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Influences on student decisions to enrol in higher-level mathematics courses

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Abstract
Addressing the participation rates in senior secondary mathematics courses in Australian schools remains a critically important issue. In this paper, the authors report on quantitative findings from a study in which all year 11 and year 12 (aged 17–18 years) Australian Tertiary Admissions Ranking (ATAR) students in Western Australia were invited to participate. The aim was to explore the perceptions of these students regarding their enrolment in higher-level mathematics courses. Data from 1633 students were collected using a survey instrument comprised of 12, 5-point, Likert-scale items. Data were analysed by applying two statistical procedures: calculating frequencies of the 12 items in the scale and examining associations with demographic characteristics and individual items through generalised linear modelling. Analyses indicated most students agreed that other courses of study were more attractive, with almost half indicating that they did not like mathematics. In addition, approximately half of the students said that they did not need to enrol in any mathematics course for ATAR or for university entrance. Significant findings were also identified for gender, school type, and school gender. The knowledge gained from this research is valuable in understanding students' reasons for choosing not to enrol in higher-level mathematics courses when they have the option to do so and, more broadly, to address persistently low or declining participation rates in these areas of study.

Keywords Secondary mathematics participation · Secondary mathematics enrolments · Senior secondary mathematics · ATAR

Introduction

The low or declining participation rates of students in senior secondary mathematics courses remains an ongoing concern in Australia [(Office of the Chief Scientist (OCS), 2020; Easey, 2019; Forgasz & Leder, 2020; Jaremus et al., 2019)] and internationally (Arnoux et al., 2009; Hogden et al., 2010; O'Meara et al., 2020). With the established

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importance of studying higher-level, senior secondary courses in mind (Australian Academy of Science, 2006; Hine et al., 2021), researchers have investigated this issue to identify relationships between participation rates in secondary mathematics courses and future success at university (Hine et al., 2015) and in other disciplines (e.g. physics) (Kennedy et al., 2014; Ker, 2013). Other researchers have focussed efforts on analysing large-scale enrolment and achievement data (e.g. Jaremus et al., 2019; Jennings, 2022) or on exploring the perceptions of key stakeholders (e.g. Hine, 2019; Kaleva et al., 2019; Noyes & Adkins, 2016) to determine key reasons underpinning enrolment decisions. Notwithstanding the methodological approach used, scholars agree that addressing current participation rates in senior secondary mathematics courses remains a critically important issue (Barrington & Evans, 2014; Brown et al., 2008; Jennings, 2014).

Traditionally, students aiming to go to university would have needed a high Australian Tertiary Admission Rank (ATAR) score, and if aiming to study Science, Technology, Engineering, and Mathematics (STEM), this would have most likely required the inclusion of a higher-level mathematics course. Over the past two decades, requirements of mathematics for entry into university have become less stringent. Australian universities have begun to admit a broader range of student achievements with alternative entrance pathways (e.g. tertiary enabling programs, university entrance schemes) becoming more widely accepted. The earlier pre-requisites of requiring mathematics have become a recommended or desirable requirement rather than essential. With increasingly different options available and with less stringent mathematics requirements for university courses (e.g. engineering, science), selection of these harder courses at secondary school level has declined. To illustrate, an audit was undertaken of mathematics and science pre-requisites in Australian universities nationwide for entry into the 2020 academic year. From 1587 courses, it was determined that only 19 courses in Australia require higher mathematics. Notably, higher mathematics was frequently listed alongside intermediate mathematics for relevant courses (OCS, 2020).

This research considers, specifically, reasons given by secondary school students in Western Australia (WA), as to their mathematics enrolment choices. In WA, there are three levels of mathematics courses: Specialist Mathematics, Mathematics Methods, and Mathematics Applications. The most demanding course is Specialist Mathematics, which is taken by students wishing to undertake tertiary study in engineering, physical sciences, and mathematics [School Curriculum and Standards Authority (SCSA), 2023a]. Mathematics Methods is an intermediate course, which '… is designed for students whose future pathways may involve mathematics and statistics and their applications in a range of disciplines at the tertiary level' (SCSA, 2023b). Mathematics Applications is a lower-level ATAR course designed for students who may continue their studies at university or Technical and Further Education (TAFE), with a wide range of educational and employment aspirations (SCSA, 2023c).

By targeting a very large number of students across one region, this research aims to provide a more unified response to identify the issues that may be reflecting student selection choices. Due to the declining rates of students selecting mathematics courses, gaining a better understanding of the reasons underpinning this is important and is the focus of this research.

