Teachers' perceptions on declining student enrolments in Australian senior secondary mathematics courses

Gregory Hine
The University of Notre Dame Australia

The study of higher-level secondary mathematics is considered essential for national economic growth, competitiveness in research and innovation, and further education opportunities. Yet the reported trend within Australian secondary schools is that enrolments in higher-level mathematics are declining and have been in a state of decline for over a decade. The little available and recent literature published on this phenomenon has looked at why secondary students elect to study higher-level mathematics courses, both from the perspective of teachers and students. This research paper presents findings as to why Heads of Learning Area: Mathematics (HOLAMs) believe capable secondary students elect not to enrol in those courses. Data were collected from 50 secondary schools across the three sectors (Government, Catholic, Independent) in Western Australia. The key findings are that capable students do not enrol in higher-level mathematics courses because these courses are not required for university entrance, other courses appear to be less rigorous and more viable, and the Australian Tertiary Admissions Ranking (ATAR) score can be maximised by taking one mathematics course instead of two courses.

Introduction

Mathematics has been heralded as a critically important subject for students to undertake (McPhan et al., 2008; Office of the Chief Scientist (OCS), 2014; Sullivan, 2011). This importance has been argued largely on the basis of students learning key interdisciplinary knowledge such as science, technology and engineering (Ker, 2013), and to use this knowledge base to add intellectual value to new technologies, drive innovation and research capacities, and to help Australia compete globally (Australian Academy of Science (AAS), 2006). Furthermore, failure to produce a workforce with sufficient training in mathematics is considered a national concern for the economy of Australia and for keeping Australia as a competitor in the technological world (AAS, 2006; Hine et al., 2016; Maltas & Prescott, 2014; Rubinstein, 2009). The importance of mathematics is also highlighted within tertiary study, where researchers suggest that university success depends on the level of mathematics studied at secondary school (Nicholas, Poladin, Mack, & Wilson, 2015; Rylands & Coady, 2009). More specifically, findings from various studies indicate that students who undertake higher-level mathematics courses at a secondary level tend to outperform their counterparts who undertook a lower-level mathematics course (Joyce, Hine & Anderton, 2017; Kajander & Lovric, 2005; Sadler & Tai, 2007).

Despite this acknowledged importance, the number of students enrolling in higher-level and intermediate secondary school mathematics in Australia is declining (Barrington & Evans, 2014; Kennedy, Lyons & Quinn, 2014; Wilson & Mack, 2014). And while a majority of Australian universities have dispensed with subject prerequisites for degree programs (Jennings, 2014; Maltas & Prescott, 2014; Nicholas et al., 2015), the phenomenon of declining enrolments is also experienced within tertiary mathematics courses (Brown, 2009; OCS, 2012). At the same time, there has been a reported increase in first-year university students lacking the appropriate mathematical background to complete courses in various disciplines (Poladian & Nicholas, 2013; Rylands & Coady, 2009; Wilson et al., 2013). Studies conducted in Australian states including New South Wales (MANSW, 2014; McPhan et al., 2008), South Australia (McPhan et al., 2008) and Queensland (Easey & Gleeson, 2016; Jennings, 2013; 2014) have identified why Australian secondary students do not enrol in higher-level mathematics courses but there is no recent research published on the same phenomenon in a Western Australian context. The aim of this research is to investigate the perceptions of Heads of Learning Area: Mathematics (HOLAMs) as to why they feel capable secondary students do not enrol in higher-level mathematics courses in Western Australia. As such, the specific question guiding the focus of the research is:

> What are the perceptions of Heads of Learning Area: Mathematics (HOLAMs) as to why capable secondary students do not enrol in the two highest mathematics courses?

Contextual framework

There are three themes underpinning the contextual framework of this study, namely: a Western Australian perspective of secondary mathematics 2010 - 2015, the importance of mathematics at secondary level, and declining mathematics enrolments at secondary level. These themes will now be explored.

A Western Australian perspective of secondary mathematics 2010-2015

In Western Australia, Year 12 students can take as many as six (but no fewer than four) subjects that can be counted towards the Tertiary Entrance Aggregate (TEA). Since 2008, the TEA has been calculated by adding any student's best four scaled subject scores, plus a 10 per cent bonus of a student's best Language Other Than English (LOTE) scaled score. The calculated TEA is then converted to an Australian Tertiary Admissions Ranking (ATAR), which can range from 0 to 99.95 (in increments of 0.05) and reports the ranking position of any student relative to all other students. According to the Tertiary Institutions Service Centre (TISC), the ATAR takes into account the number of students who sit the Western Australian Certificate of Education (WACE) examinations in any year, as well as the number of people of Year 12 school-leaving age in the total population (TISC, 2016b).

From 2010 to 2015 inclusively, Year 12 students in Western Australia were able to use one or two mathematics courses of study from a possible six courses of study in calculating their ATAR. Of these six courses, a majority of students annually choose to study one of either: 2C2D Mathematics (2C2D MAT), 3A3B Mathematics (3A3B MAT) or 3C3D Mathematics (3C3D MAT). Capable students demonstrating a proficiency for mathematics - and studying 3A3B MAT in Year 11 - had the option of undertaking a second mathematics course, Specialist Mathematics 3A3B (3A3B MAS) in Year 11. The progression into Year 12 for such students is to undertake both 3C3D Mathematics (3C3D MAT) and Specialist Mathematics 3C3D (3C3D MAS). Stage 2 courses are considered easier than Stage 3 courses, and those courses with the letters AB are considered easier than with the letters CD. The mathematics courses of study offered in Western Australian secondary schools from 2010 - 2015 are presented in Table 1.

