in the smaller survey sample (see Table 5) but is a positive effect similar to what was observed in the BOSTES data. In line with the logic of EVT, students are more likely to choose higher-level Mathematics courses if they want to pursue a career in a mathematically intensive occupation, if they also study physical sciences, if their prior mathematical literacy scores are high and if they have elevated Mathematics self-concept. As the number of students is relatively small (1178 in Table 5), none of the interactions with gender reach statistical significance but the odds ratios suggest that girls who study Mathematics are less likely (0.649) to plan a mathematically intensive career than boys and less likely to study physical sciences in combination with Mathematics (0.739). School effects from the LSAY survey are similar to those observed in the BOSTES data analysis reported in Table 4. Otherwise similar students are less likely to study higher Mathematics if they are in Catholic schools and more likely if they are girls in single-sex settings. Students' whose parents enjoy higher socio-economic status (ESCS) or whose fathers or mothers work as science professionals seem more likely to study higher-level Mathematics, but none of the family background predictors reach statistical significance in Table 5.

Table 5 Odds ratios of upper secondary Mathematics course choices in the LSAY data predicted by variables in Table 4 plus occupational expectations, study of physical sciences, Mathematics literacy and self-concept. Two level random intercept model (students nested in schools)

	General Mathematics (1) Mathematics (2) ME1 or ME2 (3) [a]	
	Odds ratio	(SE)
Female	1.543	2.121
Expects work in Mathematics intensive science occupation	1.988***	0.607
Female x Expects science occupation	0.649	0.257
Physical science subject	3.979***	0.945
Female x Physical science subject	0.739	0.228
Mathematical literacy (PISA plausible value)	1.011***	0.002
Female x Mathematics literacy	0.998	0.002
Self-concept of own mathematical ability	1.035***	0.006
Female x Self-concept of own mathematical ability	1.010	0.007
Father works in Mathematics intensive science occupation	1.261	0.278
Mother works in Mathematics intensive science occupation	1.400	0.734
Family Economic, Social and Cultural Status (ESCS)	1.024	0.164
Government school= reference category [b]		
Catholic school	0.571*	0.141
Independent school	1.272	0.334
Coeducational school= reference category		
Girls only school	2.547***	0.572
Boys only school	1.750	0.504
School level variance	0.432	0.157
Wald Chi-Square	332.41	
p-value for Wald Chi-Square	0.000	
Number of schools	105	
Number of students	1178	

Data source: The 2009 LSAY cohort, data for 2010

*p<0.05

**p<0.01

***p<0.001

[a] The LSAY survey groups Mathematics Extension 1 and Mathematics Extension 2 into one category

[b] School level variables are measured as in Table 4

The results presented in Tables 4 and 5 provide similar messages. This is important because it suggests that our conclusions based on the BOSTES data, which have fewer control variables, are reliable. Both analyses suggest that students' prior academic record in Mathematics is an important predictor of later Mathematics course choices, in addition to students' career interests, self-concept, and other subjects they take. School context matters independently of students' individual characteristics, and gender is not the key factor determining course choices.

Moving forward from the analysis above, our next question is whether ATAR returns to course choices are similar for comparable boys and girls. Table 6 reports the results of regression analysis, based on the BOSTES administrative records. It shows how many HSC scaled Mathematics marks accrue to boys and girls who select different Mathematics courses. The benchmark for comparison is General Mathematics. Students with higher SC Mathematics test scores gain higher HSC scaled scores (by 1.628 points for each extra SC point) which confirms the expectation that the SC Mathematics test scores identify higher-ability students who tend to achieve higher ATARs. In General Mathematics, girls get about 4.6 scaled score points more than boys and this advantage is even larger for girls who obtained higher SC Mathematics test scores (by 0.084 of a point for each SC test point). Interaction terms between the remaining courses and gender show the differences in returns between students in higher-level courses and their counterparts in General Mathematics.

The first interesting finding in Table 6, given teachers' reports that students elect Mathematics courses below their ability level to maximize their ATAR (MANSW 2014), is that boys and girls who opted for Mathematics over General Mathematics received over 8 HSC scaled points less than their peers in the more basic course after allowing for the effects of all other variables, including the SC Mathematics test score. Boys in ME1 made an average gain of over 3 points compared to their counterparts in General Mathematics but girls made no gain at all over their female peers in this course. Finally, the gain made by boys in ME2 over their male peers of comparable ability in General Mathematics was 8.698 points while for girls this gain was only 4 points. First, it appears that students' strategies of opting for lower-level courses, reported by teachers, seem rational in light of these patterns, particularly the negative difference in returns to Mathematics over General Mathematics. Second, girls do not have as strong ATAR-related incentives as boys do to take up higher-level courses, namely ME1 and ME2.