Literature review

Factors impacting on selection of mathematics courses in Australia

Past research efforts have uncovered various factors impacting on students' decisions regarding the elective study of senior secondary mathematics. Most researchers have reported on features considered inherent to the individual student, such as prior achievement, expectations of success, self-efficacy, subjective task value (interest, enjoyment, attainment value), perceived difficulty, and affective response (e.g. Easey, 2019; Hine, 2018, 2019; Kennedy et al., 2014; Prieto & Dugar, 2017; Sikora & Pitt, 2019). Gemici et al. (2014) noted that these individual perceptions do not develop in isolated instances; rather, they tend to be heavily influenced by the people with whom students spend most time in their immediate environment. To illustrate, Kirkham et al. (2020) found that family influences, and teacher and peer advice, were frequently cited reasons by students who chose intermediate and advanced mathematics courses. As young adults, there is a possibility that senior secondary students may not appreciate the importance of mathematics in their future careers, although there is evidence that such perceptions of usefulness are critical in the decisions made to study basic versus advanced-level mathematics (Kirkham et al., 2020).

Wilkie and Tan (2019) explored Australian mathematics teacher leaders' (TLs) actions to influence senior secondary students' subject enrolments. Key attributions influencing TLs' actions included students' lack of ability, changes in university courses' pre-requisites, students' lack of effort or persistence, and negative attitudes towards mathematics. In addition, the removal of mathematics pre-requisites for many Australian degree programs (Jennings, 2022; Universities Admissions Centre, 2017) and increasing options of university bridging courses may have resulted in students perceiving higher-level mathematics as having low utility value, or even unnecessary if there is an option to 'catch up' once at university. While Jennings determined that Queensland students elected not to undertake a higher-level mathematics course due to low utility, these same students agreed that their perceptions of the subject and self-assessment of their mathematical ability did not influence their decision not to participate. In the same study, it was determined that students undertaking advanced courses had an affinity with mathematics and were influenced by their parents and mathematics teachers (Jennings). State-level or jurisdictional changes on how secondary school results are calculated and reported may have also resulted in students 'playing the system' to maximise their final year results (Hine, 2018, 2019; Kirkham et al., 2020; Wilkie & Tan, 2019). Scholars have also given attention to how enrolment decisions may be related to gender (Jaremus et al., 2019; Sikora & Pitt, 2019), geolocation (Murphy, 2019), and school type (e.g. Forgasz & Leder, 2020; Getenet & Beswick, 2021). These issues will now be explored.

Gender issues

Commentators have underscored how enrolment decisions operate as a function of gender, with a persistent and disproportionate number of girls opting out of higher-level mathematics courses. In the UK, Brown et al. (2008) found a tendency for girls to hold a lower self-academic concept about mathematics than boys (e.g. 'too difficult') and a lower subjective task value ('do not enjoy/like it'; 'boring'). These findings were echoed nearly a decade later by Smith (2017), who suggested that girls hold a lower mathematics self-concept than boys with the same prior achievement and that boys were more likely to regard mathematics as easier than other subjects. Additionally, Smith indicated that girls are more likely to continue in a subject if they enjoyed it and felt they were succeeding, as well as to cite stereotypical images associated with mathematicians as a reason not to continue in the subject. In Finland, Kaleva et al. (2019) posited that although the Finnish girls were the topmost mathematics performers in the world (Ministry of Education and Culture, 2016), further mathematics study interests were significantly segregated by gender. To illustrate, girls reported more reasons than boys related to subjective value (enjoyment, interest) and self-concept (self-efficacy, ability, competence) for rejecting advanced mathematics, a pattern consistent with responses for choosing basic mathematics.

In Australia, while Forgasz and Leder (2020) found no consistent pattern to explain senior secondary boys' and girls' enrolments in STEM subjects by school type in Victoria (single-sex or co-educational), Jaremus et al. (2019) offered some insights for enrolment data in New South Wales (NSW). In particular, these researchers interrogated year 12 enrolment data from 1991 to 2017 in NSW to determine any patterns in course enrolments. These researchers confirmed declining enrolments in digital technologies and mathematics, especially for girls. Conversely, while science enrolments were found to have been increasing since 2001, there was a noted decline in advanced mathematics enrolments. Despite an increase in intermediate level mathematics in 2017 (the first increase since 1991), Jaremus et al. concluded that students were selecting less-challenging courses, with one in four year 12 girls in NSW undertaking no mathematics. This finding corresponds with the earlier work of various researchers in different Australian states (e.g. Forgasz, 2005; Hine, 2018, 2019: Mathematical Association of NSW, 2014). Sikora and Pitt (2019) analysed administrative data for over 46,000 senior secondary students in NSW who completed year 12 studies in 2011. These researchers found that for year 10 students' given level of performance in mathematics, girls demonstrated greater improvement than boys in year 12 across all levels of mathematics; except the most advanced mathematics course. In addition, girls undertaking basic mathematics courses achieved similar ATAR increments as girls participating in some advanced courses.