Table 1: Mathematics courses of study in Western Australian schools, 2010 - 2015

Year 11	Year 12
2A/2B MAT	2C/2D MAT
2C/2D MAT	3A/3B MAT
3A/3B MAT	3C/3D MAT
3A/3B MAT and 3A/3B MAS	3C/3D MAT and 3C/3D MAS

The three figures presented (Figures 1, 2 and 3) display data concerning enrolment trends in WACE Mathematics courses of study from 2010-2015. Although the principal focus of this project is to investigate student enrolments in the two maths (i.e. 3C3DMAT & 3C3DMAS), the enrolment data for the other four WACE Mathematics courses of study have also been presented for discussion (e.g. enrolment transition between courses). Figure 1 displays the number of candidates sitting in the WACE examinations for each course of study from 2010 to 2015. From this figure, and with the exception of 2C2DMAT and 3A3BMAT, all courses of study experienced consistent enrolments over the period 2010-2013. From 2013 to 2014, all courses had a significant decrease in enrolments; from 2014 to 2015 all courses experienced an enrolment increase.

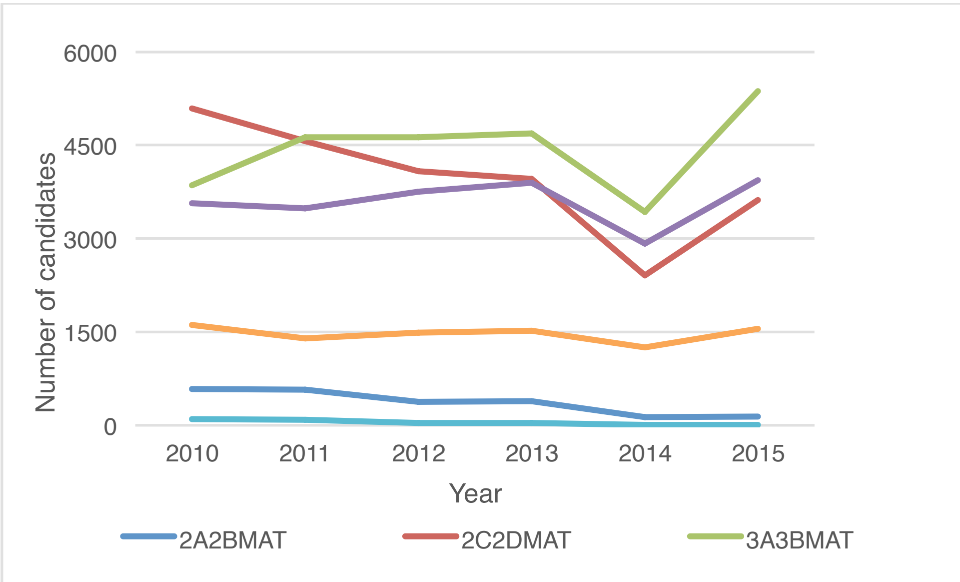

Figure 1: Number of candidates sitting in the WACE examinations 2010-2015

Figure 2 presents the overall percentage change in WACE course enrolment on a year-to-year basis from the period 2011 to 2015. From this figure, all courses experienced either a decrease or no change in enrolments over the period 2011-2014, and a majority of courses had increasing enrolments in 2014-2015. The courses 3C3DMAT and 3C3DMAS both saw a moderate increase in enrolments in the periods 2011-2012 and 2012-2013, but a significant decrease in 2013-2014. It should be noted that the precipitous decrease in 2013-2014 enrolments is largely due to the 'half cohort' in Western Australian schools reaching Year 11 and Year 12. The 'half cohort' refers to those children affected by the Western Australian Government's decision to change the age at which children commenced Kindergarten. Specifically, from 2001 the age that children entered Kindergarten was modified to include only those children turning four years of age before June 30. As such, in 2001 only half of a cohort of students was enrolled; these same students left the education system as Year 12s in 2014 (Western Australian Government, 2018).