The control variables at school level in Table 6 show that students in non-government and single-sex schools do a little better in terms of ATAR-related Mathematics scaled scores than their peers in other schools. Relative to the model with no predictors, the model in Table 6 explains 70% of the variance in HSC scaled scores and the school level contribution to the variance in HSC scaled Mathematics score is about 14%.[3]

To illustrate the range of options that an individual student would have if they had perfect knowledge of ATAR returns to the study of different Mathematics courses, Fig. 2 shows the predicted HSC Mathematics scaled scores (average partial effects) for boys and girls who received 85 points on their Year 10 Mathematics SC test (Mood 2010; Williams 2012). An SC Mathematics test score of 85 points is one standard deviation above the mean, and students with this SC Mathematics test score could realistically enter any of the four HSC Mathematics courses. All else being equal, a typical boy with a score of 85% on the SC Mathematics test received an HSC scaled score of 65.0 if he chose General Mathematics, 56.8 if he chose Mathematics, 68.0 if he chose to study ME1, and 73.7 if he studied ME2. For a typical girl with an SC Mathematics test score of 85, the corresponding returns were 70.4, 61.8, 70.6, and 74.4 HSC Mathematics scaled points (Fig. 2). So, the girl was better off than the boy in all courses except for ME2, where the results were

[3] In the baseline model without any predictors, the school level variance is 158.868 and the student level variance is 332.488. So, the overall explained variance for the model in Table 6 is ((158.868 + 332.488) − (16.606 + 129.010)) / (158.868 + 332.488) which is 70%.

Table 6 Predictors of the HSC scaled score in Mathematics (i.e. the contribution that the study of Mathematics makes to ATAR). Two-level random intercept linear model

	HSC Mathematics scaled score (contribution to ATAR 0 – 100 points)	
	Unstandardized coefficient	(SE)
Constant	45.379***	(0.257)
Year 10 School Certificate Mathematics test (0-100)	1.628***	(0.015)
Female	4.554***	(0.199)
Female x Year 10 School Certificate Mathematics test	0.084***	(0.018)
General Mathematics = reference category		
Boys x Mathematics	-8.255***	(0.423)
Girls x Mathematics	-8.605***	(0.378)
Boys x ME1	3.011***	(0.464)
Girls x ME1	0.176	(0.447)
Boys x ME2	8.698***	(0.562)
Girls x ME2	4.002***	(0.71)
Government school = reference category		
Catholic school	4.664***	(0.451)
Independent school	5.892***	(0.466)
Selective school (government school for high achieving students)	3.434***	(0.697)
Coeducational school= reference category		
Boys only school	3.549***	(0.588)
Girls only school	3.917***	(0.492)
School level variance	16.606	(1.220)
Student level variance	129.010	(1.740)
Wald Chi-Square	39215.05	
p-value for Wald Chi-Square	0.000	
Number of schools	757	
Number of students	46,355	

Data source: BOSTES

*p<0.05

**p<0.01

***p<0.001

broadly the same for both genders (as 73.7 is not statistically different from 74.4 given the overlapping confidence intervals bounds in Fig. 2). Overall, the between-gender comparison shows an advantage to girls. However, the relative gains over peers of the same-sex differ for boys and girls.

Girls, just like boys who studied Mathematics, did worse than students in General Mathematics, in line with teacher reports that students hope to get a better ATAR score by going for a lower-level Mathematics course. This lower outcome is of similar magnitude (over 8 points less) for boys and girls and could be attributed to the ATAR