The extent to which attendance at a single-sex school (particularly for girls) might influence higher participation and achievement in mathematics has also been explored (e.g. Croswell & Hunter, 2012; Forgasz & Leder, 2020; Lenzner, 2006). Norton and Rennie (1998) examined the attitudes of secondary students towards mathematics, across four school types (single-sex schools for boys and girls, state and private co-educational schools), finding no differences between students attending co-educational schools. While students' attitudes were found generally to be less positive in more senior grades, boys overall expressed more positive attitudes than girls, and girls provided less stereotyped perceptions than boys. More recently, Forgasz and Leder examined the participation rates in STEM-related subjects of year 12 students. They found that boys were more likely than girls to study these subjects. Moreover, for some mathematics-related subjects, higher proportions of girls attending single-sex schools were enrolled than girls attending co-educational schools. Similar trends were noted for boys. More recent research conducted by Forgasz and Leder (2022) suggested that the mean 2017 year 9 NAPLAN numeracy scores in single-sex boys' and girls' schools were higher than the mean scores across Australia for boys and for girls, respectively.

Geolocation

Researchers have investigated the extent to which geolocation impacts students' mathematics achievements and participation rates in mathematics. To commence, Murphy (2019) repurposed school-level data to examine patterns of participation and achievement in senior secondary school mathematics courses in Victoria. An analysis confirmed that socioeconomic states was strongly tied to participation and achievement in these courses and that non-metropolitan schools tended to perform more poorly than metropolitan schools in these areas. In addition, non-metropolitan schools were less likely to offer advanced mathematics courses than metropolitan schools, and when they did, their students were less likely to choose those options. Moreover, Murphy found that correlations between mathematics performance and socioeconomic status were far weaker in non-metropolitan schools than in metropolitan schools. Australian researchers have analysed the numeracy results from the National Assessment Program Literacy and Numeracy (NAPLAN) data in primary school-aged children (i.e. years 3 and 5). Across various studies, it has been concluded that metropolitan students outperform those in regional or remote schools in numeracy (Forgasz & Hill, 2013; Getenet & Beswick, 2021; Jorgensen & Lowrie, 2013).

In the USA, Anderson and Chang (2011) examined participation rates of secondary students in mathematics courses as they pertained to geolocation. These researchers found that secondary school graduates in rural schools typically earn fewer mathematics credits than their non-rural counterparts. To amplify, findings suggest that rural students also tend to commence secondary school at a slightly lower mathematical ability and end their mathematics studies sooner, therefore attaining an overall lower course-level of mathematics. Furthermore, rural graduates tend to have substantially less access to advanced placement mathematics courses. Graham and Provost (2012) found that the average increase in mathematics achievement from kindergarten to eighth grade for rural and urban children was smaller than the increase for suburban children, resulting in a widening achievement gap over time. Ihrig et al. (2018) concluded that high-achieving students in economically disadvantaged, rural schools lack access to advanced coursework necessary to pursue STEM educational and employment goals at the highest levels, contributing to the excellence gap.

To summarise, a number of factors impacting on student selection of mathematics courses in Australia have been explored and presented. Drawn from the literature base, these factors include those inherent to students (e.g. prior achievement, subjective task value), as well as external influences (e.g. advice from family, friends, and teachers). Students' enrolment decisions are also affected by institutional factors which largely comprise university entrance requirements, school geolocation, and school type. These factors and others have been considered in the development phase of the research instrument for this project, which is outlined in the next section.

Research aim

The aim of this project was to investigate the perceptions of year 11 and year 12 ATAR students in WA secondary schools regarding declining student enrolments in higher-level mathematics courses. The overarching question to be explored was: What are the reasons that senior students enrol in higher-level mathematics courses?

Method

Development of survey

The survey items were developed from the findings of two previous studies (Hine, 2018, 2019) as well as from current literature (Barrington & Evans, 2014; Kennedy et al., 2014; McPhan et al., 2008; Wilson & Mack, 2014). The originally drafted 10 survey items were presented at a Catholic Education Western Australia network day involving 40 Heads of Learning Area (Mathematics) for review and feedback. This resulted in the inclusion of two further items: (k) *Their friends are doing the same courses as them* and (l) *They do not like the teachers who take higher mathematics courses*. The final questionnaire consisted of 12 items forming the survey instrument designed to explore the reasons that senior students enrol in higher-level mathematics courses.

Demographic characteristics included gender (male, female, non-binary/third gender, prefer not to say); year level (11 or 12); school type (K-year 12 (primary and secondary combined), secondary); school's gender composition (co-educational, single sex (male, female); and school geolocation (metropolitan, non-metropolitan). Mathematics choices in WA provide three options. Students may enrol in either Applications or Methods as single courses, and in this study, these are considered to be lower-level mathematics. Alternatively, they may enrol in Methods and Specialist together, and in this study, this is referred to as higher-level mathematics. Students are unable to enrol just in Specialist without undertaking Methods. Analysis of courses is undertaken in relation to either lower-level or higher-level mathematics [Lower-level mathematics (Applications only, Methods only), Higher-level mathematics (Specialist and Methods together)].