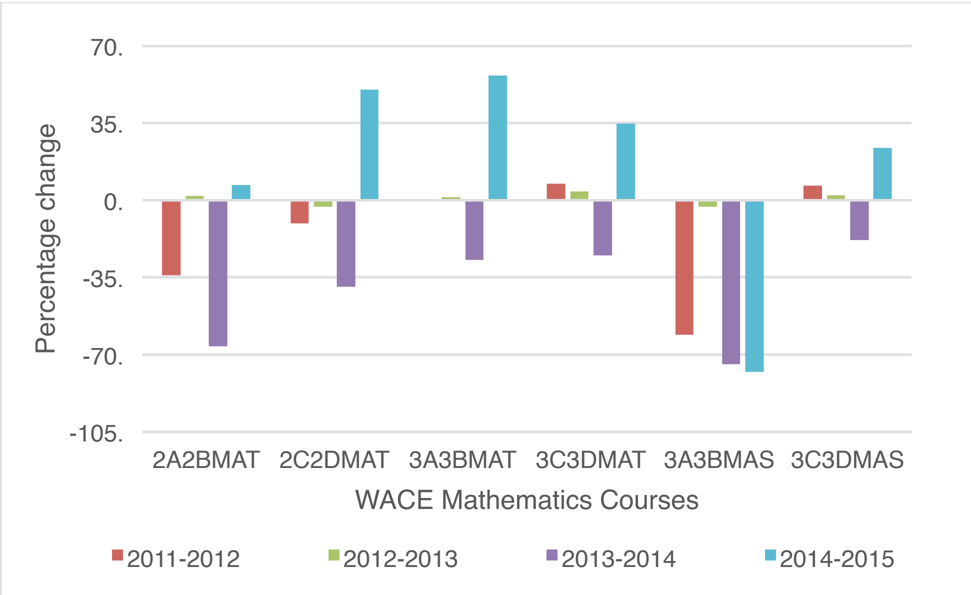

Figure 2: Percentage change in WACE course enrolment from year to year 2011-2015

Data in Figure 3 display the trend for each WACE course with regards to the number of candidates sitting WACE examinations as a percentage of the total WACE candidature. Over the period 2010-2014, 3C3DMAT experienced a steady increase in numbers (from 22% to 28%) before a modest enrolment decrease in 2015 (down to 26%). Similarly, 3C3DMAS had an increase in enrolments from 2010 to 2014 (9% to 12%) and then a slight decrease in 2015 (down to 10%). The course 3A3BMAT experienced a steady increase in enrolments across all years, while both Stage 2 courses (i.e. 2A2BMAT & 2C2DMAT) had a steady decrease in enrolments.

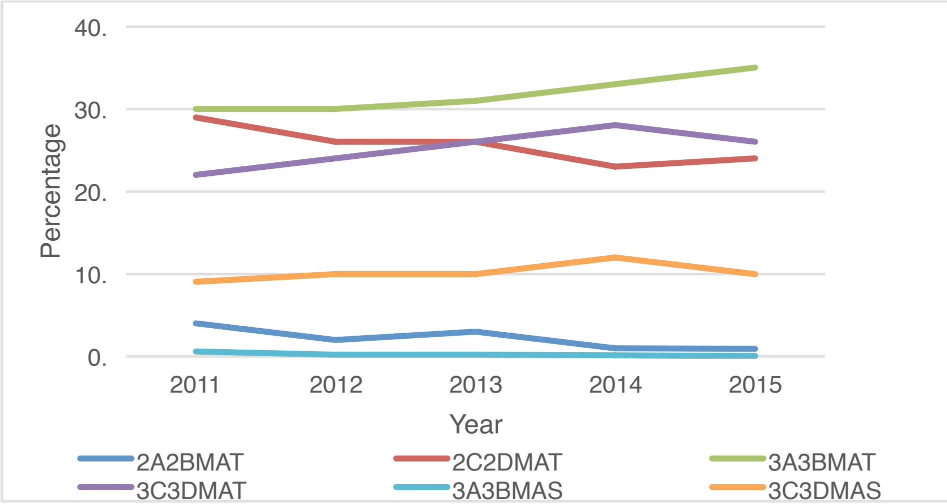

Figure 3: Candidates in WACE Examinations 2011 - 2015 as a % of total candidature

For this project, the researcher has investigated the perceptions of Heads of Learning Area: Mathematics (HOLAMs) as to why they believe capable students do not undertake both 3A3BMAT and 3A3BMAS in Year 11, and both 3C3D MAT and 3C3D MAS in Year 12. For this study these combinations of higher-level mathematics courses will be referred to as *the two maths*. The contents for these two courses of study are tabulated in Table 2 and Table 3, along with the prescribed amount of time required to teach students particular topics (SCSA, 2007).

Table 2: WACE courses of study 2010 - 2015: 3A3B MAT and 3A3B MAS

3A3B Mathematics	3A3B Mathematics specialist
Number and algebra (58 hours) - Estimation and calculation - Functions and graphs - Equations and inequalities - Patterns - Finance - Calculus	Exponentials and logarithms (21 hours) Functions (25 hours) Mathematical reasoning (7 hours) Vectors (27 hours) Trigonometry (21 hours) Complex numbers (5 hours) Polar coordinates (2 hours)
Measurement and geometry (16 hours) - Rate - Measurement - Networks - Reason geometrically	
Statistics and probability (36 hours) - Quantify chance - Interpret chance - Collect and organise data - Represent data - Interpret data	

Table 3: WACE courses of study 2010 - 2015: 3C3D MAT and 3C3D MAS

3C3D Mathematics	3C3D Mathematics specialist
Number and algebra (45 hours) - Estimation and calculation - Functions and graphs - Equations and inequalities - Calculus	Exponentials and logarithms (14 hours) Functions (26 hours) Mathematical reasoning (10 hours) Matrices (14 hours) Vectors (12 hours) Trigonometry (10 hours) Complex numbers (19 hours) Polar coordinates (2 hours)
Measurement and geometry (28 hours) - Rate - Measurement - Reason geometrically	
Statistics and probability (37 hours) - Quantify chance - Interpret chance - Represent data - Interpret data	

Importance of mathematics at a secondary level

There is widespread consensus among policymakers, curriculum planners, school administrations, business leaders and industry leaders that mathematics is a critically important element of the school curriculum (Sullivan, 2011). At a national level, science, technology, engineering and mathematics (STEM) and STEM-related careers are frequently exhorted as critical to the economic growth and global competitiveness of Australia (McPhan et al., 2008; OCS, 2014). Commentators have argued that for students to succeed in a variety of disciplines at university, an appropriate level of mathematics must be undertaken in the senior years of secondary school (Chubb et al., 2015; Nicholas at al., 2015). These post-secondary disciplines can include engineering, business and finance (Hine, 2016) as well as agriculture, pharmacy and economics (Nicholas et al., 2015).

