Senior High School Mathematics Subjects in Queensland: Options and Trends of Student Participation

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Received: 04/12/2020
Accepted for publication: 15/06/2021
Published: 06/11/2021

Abstract

In the State of Queensland in Australia, Years 11 and 12 students can opt to study calculus based or non-calculus based mathematics. Calculus based mathematics subjects are a prerequisite for Science, Technology, Engineering and Mathematics (STEM), which has been identified as critically important for current and future productivity by the Australian government. The objective of this study was to identify broad trends in senior Queensland students' participation in calculus and non-calculus based Mathematics purely from a statistical viewpoint using a large data set from the Queensland Curriculum and Assessment Authority (QCAA). To this end, trends in Years 11 and 12 students' participation in calculus based Mathematics B and C, and non-calculus based Mathematics A and Prevocational Mathematics between 2010 and 2019 was investigated. The QCAA data was analysed using quantitative methods to identify trends in student participation in the various mathematics subject options. The data included number of schools, location, gender, indigenous or non-indigenous, residence status and number of students in different options. The results indicated that more male students opted for Mathematics B and C compared to females, and not all schools offered all options.

Keywords: Senior High School Mathematics, Student Participation, Calculus & Non-Calculus

1. Introduction

Mathematics has been described as a critical filter for future academic and career options and participation in advanced mathematics subjects in high school paves the way for high-status careers (Watt et al., 2017). Furthermore, advanced mathematics is central in the study of many university courses including science, technology, engineering and mathematics (STEM) courses. 'Mathematics is a key science for the future, through its enabling role for science, engineering and technology. This is illustrated by dramatic advances in communications, bioinformatics, the understanding of uncertainty, and

  ISSN: 2514-5347

dealing with large data sets' (Lemaire, 2003, p.1). Students need a strong foundation of mathematical skills, especially at secondary school, to make a successful transition from school to studying STEM disciplines at university (Lyakhova & Neate, 2019). Consequently, government programs often target mathematics as one important part of STEM education that will lead to better jobs, innovation, improved economy, and greater global leadership (Peters et al., 2017). Importantly, the post COVID-19 economic reboot will require students with advanced mathematics skills as demand for skilled STEM professions will increase (Vernon, 2020). The important contribution that mathematics makes towards STEM based careers makes it essential to understand students' participation in different options the subject offers, especially options that are prerequisites for STEM courses.

The technology driven modern world requires a deep understanding of mathematics, hence equipping citizens with advanced mathematics skills becomes a right (Centre for Curriculum Redesign, 2013). Students who take calculus based or advanced mathematics in countries such as Australia, United States of America and England are better positioned to enrol in STEM related courses at tertiary level (Carnevale et al., 2011; Lyakhova & Neate, 2019). Advanced mathematical knowledge, skills and understanding of distinct concepts are important for further study in fields where mathematics plays a key enabling role (Maltas & Prescott, 2014). Calculus based or advanced mathematics as prerequisites of tertiary STEM courses have a direct impact on university enrolments and the diverse opportunities students have after high school. Therefore, it is essential to look at the participation rates of senior students in different mathematics curricula. Analyses of student participation trends in different mathematics options can be confounded by the diverse classifications of mathematics subjects. The following sections will discuss how mathematics is classified internationally followed by the classifications used in Australia. This will be followed by a discussion of global and Australian trends in student participation in senior school mathematics with a final focus on trends in the state of Queensland, which is the context of this study.

2. Mathematics Classifications Internationally

Senior high school mathematics curricula differ from country to country. Some countries follow a national curriculum where all students engage with the same mathematics curriculum. In the United Kingdom (UK), students who progress to A-level studies and opt for mathematics have an option of obtaining AS (Advanced Subsidiary) qualifications after a year or the full A-level (A2) or Further Mathematics (FM) at the end of two years (Noyes & Adkins, 2016). New Core mathematics qualifications were introduced in 2015 as an alternative pathway for students who have passed GCSE Mathematics but want to pursue courses that do not demand advanced mathematics (Lee, 2016). Countries that have a national curriculum classify all mathematics options under a common nomenclature. This eliminates complications in defining subject classifications when undertaking analysis of national trends in student participation.

Federal countries with autonomous states that determine their own curricula may not have a consistent framework of naming mathematics subjects. For example, in the United States of America (USA), some states even allow the education structure to be decided at local level. As a result, compiling these data into nationally consistent and coherent information is problematic as nomenclature is not consistent between state jurisdictions. Thus, subjects with very similar course content can have different titles and possibly be classified as belonging to different learning areas. National Centre for Education Statistics [NCES], (2007) cited in Rasmussen et al (2011) classified different mathematics subjects in order of complexity as: Algebra I or Plane Geometry, Algebra II, Algebra III/Trigonometry or Analytical Geometry, Pre-calculus, Calculus and Advanced Placement (AP). Clarity around the categorisation of mathematics options offered in different states is an important prerequisite for an informative analysis of student participation trends in this subject as the criteria used for categorisation can be contested.