Participant selection

Prior to the commencement of the participant selection process, the Chief Investigator sought and gained Institutional Human Research Ethics Committee approval from the university (Ref 019182F), the Department of Education (Ref D20/0293437), and Catholic Education WA. From the 198 WA secondary schools (39 Catholic, 61 independent, 98 government) offering higher-level mathematics courses to year 11 and year 12 students (aged 17–18) years) in 2021, 43 principals gave their permission for the project which proceeded at all schools. Of these 14 were Catholic, 12 were independent, and 17 were government. A project information sheet was sent to parents and students at participating schools to outline the scope and procedure of the project. Using an opt-out process, students gave their consent to participate by completing an anonymous, online survey. A total of 1633 senior students responded to the questionnaire. Of these, 49 were incomplete and discarded. The resulting sample was 1584.

Demographic characteristics are summarised in Table 1. Students mostly identified as male or female (96.2%) were spread across years 11 and 12, with almost two-thirds of respondents studying Mathematics Applications and only one-tenth studying the higher-level Mathematics Methods and Specialist combination. Two-thirds of students came from secondary schools, with the remainder combined primary and secondary schools, with schools mostly from the metropolitan areas.

Statistical analysis

Frequencies of the 12 items in the scale were scored according to the Likert scale value (1 = completely disagree, 2 = slightly disagree, 3 = neutral, 4 = slightly agree, 5 = completely agree). A higher score represented a higher agreement with the item statement. Unless otherwise noted, statistical analysis was undertaken using IBM SPSS (Version 28, 2021), standardised test statistics and 2-sided *p*-values reported, with statistical significance set at $p < 0.05$.

Chi-square (χ^2) (or Fisher-Freeman-Halton Exact for cell counts < 5) was used to examine the association between demographic characteristics and higher mathematics (Methods & Specialist) versus lower mathematics (Methods or Applications only) with exact 2-sided *p*-value reported.

Generalised linear modelling was undertaken to explore associations with demographic characteristics and individual items, particularly as these enable the analysis of unbalanced and non-normal data with binary outcome variables (Bono et al., 2021). Generalised linear models (GLM) used a binomial probability distribution with logit link function and Bonferroni corrected pairwise comparison. The binary outcome (higher mathematics — Methods and Specialist) versus other mathematics (Applications or Methods only) was used to explore associations with individual demographic characteristics (model 1); individual mathematics items (model 2); and a combined model with identified factors (test of fixed effects $p < 0.10$) for (model 3). Tests of model effect (Wald chi-square ($\chi 2$), parameter odds ratio (OR) (Exp(β)), and 95% Wald confidence intervals (CI) are reported.

Table 1 Demographic characteristics for total sample

Characteristic	Total sample *f*	%
Gender		
Male	821	51.8
Female	704	44.4
Non-binary/third gender	33	2.1
Prefer not to say	25	1.6
Missing	1	0.1
Year level		
Year 11	860	54.3
Year 12	720	45.5
Missing	4	0.3
Mathematics course		
Applications	962	60.7
Methods	368	23.2
Methods & Specialist	175	11.0
Missing	79	5.0
School type		
Primary & secondary	581	36.7
Secondary only	994	62.8
Missing	9	0.6
School gender composition		
Co-educational	1,334	84.2
Single sex	248	15.7
Missing	2	0.1
School geolocation		
Metropolitan	1,121	70.8
Non-metropolitan	454	28.7
Missing	9	0.6

f frequency, % percent

Results

The research utilised the 12-item survey instrument to identify the reasons that senior students enrol in higher-level mathematics courses. Only 11.0% ($n = 175$) of the sample reported studying higher-level mathematics (Specialist and Methods) compared to lower-level mathematics (Applications ($n = 962$ 60.7%) or Methods only ($n = 368$ 23.2%)). Table 1 provides a summary of findings for gender, school type, school gender composition, and school geolocation. Chi-square analysis reported higher-level mathematics was studied by mostly boys (78.9%, $p < 0.001$) compared to an equal male–female split for lower-level mathematics. Lower-level mathematics was proportionally higher at secondary only schools ($p < 0.001$) and co-educational schools ($p < 0.001$) and non-metropolitan schools ($p = 0.003$).