Furthermore, mathematical competency is regarded as an integral component of many scientific and clinical undergraduate degrees (Hall & Ponton, 2005; Koenig et al., 2012; Nakakoji & Wilson, 2014), and an ability to apply mathematical and statistical thinking in the context of science is an issue requiring urgent attention (Belward et al., 2011). Such competency – acknowledged generally as the acquisition of mathematical skills and knowledge – is considered by researchers as essential for students undertaking university courses in health sciences (Anderton, Evans & Chivers, 2016; Hine, Joyce, & Anderton, 2015), and nursing (Galligan, Loch & Lawrence, 2010; Wright, 2007). Specifically, McNaught and Hoyne (2012) have suggested that those mathematical skills which can be applied broadly across various courses include representation, interpretation, reasoning, problem solving, and analytical skills.

Building on the well-established axiom that mathematics is important for post-secondary studies, researchers have drawn attention to how university success depends on the level of mathematics studied at secondary school (Nicholas et al., 2015; Rylands & Coady, 2009). To illustrate, researchers at an Australian university found considerable differences within a cohort of first-year students enrolled in a health science degree (Hine, Joyce & Anderton, 2015) and in allied health sciences degrees (Joyce, Hine & Anderton, 2017). Irrespective of gender, it was found in both projects that those students who had studied a more difficult mathematics pathway at secondary school attained a significantly higher grade point average (GPA) than those who had taken an easier mathematics pathway. Still within an Australian context, Rylands and Coady (2009) suggested that the level of secondary mathematics studied at secondary school – and not the attained Australian Tertiary Admissions Ranking (ATAR) – had a significant effect on the pass rates of first-year university students.

In the United States, Sadler and Tai (2007) suggested that the 'two pillars' supporting academic success within college science are high school study in the same science discipline (e.g. human biology, chemistry) and an advanced study of mathematics. Concerning the latter discipline, these researchers noted that "students who take high-school calculus average better grades in college science than those who stop at pre-calculus" (Sadler & Tai, 2007, p. 457). Canadian-based research highlighted how the amount of time students spent learning mathematics in their final years of secondary school correlated strongly with their academic performance in a first-year calculus course (Kajander & Lovric, 2005). Findings from other studies indicate that those university students who completed advanced mathematics courses at secondary school are significantly contrasted with students who took intermediate mathematics, especially with regards to performance and engagement (Varsavsky, 2010) and performance and retention (Poladian & Nicholas, 2013).

Declining mathematics enrolments at secondary level

A recent nationwide report has revealed that over the past two decades, Australian secondary schools have experienced a steady decline of student enrolments in higher-level mathematics courses (Kennedy et al., 2014). Previous reports have noted a similar decline in enrolments in advanced and intermediate levels of secondary mathematics (Barrington, 2006; Forgasz, 2005) and tertiary mathematics (Brown, 2009; OCS, 2012). Moreover, Ainley, Kos and Nicholas (2008) discovered that from 2004 to 2007 – and after remaining consistent from 1994 to 2003 – enrolments in the highest mathematics courses in both New South Wales and Victoria had decreased (22.5% to 19%; 12.5% to 9.8%, respectively). Poladian and Nicholas (2013) highlighted that in New South Wales the proportion of students taking calculus-based courses has reduced from 61% of the students studying mathematics in 1992 to 35% in 2012. In New South Wales, Wilson and Mack (2014) reported declining participation rates in a mathematics-science combination between 2001 and 2013. Specifically, these authors highlighted that much of this decline is due both to shifts in proportions of students undertaking mathematics courses and to an increase in the proportion of students taking no mathematics at Higher School Certificate (HSC) level. Additionally, the proportion of students undertaking no mathematics for the HSC across all cohorts has tripled (Wilson & Mack, 2014). However, the national trend of declining enrolments in higher-level mathematics courses appears to have been reversed in

Queensland due to a ‘bonus points’ system offered to students (Malthas & Prescott, 2014). From the period 2010 to 2015, enrolments in the Mathematics C course have increased for Year 11 students (25%) and Year 12 students (22%) (QCAA, 2010; 2015).

Commentators have also outlined how declining enrolments at a secondary school level are accompanied by increasing numbers of students opting for lower levels of study in mathematics and the ‘softer’ sciences (Dow & Harrington, 2013; Kennedy et al., 2014). Other scholars have expressed concern that shortages of suitably qualified mathematics teachers may contribute to declining student enrolments in higher-level mathematics courses (Chinnappan et al., 2007; Harris & Jensz, 2006). Research conducted with 1084 mathematics teachers in New South Wales (approximately 18% of all mathematics teachers in NSW) outlined that 51% of respondents felt that mathematically able students in their school are selecting a senior mathematics course below their academic ability (MANSW, 2014). The most frequently proffered teacher perceptions for this phenomenon included: a desire by students to maximise their ATAR and HSC results, the level of difficulty and time demands of 2-unit mathematics, the attraction of other HSC courses, and an overall lack of interest, motivation and confidence in mathematics (MANSW, 2014). Findings from the *Maths? Why Not?* research project (McPhan et al., 2008) indicated key influences why Australian students do not enrol in higher-level mathematics courses. These findings were presented as school influences, sources of advice influences, and individual influences (McPhan et al., 2008). Furthermore, these authors found that the associated heavy workload, greater appeal of less demanding courses, and perception of difficulty of higher-level mathematics courses influenced students’ decisions to not enrol in those courses (McPhan et al., 2008).