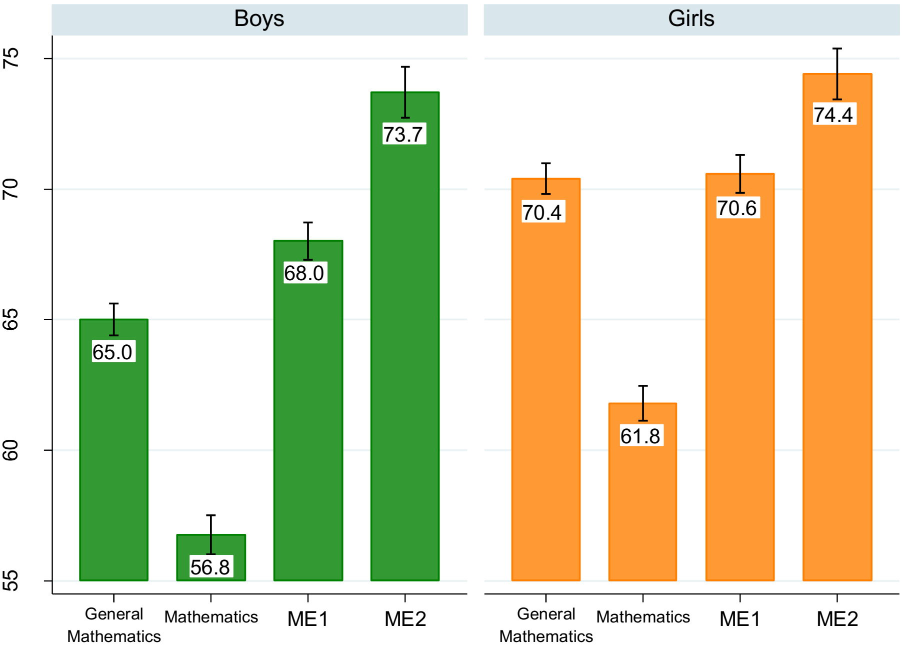


Fig. 2 Predicted HSC Mathematics Scaled Scores for boys and girls who received 85 points on their Year 10 SC test with other predictors in Table 6 kept at mean values. Data source: BOSTES

scaling procedures used in 2011 (Pitt 2015). These are very similar to those used at the time of writing this paper.

Boys, in contrast to girls, made significant gains in higher-level courses over what they could expect in more basic courses. For girls with an SC Mathematics test score of 85% however, the study of General Mathematics typically produced an HSC Mathematics scaled score of 70.4 which is the same as what girls scored in ME1 and 4 points less than what girls in ME2 received. These patterns could be seen as lack of ATAR-related incentive for girls to study ME1. If boys' gain of 8.698 points was to be taken as a benchmark of the extra ATAR bonus that ME2 students should return, girls' gain of 4 points might be seen, in relative terms, as a weaker incentive to study ME2.

Table 6 also raises the question of why girls in advanced courses do not gain over girls in lower-level courses by a margin comparable to what boys in advanced courses achieve over their peers. In ME2, we note that the gain by boys was nearly 9 points compared to around 4 points for girls. EVT and the associated theories suggest three possible reasons. The first could be lower Mathematics self-concept of girls relative to boys, but the interaction term between gender and self-concept in Table 5 is not significant and the coefficient close to 1 (1.01) suggests that girls in Mathematics courses do not have a lower self-concept than boys. The second reason is that boys and girls often have very different plans for their future areas of study and work after school. Finally, high-level Mathematics courses contain more elements of calculus which have many practical applications in Physics. Therefore, students who concurrently study physical sciences and calculus may benefit in terms of grades from doing these subjects in combination. Indeed, although interaction terms between gender and

Table 7 Career expectations and science subjects of students who took advanced mathematics courses (ME1 or ME2) by gender

Panel 1: ANZSCO codes and titles depicting 10 most popular occupations by gender					
	Boys	%		Girls	%
2613	Software and Applications Programmers	10.6	2530	Medical Practitioners	11.3
2330	Engineering Professionals	8.5	2713	Solicitors	9.3
2530	Medical Practitioners	8.5	2525	Physiotherapists	6.2
2531	Generalist Medical Practitioners	7.4	2349	Other Natural and Physical Science Professionals	5.2
2321	Architects and Landscape Architects	5.3	2340	Natural and Physical Science Professionals	4.1
2332	Civil Engineering Professionals	4.3	2410	School Teachers	4.1
2339	Other Engineering Professionals	4.3	2723	Psychologists	4.1
2349	Other Natural and Physical Science Professionals	4.3	2330	Engineering Professionals	3.1
4411	Defence Force Members	4.3	2343	Environmental Scientists	3.1
2112	Music Professionals	3.2	2523	Dental Practitioners	3.1
	Total	60.7			53.6
	Mathematically intensive science professions [a]	48			13
Panel 2: Year 11 Science subjects by gender					
	At least one physical science subject [b]	81			53
	At least one life science subject [c]	18			40

Data source. The 2009 LSAY cohort, data for 2010

[a] See Table 1 for definitions

[b] Physics, Chemistry, Earth and Environmental Science

[c] Biology, Senior Science

occupational expectations or take-up of physical sciences in Table 5 did not reach statistical significance, Table 7 shows that girls in advanced Mathematics courses are less likely than boys to expect careers in computing, engineering, or the physical sciences and they are less likely than boys to study physics with advanced Mathematics. Instead, girls opt more often for life sciences. This corresponds with full administrative records reported by Mack and Walsh (2013) on subject combinations for the same 2011 NSW HSC cohort.