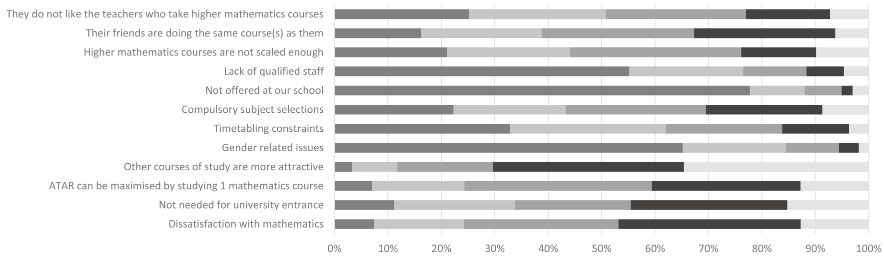
Student responses to the 12 mathematics items are summarised for the total sample in Table 2. More than two-thirds of respondents (70%) slightly or completely agreed that other courses of study were more attractive. Almost half of the students slightly or completely agreed that they were dissatisfied with mathematics (47%), did not need mathematics for university entrance (45%), and/or believed they could maximise their ATAR by only studying one mathematics subject (41%). One-third slightly or completely agreed their choice was influenced by their friends doing the same course(s) as them (33%) and/or compulsory subject selections (30%). One-fifth slightly or completely agreed that higher-level mathematics courses were not scaled enough (24%), and/or they did not like the teachers who were teaching the higher-level mathematics course (23%). Very few participants reported timetabling constraints (16%), lack of qualified staff (12%), gender related issues (6%), and subject not on offer at their school (5%).

General linear modelling examined associations between those respondents who reported studying higher-level mathematics course (Specialist and Methods) compared to those who did not (Applications or Methods only). Three models are described (Tables 2, 3, and 4).

Model 1 explored the association of demographic characteristics with the selection of higher-level mathematics. Model 1 identified gender (Wald $\chi 2=29.1$, $p<0.001$; post hoc male v female, $p<0.001$), school type (K-year 12 v secondary only) (Wald $\chi 2=4.7$, $p=0.030$), and school gender (co-educational v single sex) (Wald $\chi 2=6.3$, $p=0.012$) as important associations with odds ratio for the model reported at Table 3. Higher-level mathematics course selection was 3.3 times higher for boys, 1.5 times higher for students at a combined primary and secondary school, and 1.7 times higher for students at single-sex school.

Model 2 explored each of the 12 items individually for higher mathematics reported at Table 4. Important mathematics items identified in model 2 were dissatisfaction with mathematics (Wald $\chi^2=15.5$, $p=0.004$), ATAR can be maximised

Table 2 Level of agreement with each of the 12 mathematics items



	Dissatisfaction with mathematics	Not needed for university entrance	ATAR can be maximised by studying 1 mathematics course	Other courses of study are more attractive	Gender related issues	Timetabling constraints	Compulsory subject selections	Not offered at our school	Lack of qualified staff	Higher mathematics courses are not scaled enough	Their friends are doing the same course(s) as them	They do not like the teachers who take higher mathematics courses
Completely Disagree	118	176	112	53	1032	520	352	1227	871	333	257	398
Slightly Disagree	266	360	273	133	306	461	332	162	336	362	357	405
Neutral	457	342	555	283	158	343	413	109	187	507	452	414
Slightly Agree	541	465	441	566	59	198	344	33	111	222	418	249
Completely Agree	201	241	202	547	29	58	137	47	73	155	99	114

The sum of each column in Table 2 is not the same because not all participants answered each question

Table 3 Model 1: Results examining demographic influences associated with studying higher-level mathematics course (Methods & Specialist)

Parameter	Exp (B)	95%CI		Wald Chi-square	p-value
		Lower	Upper		
Intercept	*0.1*	*0*	*0.6*	*6.7*	*.010*
Gender [a]					
Male[1]	1.6	0.4	7.2	0.4	.509
Female[1]	0.5	0.1	2.2	0.9	.492
Non-binary/third gender[1]	1.6	0.3	9.1	0.3	.609
Year 11[2]	1.1	0.8	1.5	0.3	.612
School type: primary & secondary[3]	**1.5**	**1.0**	**2.2**	**4.7**	**.030***
Co-educational[4]	**0.6**	**0.4**	**0.9**	**6.3**	**.012***
Metropolitan[5]	1.2	0.8	1.9	0.7	.409

Bolded indicates test of fixed effects $p < .10$, with these items included in the combined model 3 analysis

by studying one mathematics course (Wald $\chi^2 = 12.8$, $p = 0.013$), higher mathematics courses are not scaled enough (Wald $\chi^2 = 14.1$, $p = 0.007$), and friends are doing the same course(s) as them (Wald $\chi^2 = 20.1$, $p < 0.001$). Only friends are doing the same course(s) as them reported any significant pairwise comparisons (completely disagree versus neutral, $p = 0.006$, and slightly agree, $p = 0.003$).

Model 3 combined the identified demographics of gender, school type, and school gender and the identified items of dissatisfaction with mathematics, maximising ATAR by studying one mathematics course, higher mathematics courses not being scaled enough, and friends doing the same course. All of these remained significantly associated with selecting higher-level mathematics courses (Table 5). Higher-level mathematics course was more likely to be chosen if respondents completely disagreed with ATAR being maximised by studying only one mathematics course (OR = 2.6 times more likely). Further, respondents were more likely not to choose higher-level mathematics if they were dissatisfied with mathematics or neutral (OR = 1.7 and OR = 2.5, respectively) and neutral to 'higher mathematics courses are not scaled enough' (OR = 2.5).