Compared with other developed countries, Australia does not prescribe mandatory requirements for upper secondary courses, with the exception of English (Wilson & Mack, 2014). While national curricula and assessment programs now mandate uniform mathematics and science courses to Year 10, undertaking mathematics in upper secondary school is not required in some Australian states and territories (Nicholas et al., 2015). For instance, in New South Wales, “the requirement for students to study at least one mathematics or science subject was removed in 2001” (Nicholas et al., 2015, p. 38). According to Wilson et al. (2013), this change in educational policy and the increase in alternative subject choices are key factors contributing to the decreasing mathematics enrolments in that state. In addition to New South Wales, mathematics is not a requirement in Victoria and Western Australia; it is required in South Australia, Queensland and the Northern Territory (Wilson & Mack, 2014). At the same time, the admissions policies at many Australian universities do not require subject prerequisites for entry into degree programs (Maltas & Prescott, 2014; Nicholas et al., 2015). Prospective university students are typically advised of a certain level of secondary mathematics considered to be assumed knowledge for a degree, but ultimately most are offered a place on the basis of their ATAR score (Nicholas et al., 2015). In some cases, students are counselled into undertaking university bridging courses to make up for any mathematics they have not learned at secondary school (Chubb et al., 2015; Poladian & Nicholas, 2013).

Method

This study was interpretive in nature, and relied predominantly on qualitative research methods to gather and analyse data about how HOLAMs perceived capable students not enrolling in two higher-level mathematics courses (i.e. both 3A3BMAT and 3A3BMAS in Year 11, and both 3C3D MAT and 3C3D MAS in Year 12). Participants registered perceptions through the completion of a single anonymous, online survey comprising one closed and two open qualitative questions, and ten five-point, Likert scale items. The closed question asked whether participants felt the number of students taking the two maths had increased, decreased, or remained constant. The Likert scale items required participants to indicate (across 10 items) the extent to which they felt capable students do not choose to study the two maths (1 = Strongly disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly agree). The two open-ended questions asked participants to (i) elaborate on their responses to the Likert scale items, and (ii) to make any further comments regarding students' reasons not to study the two maths. Additional demographic information of participants was obtained through a series of closed questions regarding gender, number of years teaching mathematics, school size (by student enrolment), type of school (e.g. secondary 7-12), gender composition of school (e.g. co-educational), and location of school (metropolitan, regional).

Participants

In Western Australia there are 135 secondary schools (33 Catholic, 43 Independent, 59 Government) offering higher-level, ATAR mathematics courses to Year 11 and 12 students (SCSA, 2016). The ATAR is a percentile score which denotes a student's academic ranking relative to his or her peers upon completion of secondary education. The HOLAMs of these purposively sampled schools were invited to participate in the research, and a total of 50 HOLAMs gave their consent to participate (23 Catholic, 10 Independent, 17 Government). HOLAMs were purposively selected as participants suitably qualified to respond to the types of questions asked which required both experience as mathematics educators and knowledge of enrolment trends within their schools and the larger educational system. For instance, within secondary schools HOLAMs are those personnel privy to conversations (with students, parents, colleagues) and decisions regarding Year 11 and Year 12 course enrolments. Demographic information for the 50 participants is tabulated in Tables 4 and 5.

Data analysis

Qualitative data from the 50 completed surveys were explored using a content analysis process. According to Berg (2007, p. 303), content analysis is "a careful, detailed systematic examination and interpretation of a particular body of material in an effort to identify patterns, themes, biases and meaning". After the two open-ended questions had been examined for themes, patterns and shared perspectives, the researcher analysed the data according to a framework offered by Miles and Huberman (1994) which comprises the steps: data collection, data reduction, data display, and conclusion drawing/ verification. The themes drawn from the qualitative data are displayed in Table 7. For responses to the Likert scale items, descriptive statistics (mean, standard deviation) were used to analyse collected data.

Table 4: Summary of participants' demographic data (by sector and gender)

Sector	Descriptor	Male	Female
Catholic	Number of teachers	14	9
	Mean teaching experience (years)	25.8	20.2
	Mean school size (students)	1070	1084
Independent	Number of teachers	8	2
	Mean teaching experience (years)	22.6	23
	Mean school size (students)	856	650
Government	Number of teachers	10	7
	Mean teaching experience (years)	25.6	20.4
	Mean school size (students)	859	1040

Table 5: Summary of participants' demographic data (by system and location)

System	School type and composition	Metro.	Regional
Catholic	Composite	3	0
	Secondary	18	2
	Coeducational	17	2
	Single sex	4	0
Independent	Composite	3	0
	Secondary	4	3
	Coeducational	6	1
	Single sex	3	0
Government	Coeducational	14	3

Note: In Western Australia all Government schools are coeducational institutions.

Findings

In response to the closed question, 49 of 50 HOLAMs indicated that student enrolments had either remained constant (22) or decreased (27). One HOLAM felt that student enrolments had increased. These responses are summarised in Table 6.

Table 6: HOLAMs' perceptions on student enrolment trends

System	Increased	Decreased	Remained constant
Catholic	1	11	11
Independent	0	5	5
Government	0	11	6

For the Likert scale items, the means and standard deviations of HOLAMs' responses according to sector have been included in Table 7. Within this table, a higher mean represents stronger agreement, while a lower mean represents stronger disagreement. Key themes generated from an analysis of the extended answer responses are displayed in

Table 8, with the numbers indicating how many HOLAMs from each sector proffered that response.