3. Mathematics Classification in Australia

In Australia, senior school curricula is the responsibility of states and territories. This means that the classification and scope of the mathematics subjects can be different from state to state. Researchers in Australia have differing views on the way that mathematics subjects ought to be classified. Some researchers only take into consideration the opportunities that the subject offers postsecondary while others consider subject content as a basis for their classification. This prompted some scholars to meet in 2004 where they resolved that the categorisation of subjects and compilation of participation data be done alongside each other (Barrington & Brown, 2014). Table 1 shows the different classifications researchers have used in analysing mathematics subjects. Mathematics subjects are classified into three categories: basic or elementary or low-level, intermediate and advanced or high-level (Kennedy et al., 2014). Basic Mathematics covers basic mathematics skills and is terminal, intermediate mathematics is considered useful in pursuing courses in which mathematics content is minimal while advanced mathematics is a prerequisite of university courses in which mathematics plays an integral role (Dekkers & Malone, 2000). Thus, entry level (see Table 1) is part of elementary mathematics which include mathematics subjects that are considered as a numeracy option for tertiary admission (Kennedy et al., 2014).

Classification of mathematics subjects

Dekkers, DeLaeter &Malone, (2000) Classification.	Barrington &Brown Classification (2004)	Kennedy, Lyons & Quinn Classification (2014)	General Course Content
Low- Level	Elementary	Background	Terminal Mathematics courses that are not designed for further tertiary study and do not contribute towards tertiary admissions rank.
		Entry	Terminal Mathematics courses that are not designed for further tertiary study yet do contribute to the calculated tertiary admissions rank.
Intermediate	Intermediate	Intermediate	Mathematics courses that provide a satisfactory knowledge-base for tertiary courses requiring minimal understanding
High-Level	Advanced	Advanced	Mathematics courses that provide a specialised knowledge-base for tertiary studies in STEM courses or in courses mathematics is an integral part

Table 1- Researchers' classifications of Australian High School Mathematics Subjects (Kennedy et al., 2014 p 36).

The curriculum diversity and options offered in different countries reinforces the idea that mathematics should prepare students for different career choices, highlighting the 'critical filter' tag that has been used to describe the subject (Watt et al., 2017). As countries adjust or change mathematics curricula, their objective should be to increase students' participation, especially in advanced or calculus based options as these provide students with diverse and better career opportunities. Increased mathematics choices naturally means different subjects compete for students. As a result, an analysis of the trends in student participation may shed some light on the distribution of students among subject options.

4. International Trends in Student Participation in Mathematics Subjects

Global trends in student participation in senior school mathematics indicate that students' enrolment in calculus based mathematics subjects is either declining or have reached a stagnation point. For example, participation in advanced mathematics in countries such as Germany, Ireland, Netherlands, Russia and Spain is 15% or less (Hodgen et al., 2010b). Correspondingly, South Africa has also declined in calculus based mathematics by 16% between 2015 and 2019 (Businesstech, 2020). On the other hand, in Japan, South Korea, New Zealand, Singapore and Taiwan, approximately 31% of upper secondary students choose to study advanced mathematics and are regarded as countries with the highest share of students' participation in advanced mathematics (Hodgen, 2013; Hodgen et al., 2010b). Similarly, the USA witnessed a general increase in advanced mathematics enrolments until 2005 when calculus and AP (Advanced Placement) had a combined rate of 23% participation, thereafter there was stagnation (Hodgen et al., 2010b; National Science Board, 2018). In the United Kingdom (UK), following the introduction of Curriculum 2000, a steady increase in students opting for mathematics at A-levels was noted between 2006 (7.9%) and 2015 (12.7%) (Hodgen et al., 2010b; Noyes & Adkins, 2016). However, mathematics still remains a minority subject and females are less represented in A2 (Hodgen et al., 2010b).

5. Trends in Student Participation in Mathematics Subjects in Australia

Available national trends in Australia focus on Year 12 enrolment statistics from all states and territories which are generally categorised as elementary, intermediate and advanced. Concerns have been raised about students' participation in intermediate and advanced mathematics options. For example, Australia's former Chief Scientist, Professor Ian Chubb, expressed his concerns about the lack of appetite by students in studying higher levels of mathematics in Year 11 and 12 (Evershed & Safi, 2014). "Intermediate and especially, Advanced Mathematics students are essential for a strong science, research and innovation capacity. The statistics at hand indicate that enrolment numbers in these areas are shrinking and students are instead electing to take Elementary Mathematics." (Australian Council of Deans of Science, 2007, p.2).