Discussion

Internationally, the lack of engagement of girls in mathematics courses has become a cause for concern. Similarly, declining enrolments for girls in mathematics has been recorded over the past two decades in many regions in Australia. In NSW for example, Jaremus et al. (2019) found that approximately a quarter of all girls were undertaking no mathematics courses. A range of less rigid constraints have been introduced leading to the need for mathematics to become recommended or desirable rather than pre-requisite. Similar transitions have been happening internationally. The critical need for higher-level mathematics, nevertheless, continues to be expounded by international governments as essential for success at university,

Table 4 Model 2: Results examining mathematics item influences associated with studying higher-level mathematics course (Methods & Specialist)

Parameter	**Exp (B)**	**95%CI**		**Wald chi-square**	***p*-value**
(Test of fixed effect *p*-value)		Lower	Upper		
Intercept	.240	.059	.983	3.935	.047
Dissatisfaction with mathematics ($p = .004$)					
Completely disagree	.674	.313	1.452	1.013	.314
Slightly disagree	.888	.495	1.594	.159	.690
Neutral	.382	.213	.687	10.321	.001*
Slightly agree	.531	.311	.906	5.397	.020*
Not needed for university entrance ($p = .387$)					
Completely disagree	.795	.420	1.503	.500	.480
Slightly disagree	.613	.345	1.089	2.791	.095
Neutral	.786	.443	1.397	.673	.412
Slightly agree	.975	.579	1.640	.009	.923
ATAR can be maximised by studying 1 mathematics course ($p = .013$)					
Completely disagree	1.939	.979	3.839	3.604	.058
Slightly disagree	1.284	.705	2.340	.668	.414
Neutral	.725	.408	1.288	1.203	.273
Slightly agree	.834	.470	1.481	.384	.536
Other courses of study are more attractive ($p = .091$)					
Completely disagree	2.089	.841	5.189	2.517	.113
Slightly disagree	1.321	.691	2.527	.710	.400
Neutral	1.975	1.187	3.286	6.859	.009*
Slightly agree	1.238	.796	1.925	.901	.343
Gender-related issues ($p = .703$)					
Completely disagree	.560	.142	2.206	.688	.407
Slightly disagree	.536	.130	2.220	.739	.390
Neutral	.809	.186	3.522	.079	.778
Slightly agree	.698	.144	3.384	.199	.656
Timetabling constraints ($p = .762$)					
Completely disagree	.976	.390	2.447	.003	.959
Slightly disagree	.847	.331	2.164	.121	.728
Neutral	.683	.256	1.819	.583	.445
Slightly agree	.809	.298	2.195	.173	.677
Compulsory subject selections ($p = .114$)					
Completely disagree	.798	.402	1.581	.419	.517
Slightly disagree	.966	.489	1.909	.010	.920
Neutral	.837	.424	1.652	.264	.608
Slightly agree	.461	.221	.963	4.239	.039*
Not offered at our school ($p = .901$)					
Completely disagree	1.866	.418	8.335	.667	.414
Slightly disagree	2.175	.455	10.410	.947	.331
Neutral	1.805	.338	9.638	.478	.489

Table 4 (continued)

Parameter (Test of fixed effect *p*-value)	Exp (B)	95%CI Lower	95%CI Upper	Wald chi-square	*p*-value
Slightly agree	1.491	.226	9.841	.172	.678
Lack of qualified staff ($p = .223$)	1				
Completely disagree	1.091	.339	3.518	.022	.883
Slightly disagree	.767	.234	2.514	.191	.662
Neutral	.452	.123	1.663	1.427	.232
Slightly agree	.765	.216	2.707	.173	.677
Higher mathematics courses are not scaled enough ($p = .007$)					
Completely disagree	.792	.440	1.427	.602	.438
Slightly disagree	.513	.277	.951	4.497	.034*
Neutral	.375	.203	.694	9.770	.002*
Slightly agree	.756	.397	1.439	.727	.394
Their friends are doing the same course(s) as them ($p < .001$)					
Completely disagree	.440	.181	1.070	3.280	.070
Slightly disagree	.923	.404	2.105	.037	.848
Neutral	1.548	.697	3.437	1.151	.283
Slightly agree	1.681	.751	3.764	1.597	.206
They do not like the teachers who take higher mathematics courses ($p = .093$)					
Completely disagree	2.259	.867	5.886	2.783	.095
Slightly disagree	2.234	.881	5.666	2.867	.090
Neutral	1.812	.716	4.586	1.572	.210
Slightly agree	1.029	.381	2.778	.003	.955

Odds ratio is reported for the higher-level mathematics course group (methods and specialist). For all items, the reference group compared is completely agree which is set to zero. **Bolded** indicates test of fixed effects $p < .10$, with these items included in the combined model 3 analysis. Exp (B) odds ratio

CI confidence interval

*indicates $p < .05$

especially in technology and science subjects such as physics (DeWitt et al., 2019; Hine et al., 2015; Kennedy et al., 2014). To address this, it is important to gain a better understanding of the main reasons behind student choice, which are current and especially context specific. While this study investigated student choice within one region in Western Australia, the findings highlight areas of potential interest to be researched internationally.