Table 7: Responses to Likert scale question items

Item	Catholic		Independent		Government	
	Mean	Std dev	Mean	Std dev	Mean	Std dev
Dissatisfaction with mathematics	2.22	1.06	2.00	0.63	2.35	1.33
Not needed for university entrance	4.09	1.26	4.50	0.50	4.06	1.11
Maximise ATAR without 2 maths	3.78	0.98	4.30	0.64	4.24	0.94
Other courses more viable/attractive	3.22	1.10	4.10	0.70	4.00	0.84
Gender-related issues	2.17	1.23	2.60	0.92	2.53	1.19
Timetabling constraints	2.61	1.34	2.00	1.00	3.00	1.64
Compulsory subject selections	3.43	1.50	2.00	1.10	2.41	1.24
Not offered at our school	1.48	1.17	1.50	0.81	2.29	1.40
Lack of qualified staff	1.65	1.24	1.90	1.14	1.94	1.16
Scaling issues	3.09	1.21	3.70	0.87	3.82	1.20

Table 8: Summary of extended answer questions

Key themes	Catholic	Independent	Government
Not required for university entrance	10	5	10
Less rigorous/more viable courses to take instead	9	5	9
Maximise ATAR without 2 maths enrolment	9	6	7
Not needed for students' careers	4	5	11
Scaling does not incentivise higher maths	7	6	4
Timetabling and budgetary constraints	4	3	7
Compulsory courses hinder 2 maths enrolment	9	0	0

The means for Likert scale responses highlighted similar perceptions for HOLAMs working in Catholic, Independent and Government sector schools. For instance, the four items 'Not needed for university entrance', 'Maximise ATAR without 2 maths enrolment', 'Compulsory subject selections' and 'Other courses more viable/attractive' consistently scored the highest means across each sector. Equally, the items 'Lack of qualified staff' and 'Not offered at our school' consistently received the lowest means. In addition, the most commonly proffered qualitative responses indicate that the two maths are not needed for university entrance, capable students elect to take more attractive or more viable courses, and students' preference to maximise an ATAR without enrolling in the two maths. These qualitative responses will now be explored.

Not required for university entrance

Half of the participants asserted that the chief reason capable students do not enrol in the two maths is because these courses of study are not required for university entrance. One Government school HOLAM illustrated this claim, stating:

> It seems that pre-requisites for study in some tertiary courses have been lowered over the years, and kids are asking themselves 'Why bother with the harder mathematics, when I can get in with the easier courses?'

From the Independent sector, another HOLAM claimed:

> The universities have not set pre-requisites for their courses and have relied on the bridging courses so [students] have adopted the attitude that they would do subjects they would enjoy, maximise their ATAR and then look at what is needed at university.

In a similar vein to this participant, another Government school HOLAM attributed declining mathematics enrolments directly to universities, who, made:

> ... the decision to abandon university course pre-requisites and focus only on an ATAR score to enter university degree courses… Moreover, universities offer fee-for-service bridging courses which makes them money – clearly not interested in addressing the problem, only on profits!

One Catholic school HOLAM recalled how his past students had relayed how "they were studying engineering at university and did not [study] Specialist [Mathematics] at school, and struggled in their first year". As a possible solution to the problem of declining enrolments, one HOLAM suggested that universities ensure all degree courses have prescribed school prerequisites (and a letter grade) to enable tertiary entry. This suggestion to reintroduce tertiary course pre-requisites was echoed by a majority of those participants who regarded the withdrawal of pre-requisites as the factor deterring capable students from studying the two maths.

Other courses less rigorous or more viable

Just under half of the HOLAMs (23 of 50) described how Year 11 and Year 12 students select less academically rigorous courses instead of enrolling in the two maths. Some HOLAMs justified this choice by claiming that students have broad study interests which are demonstrated in their selection of ATAR courses. One Independent school HOLAM asserted students "appear to be more interested in subjects like Languages, Physical Education Studies, and Psychology". Furthermore, this selection appears predominantly to include five ATAR courses in Year 12 and one non-ATAR course. For instance, one Government school HOLAM stated that

> Many students prefer to study only 5 ATAR courses in Year 12 and prefer to select a non-ATAR or general course as their sixth course, as a break from rigorous academic study. Leisure-type courses such as Outdoor Education, Art and Physical Education. Studies are selected by students to give some balance to the Maths/Science courses they select.

On the related topic, HOLAMs at Independent and Catholic schools tended to describe how students completed fewer ATAR courses in Year 12 than they did in Year 11. To illustrate, one HOLAM explained at his school:

> Students are not required to complete six subjects in Year 12. In 2015 we had 140 students achieve an ATAR, however, fewer than 10 completed 6 subjects. The great majority choose to study 5 subjects, giving them a whole line off which become study periods. Students at our school feel that they would be at a disadvantage if they gave up

> these study periods to study 6 subjects. Specialist Mathematics doesn't fit into most students' loads if they do 5 subjects. Most years our Specialist numbers drop significantly from Year 11 to 12 as students drop from 6 subjects to 5.