Mack and Walsh (2013) found that the odds of boys taking a Physics course concurrently with advanced Mathematics were nearly two and a half times greater than the odds for girls. Our survey data, which are subject to attrition and contain relatively few observations, do not have enough explanatory power to fully show these differences. Nevertheless, in combination with prior evidence, our data suggest that occupational expectations and the associated subject choices could explain why girls in advanced Mathematics do not achieve as highly, relative to their same-sex peers in lower-level courses, as boys do.

Conclusion and discussion

This paper extends the literature on cost and utility considerations in the choices of Mathematics courses by illustrating how students might strategize course choices with respect to expected returns related to university entry ranks. In NSW, students elect Mathematics courses in line with their prior achievement, vocational interests, and self-concept, but, as we have shown, it is likely that they also respond to what they perceive as systemic tendencies to reward particular course-choice strategies. The first strategy is opting for the most basic course rather than the next one up; the second is the tendency for some capable girls to opt for more basic rather than for advanced courses. Both strategies might strengthen gender stereotypical course selections despite the fact that girls do not lag behind boys in any particular Mathematics course in terms of ATAR returns. In fact, they have higher returns than boys in all but the most advanced Mathematics.

Apart from ATAR returns, boys' and girls' choices of Mathematics courses depend on previous levels of achievement in Mathematics much more than on gender. Nevertheless, girls are overrepresented in the two lower-level courses even when their prior Mathematics performance is strong. In girls-only schools, girls are more likely than similar girls elsewhere to take up advanced Mathematics which attests to the necessity of accounting for school type effects in utility and cost research informed by EVT and associated theories.

For research outside of Australia, this paper illustrates the value of triangulating information from large scale administrative data with survey data. Gender differentials in returns to particular Mathematics courses found in this analysis would be undetectable in surveys, due to the lack of relevant variables, small samples, and attrition problems. We do not have direct reports from students on their motivation or their strategies employed when making course choices. However, the patterns of returns to particular courses we describe, based on administrative data, correspond to the reports of NSW Mathematics teachers who maintain that some students are inclined to choose Mathematics courses below their ability level in the hope of raising their ATARs. With the international growth of reliance on high-stakes testing, it is necessary to explore more the workings of assessment systems such as the ATAR in order to understand how students utilize their knowledge of these systems in their cost and utility considerations. While there is little doubt that students choose subjects based on their prior academic performance, self-concept, and career aspirations, so far little research has been devoted to examining the strategies that students might employ because they perceive a potential in lower-level Mathematics to raise their university entry rank. As standardized test assessments and rankings are assumed to be equitable with respect to how students of different genders, ethnicity, social class, and other social characteristics fare in them (Brookhart 2009), it is important to understand whether gender differentials of the type identified in this paper are stable or transitory, consequential or trivial, brought about by student self-segregation or generated within the assessment system itself through an un-designed institutional contingency effect. The same applies to the apparent and actual advantages of completing more basic Mathematics courses. To understand these issues better, two types of over time comparisons are necessary: between-genders within courses and within-genders between courses.

There are three important implications of our research. First, the differences in ATAR-related gains between high achieving girls who study basic and advanced Mathematics might not be large enough to motivate these girls to take the more demanding courses unless their vocational interests in the relevant areas are particularly strong. Second, while prior Mathematics performance, self-concept beliefs and occupational plans matter, in comprehensive systems individual student preferences in combination with test scaling procedures generate additional contingencies that might come across as systemic tendencies to award certain course-choice strategies and re-enforce gendered self-segregation. This is why some students in Australia seem to opt for the most basic course in the hope of securing a better university entry rank and why girls have weaker ATAR-related incentives to study higher Mathematics courses. Third, the magnitudes of gender differences found in our analysis although small may be consequential given that universities use specific thresholds to admit students into the most competitive programs. In this context, to enter a course that accepts only students with an ATAR of 95 or above a student may end up short of the crucial one ATAR point and attribute this to (not) having studied a specific Mathematics course. Although many students enter universities through pathways other than the ATAR, most applicants who are Year 12 students at time of application and most admissions to elite universities, known as The Group of Eight in Australia, rely on ATARs (Pilcher and Torii 2018). Our focus here is therefore on the ATAR and gender differentials.

To gain a better insight into these processes and their implications, more research is needed on how NSW adolescents negotiate the HSC system, how other youth negotiate similar systems elsewhere in the world, and how effective incentives could be created in ATAR-like systems to counter perceptions, particularly among girls, that opting for more basic Mathematics courses is a good strategy to secure a higher university entry rank.

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