The survey instrument was employed to consider the reasons that students in WA enrol in higher-level mathematics courses. Many reasons have been sighted internationally for the decline in students' lack of enthusiasm for mathematics subjects. Students' perceived lack of confidence, influence of social circles, out-of-field teaching (O'Meara et al., 2020), and to a greater extent the difficulty of the courses and time and effort required to succeed (Brown et al., 2008) are all prevalent internationally. In Western Australia, higher-level mathematics courses have been seen previously as too challenging with no additional reward for success (Hine, 2019). This

Table 5 Model 3: results examining demographic and mathematics item influences associated with studying higher-level mathematics course (Methods & Specialist)

Parameter	**Exp (B)**	**95%CI**		**Wald chi-square**	***p*-value**
		Lower	Upper		
Intercept	*0.2*	*0.0*	*1.2*	*3.2*	*.010*
Gender[a]					
Male[1]	2.0	0.4	9.3	0.9	.355
Female[1]	0.6	0.1	2.9	0.4	.544
Non-binary/third gender[1]	1.4	0.2	8.3	0.1	.731
School type: primary and secondary[3]	**1.5**	**1.0**	**2.2**	**4.6**	**.032***
Co-educational[4]	**0.5**	**0.4**	**0.8**	**7.8**	**.005***
Dissatisfaction with mathematics					
Completely disagree[6]	0.8	0.4	1.5	0.6	.425
Slightly disagree[6]	0.8	0.5	1.5	0.4	.523
Neutral[6]	**0.4**	**0.2**	**0.6**	**12.0**	**< .001***
Slightly agree[6]	**0.6**	**0.3**	**0.9**	**5.0**	**.025***
ATAR can be maximised by studying one mathematics course					
Completely disagree[6]	**2.6**	**1.3**	**5.1**	**7.6**	**.006***
Slightly disagree[6]	1.6	0.9	2.9	2.3	.130
Neutral[6]	0.9	0.5	1.6	0.1	.714
Slightly agree[6]	1.0	0.6	1.8	0.0	.883
Higher mathematics courses are not scaled enough					
Completely disagree[6]	1.0	0.5	1.7	0.0	.872
Slightly disagree[6]	0.6	0.3	1.0	3.5	.061
Neutral[6]	**0.4**	**0.2**	**0.8**	**7.0**	**.008***
Slightly agree[6]	0.8	0.4	1.6	0.3	.536
Their friends are doing the same course(s) as them					
Completely disagree[6,b]	0.7	0.3	1.6	0.7	.398
Slightly disagree[6]	1.1	0.5	2.3	0.0	.895
Neutral[6,b]	1.7	0.8	3.6	1.9	.173
Slightly agree[6]	1.6	0.7	3.3	1.3	.251

Bolded indicates test of fixed effects $p < .10$, with these items included in the combined model 3 analysis

trend appears to be continuing in 2022 with more than 70% of the students in this study agreeing that other courses of study were more attractive and almost half indicating that they did not like mathematics. They did suggest, however, that having friends studying the same course was influential in them doing so, although this was not the only reason for selecting higher-level mathematics.

Similar to the dampening down of university entrance requirements internationally, in addition, approximately half of the students in this cohort said that they did not need any mathematics course for ATAR or for university entrance. The removal of higher-level mathematics pre-requisites for many university courses has been highlighted recently by Jennings (2022), and these students appeared to support this new direction, perceiving low benefit or value for studying higher-level mathematics.

Some significant findings were identified for gender, school type, and school gender. Across all school types, selection of higher-level mathematics courses was 3.3 times higher for boys compared to girls. In this WA cohort, in single-sex schools, selection of higher-level mathematics was 1.7 times higher than in a co-educational school. This supports similar findings by Forgasz and Leder (2020), who found that boys were more likely than girls to study these higher-level mathematics subjects. With an increasing trend in the need for better gender equality in the workforce, and especially in Australia where many jobs are offered working in a skilled FIFO (Fly-in Fly-out) situation, more girls are likely to need improved mathematics literacy. This has the potential to reverse the traditional role of boys studying mathematics and science and for there to be an increase in opportunities for girls seeking more professional jobs that require higher level mathematics. This is an area that requires close consideration over the next 5 years to understand how equality of employment maybe leading to a change in school subject selection by girls. This will also require consideration of whether access to mathematics for girls is overcoming the prior stereotypical images that Smith (2017) found in the UK as a reason for girls not continuing with mathematics and the subjective values given to choice identified by Kaleva et al. (2019), in Finland.