A HOLAM in a Catholic school supported this notion, asserting "At our school prior to this year students study 7 subjects in Year 11 then drop to 6 subjects in Year 12. The subject they may drop off is 3C3D MAS". Speaking specifically about the Specialist Mathematics courses, this HOLAM noted that because they are "so jammed packed with content that students feel they can't get a handle on things before being forced to move on with the next topic". At the same time, other HOLAMs drew attention to the significant commitment required to study the 2 maths. To illustrate, one Government school HOLAM offered that students

> know a big commitment of time is required to study 2 mathematics courses and to complete them successfully. The distractions of social media and other commitments in their lives, such as part-time work, sport, music, and a social life mean they simply cannot or are not prepared to commit the out-of-school-hours' time necessary to be successful in 2 higher-level mathematics courses.

Similar assertions about students not committing to the two maths were voiced by a majority of HOLAMs across all sectors. Other concerns raised included students becoming increasingly worried about not graduating, not achieving their desired ATAR, and not being accepted into the university they want to attend.

Maximising ATAR without two mathematics

Twenty-two HOLAMs agreed that students decide not to enrol in the two maths in order to maximise their ATAR. Overall, capable Year 12 students elect to study only one mathematics course (e.g. 3C3D MAT) or an easier course to achieve a better ATAR for less effort. From the Catholic sector, one HOLAMs offered her opinion: "I think today's students focus very much on achieving the numerical ATAR score rather the benefit from studying mathematics at school". Another HOLAM (Catholic sector) drew attention to the decision-making process students encounter when choosing ATAR courses:

> The perception here is the workload required for a mark comparable to other 'less rigorous' subjects is significantly more in MAS. The students making these choices are highly intelligent students for whom maximising their ATAR while addressing any prerequisites is their prime concern. They are very adept at 'playing the system' to appease their preferred outcomes.

A third HOLAM (Catholic sector) offered insight into the behaviours of female and males students *vis-a-vis* higher level mathematics. This person commented:

> Many girls do not select maths at the higher level even though they are well capable as either they do not see it as a requirement for their desired pathway or more the case seems to be that they may not do exceptionally well (e.g. above 80%) so think that they cannot succeed (a mindset that needs to change given many boys who struggle with double maths still attempt it. In my time I have not had girls fail double maths but many boys have!).

Of the 22 HOLAMs who asserted that students wished to maximise their ATARs without studying the two maths, 17 HOLAMs expressed concern that enrolling in Specialist Mathematics was not incentivised by the scaling process (see Table 5). The unanimous recommendation was for the scaling process to adequately reward students who enrolled in harder subjects, particularly Specialist Mathematics. For example, an Independent school HOLAM conjectured:

> If selecting between a Language and Specialist, the students will study the language because of the bonus marks offered. Students will drop Mathematics Specialist in Year 12 after having studied it in Year 11, because they believe it will be too much work and they don't need it as a pre-requisite and/or they will drop it to pick up extra study periods during school time.

If studying Specialist Mathematics translated into a tangible benefit for students, many HOLAMs indicated that this incentive would result in greater student numbers enrolling in the two maths. However, without an incentive the general view is that enrolments into higher level mathematics will remain constant or continue to decrease.

Discussion

The aim of this paper was to investigate the perceptions of Western Australian HOLAMs as to why they felt capable secondary students do not undertake higher-level mathematics courses. The most commonly proffered responses from HOLAM participants were that students did not need the two maths for university entrance, there are other less rigorous and more viable courses available, and the ATAR can be maximised without studying the two maths. As these participant responses focused largely on university-bound students, much of the discussion that follows will be directed towards the phenomenon of students completing Year 11 and Year 12 with an ATAR, and whose intentions are to undertake further study at university. To commence, HOLAMs expressed that students did not require a double mathematics pathway for university entrance due to the removal of prerequisites from degrees – a finding that is supported by earlier research (Maltas & Prescott, 2014; Nicholas et al., 2015). In the same breath, many HOLAMs avowed that the re-introduction of degree prerequisites would see increasing student enrolments in the two maths.

To amplify, several HOLAMs recalled how up until approximately a decade ago Year 12 students planning to undertake engineering at university were required to take specific subjects (i.e. physics, chemistry, double mathematics) and to do well in these subjects for admittance to the course. While there are no mathematics prerequisites listed for undergraduate degrees at any of the five Western Australian universities – only assumed knowledge – the University of Sydney is introducing mathematics course prerequisites for some courses in 2019 to "help students thrive in their science, technology, engineering and mathematics related degrees and prepare them to tackle future career challenges" (University of Sydney, 2016). The courses include: arts and social sciences, business, education and social work, engineering and information technologies, law, music, pharmacy, science and veterinary science. In accordance with current literature, a movement towards establishing realistic and unambiguous prerequisites for courses that require a mathematical background will indicate to secondary students precisely what is expected of them prior to commencing tertiary study (Maltas & Prescott, 2014; McPhan et al., 2008).

HOLAM testimony indicated that capable students elect not to take the two maths for a variety of subject-related reasons. In summary, Year 12 students tend to study a maximum of 5 ATAR courses that are spread across a variety of disciplines (e.g. humanities, sciences) and which are perceived to be 'easier' or less rigorous. Several HOLAMs across all sectors acknowledged that while a good number of capable ATAR students had commenced Year 11 with the two maths, Specialist Mathematics was not undertaken (or 'dropped') in Year 12. Furthermore, students who 'dropped' a subject in Year 12 were automatically timetabled for a 'study period' *in lieu* of undertaking that dropped subject. In light of the presented literature, scholars from a variety of countries (Australia, United States, Canada) have found that first-year university students who undertook a more difficult mathematics at secondary school tend to outperform those students who studied an easier mathematics course (Hine, Joyce & Anderton, 2015; Kajander & Lovric, 2005; Sadler & Tai, 2007).