One of the major challenges to increasing enrolments in mathematics in secondary schools and reversing the international trend of declining numbers has been to find alternative ways to compensate students for selecting higher level mathematics. This has led to regions initiating a range of different approaches. Some countries such as Ireland introduced a bonus point initiative (BPI) in 2012 to encourage students to study higher level mathematics. Students were awarded an additional 25 points if they achieved a pass grade (40%) in higher level mathematics. While this did increase the number of students enrolled in higher level mathematics, overall, this did not lead to an improvement in students' mathematical ability (O'Meara et al., 2020). A similar points system was implemented in Queensland. Although there was some evidence in 2015 that this was helping to alleviate the declining numbers of students enrolled, further research evidence is not yet available (O'Meara et al., 2020).

In Western Australia a scaling approach has been taken. According to the Tertiary Institutions Service Centre (2023), '… the purpose of scaling marks in WACE courses is to put all the results onto a common scale so the best four results can be added to produce a Tertiary Entrance Aggregate (TEA) and hence an ATAR'. Previously, it was found by almost a half of the 1633 WA students responding to a survey in 2019 that the 10% scaling incentive was sufficient (Hine, 2023). A quarter of the students in this cohort continued to suggest that a lack of better scaling discouraged them from doing higher-level mathematics.

Limitations

While these results present some important potential reasons, students choose (or not) higher-level mathematics courses they must be considered based on the study limitations of this representing only one state in Australia. Notwithstanding that the gender composition identified some significant differences, the composition of single-sex schools was predominantly male. No generalisations to single-sex female schools, therefore, can be made. Why male single-sex schools have higher proportions of students doing higher-level mathematics requires further investigation. No significant differences were found between rural and metropolitan students in this instance. Although in previous studies geolocation has been found to impact on both choice and achievement in higher-level mathematics (Anderson & Chang, 2011), this vindicates the need for further investigation with a larger data set of rural students.

Conclusion

The aim of this project was to investigate the perceptions of year 11 and year 12 ATAR students in WA secondary schools regarding their enrolment in higher-level mathematics courses. In particular, the research sought to uncover reasons that senior secondary students enrol in higher-level mathematics courses. An analysis of students' responses indicated a high level of reluctance to enrol in a higher-level course, especially when other courses on offer appear more attractive. Coupled with students' general dissatisfaction with mathematics as a subject, the removal of mathematics as a pre-requisite course for ATAR, and more broadly, for university entrance, has not helped to maintain or increase enrolments.

Acknowledging the research highlighted in the literature, it is noted that the reasons for students not enrolling in higher-level mathematics courses in their final years of schooling are intertwined and complex. From this data set, findings point to associations between combinations of variables including gender, school type, and school gender. At the same time, the limitations of the study point to a direction where these variables can be explored further. Two such areas are the sampling parameters and the low uptake of single-sex female schools as opposed to single-sex male counterparts. Broadening the sample to include more ATAR students from other states and territories in Australia could further help to determine the extent to which such findings are bound to a WA context or evident at a national or international level. Currently in WA, there is debate on the possibility of offering an intermediate Methods and Applications to be credited towards the ATAR score. Future research will need to investigate the potential impact of this change should it be implemented. Further issues to be teased out include the external and internal influences affecting students' enrolment decisions and how closely school type and gender are associated. The international expectation that regions should focus on enabling greater equity between boys and girls is also likely to impact on student choice in the future. Ensuring that mathematics courses address the different and more subjective learning needs of girls, and to overcome the stereotypical images that are generally associated with mathematics, will be vital to facilitating a more equitable society.

To safeguard that there is not a further deficiency from preparing enough students with the capacity to advance mathematical knowledge in the future, it is critical to gain a better understanding of the reasons for their course choices during their final 2 years of schooling, both nationally and internationally. Research like this is invaluable if educators wish to reverse the decline in enrolment in higher-level mathematics courses and more especially, to address the apparent dislike for mathematics in general.

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Declarations

Ethical approval Prior to the commencement of the participant selection process, the Chief Investigator sought and gained Institutional Human Research Ethics Committee approval from the university (Ref 019182F), the Department of Education (Ref D20/0293437), and Catholic Education WA. From the 198 WA secondary schools (39 Catholic, 61 independent, 98 government) offering higher-level mathematics courses to year 11 and year 12 students (aged 17–18) years) in 2021, 43 principals gave their permission for the project which proceeded at all schools. Of these 14 were Catholic, 12 were independent, and 17 were government.

Informed consent A project information sheet was sent to parents and students at participating schools to outline the scope and procedure of the project. Using an opt-out process, students gave their consent to participate by completing an anonymous, online survey.

Competing interests The authors declare no competing interests.

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