In Western Australian Catholic secondary schools, all senior students must take Religion and Life as a compulsory course of study. If students wish, they can take either the Stage 2 or Stage 3 Religion and Life courses and use the marks towards their ATAR score. For students who do not wish to use Religion and Life as an ATAR-calculable subject, they may opt for the non-ATAR Religion and Life offered at a Stage 1 level. According to both the Likert-scale item 'Compulsory subject selections' and extended responses, Catholic HOLAMs offered a different perspective than their public and private school counterparts. For instance, the weighted mean for this Likert-scale item was noticeably higher for Catholic HOLAMs (3.43) than for those in the Independent (2.00) and Government (2.41) sectors. Additionally, a number of Catholic HOLAMs commented that the two compulsory subjects (i.e. Religion and Life, English) placed timetabling constraints on mathematically capable students in Catholic schools. Ostensibly, the task for those staff in Catholic schools wishing to encourage students to undertake the two maths appears a delicate balancing act.

A third key finding was that HOLAMs perceived capable students wished to maximise their ATAR by taking only one mathematics course, or no mathematics courses at all. This finding adds to those outlined in the *Maths? Why Not?* project (McPhan et al., 2008) and as such contributes to the literature base. Tangential to the two previous discussion points, a commonly registered sentiment by HOLAMs was that students tended to focus more intently on achieving a higher ATAR score than on selecting courses which provided adequate prior learning for university studies. This sentiment appear at odds with Jennings (2014), who wrote on this issue in a Queensland context and concluded that if many students do well in the General Mathematics course this will cause difficulties in obtaining a higher score. Such a practice has been identified as detrimental to a successful transition into university for reasons of academic unpreparedness and future attrition (Rylands & Coady, 2009). Additionally, the research base suggests strongly that undertaking a harder mathematics pathway (instead of an intermediate pathway) at secondary is more beneficial for student performance, engagement and retention at university (Poladian & Nicholas, 2013; Varsavsky, 2010).

HOLAMs also emphasised how students who were rewarded with bonus ATAR marks by undertaking a foreign language, and suggested that enrolments in the two maths would increase if students were incentivised for doing so. At the time of writing this paper, TISC announced that in 2017 Mathematics Methods and/or Mathematics Specialist courses in Western Australia will be incentivised with a bonus marks system, where students will receive a 10 per cent bonus of their final scaled score in those courses (TISC, 2016a). Additionally, in 2016 and 2017 students are able to undertake any two-course combination of the three ATAR mathematics courses available (Applications, Methods, Specialist), but from 2018 the Applications/Methods and Applications/Specialist combinations will become unavailable for contributing to an ATAR. McPhan et al. (2008) noted how some Australian universities have started awarding bonus points for students undertaking high-level mathematics courses. For instance, since 2009 the University of Queensland has offered bonus points to applicants who have studied the Mathematics C course. This offer of bonus points has resulted in an upward trend in the student enrolment for that secondary school course (Jennings, 2014; Malthas & Prescott, 2014; QCAA, 2015).

Conclusion

This research explored the perceptions of HOLAMs in Western Australian secondary schools with regards to why they felt capable students do not undertake the two maths. A cursory analysis of two maths enrolment data from the period 2010-2015 show that student enrolments in the higher mathematics courses appear stable, admittedly with some years of considerable enrolment fluctuation. Nevertheless, HOLAMs across all educational sectors in Western Australia feel that such enrolments are decreasing or remaining constant. Moreover, HOLAM testimony reveals that capable students elect not to take the two maths for three chief reasons, namely: these courses are not required for university entrance, there are less rigorous or more viable courses to take instead, and their ATAR can be maximised by taking only one mathematics course. At the time of writing this paper, senior secondary mathematics courses in Western Australian schools are at a crossroads, with only three courses available for students to count towards their ATAR instead of six. This change, as well as the proposed changes *vis-à-vis* mathematics course incentivisation (from 2017 onwards) and course combinations (from 2018 onwards), may see a more palpable difference in future senior secondary enrolments.

The author acknowledges that while there are options to be exercised by schools and universities with regards to attracting capable students towards the two maths, there are other factors that may impede the progression of such students into higher mathematical courses of study. Such factors may include: developing teaching and learning practices that support the current Australian Curriculum: Mathematics, raising teacher awareness to mathematics anxiety – especially in the younger years, and providing professional development in specialist mathematics content for teachers. Although these factors were not the aim *per se* of this paper, they may form the basis of further research efforts in light of the findings presented here. Additionally, further research into declining secondary mathematics enrolments can focus principally on the student voice. Inviting students to share their perceptions of the two maths – and more broadly speaking, the degree of importance they ascribe to undertaking mathematics in their studies – could provide powerful insight into the phenomenon of declining enrolments. Furthermore, continued research into how school leaders, teachers, students and parents perceive the three newly implemented courses of study can be instrumental in monitoring the enrolment of students in higher mathematics.

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Dr Gregory Hine earned his PhD in adolescent leadership development from UNDA. He currently teaches pre-service, secondary mathematics teachers in mathematical pedagogy and content, as well educational action research at a postgraduate level. Greg's research interests include mathematical proof, secondary mathematics enrolments, and the professional learning needs of mathematics teachers.
Email: gregory.hine@nd.edu.au
Web: https://www.notredame.edu.au/about/schools/fremantle/education/staff/Gregory-Hine

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