Elementary/Entry level/Low-Level Mathematics

Student participation in elementary mathematics has maintained a significant and steady growth in enrolments from 1990 to 2012 with the exception of 2001 (Barrington & Brown, 2013). By 2010, 51% of all mathematics enrolment was in elementary mathematics, increasing to 52% in 2011 and was maintained at that proportion until 2015 (Barrington & Evans, 2014; Barrington & Evans, 2016). In 1990 around 51855 students opted for low-level mathematics but by 2015 about 117 000 students were enrolled in the subject which is a 125.6% increase (Dekkers & Malone, 2000; Barrington and Evans, 2016). Kennedy et al. (2014) also reported an increase in participation rates in entry level mathematics between 1994 (38%) and 2012 (49%). The differences in participation rates in elementary mathematics reported by the various researchers can be attributed to the different categorisations used in their analysis. However, it is clear in both trends that there was a significant increase in participation in elementary mathematics. On the other hand, female dominance in elementary mathematics declined between 1990 (56.7%) and 1999 (52.4%) then further down to almost parity with male students after 2000 (Dekkers & Malone, 2000; Forgasz, 2006b). The ratio of participation by 2012 was 11 females to 10 males (Kennedy et al., 2018) and in 2015 the percentage was approximately 51% to 49% in favour of females (Barrington & Evans, 2016). From the different categorisations presented, these trends show that the enrolment in elementary mathematics has become fairly balanced between males and females from early to mid-2000.

Intermediate Mathematics

Slight variations in participation rates in intermediate mathematics have been reported by different researchers due to their differing categorisation of this option. For example, students' participation rates in intermediate mathematics has been declining for the period 1995 (27.3%) to 2015 (19.2%) with the exception of 2002 and 2014 (Barrington & Brown, 2014; Barrington and Evans, 2014; 2016; Forgasz, 2006a). Ainley et al. (2008) report slightly different participation rates between 2001 (34.7%) and 2007 (30.6%). Kennedy et al. (2014) also report varying rates of decline in participation between 1994 (38%) and 2012 (27%). However, the findings from the various researchers point to a similar trend of a steady decline in students' participation in intermediate mathematics from mid-

1900s to 2012. Furthermore, the trends show that males have dominated participation in intermediate mathematics although females are not far behind (Kennedy et al., 2014; Barrington & Brown, 2014).

Advanced/High-level Mathematics

Participation rates in advanced mathematics declined between 1990 (24%) and 1999 (16%) (Dekkers & Malone, 2000). Kennedy et al., (2014) reported a similar decline between 1994 (16%) and 2012 (9%). The period 2001 to 2007 saw student participation numbers declining from 26216 to 22999 respectively (Ainley, 2008). Since 2007, raw enrolment data have been fairly static between 20 000 to 21 000 until 2012 (Kennedy et al., 2014). One in 10 students in 2013 studied advanced mathematics in year 12 (Mater et al., 2014). With the exception of 2003, 2008 and 2014 participation rates from 1995 to 2015 continued to decline until it stabilised at around 9.5% from 2012 (Barrington & Evans, 2014; 2016). Though researchers used different categories of classification of mathematics subjects, their findings were consistent in that advanced mathematics participation has been declining over the last few decades. Female participation rates in advanced mathematics showed a steady decline from 41.1% in 1990 to 38.9% in 1999 (Dekkers & Malone, 2000). The ratio of male and female participation in the late 1990s was six females to 10 males which declined to 14 females to 25 males by 2012 (Kennedy et al., 2014). The trend continued in 2013 as the rate of female participation was 6.7% compared to 12.7% of boys (Barrington & Brown, 2014). By 2015 the female participation rate was at 6.9% while the male rate was 12.6% (Barrington & Evans, 2016). Just 6.6% of girls participated in advanced mathematics in 2013 and it represents a 23% decline from 2004 (Mater et al., 2014). A clear dominance by males in advanced mathematics has characterised participation in this category.

Research indicates that in Australia, calculus based mathematics is becoming less popular with most students, as indicated by the low number and proportion of Year 12 students studying this option in 2013 compared to 1995 (Barrington & Brown, 2014). In fact, student participation rates in both intermediate and advanced mathematics steadily declined to around 19.2 % and 9.6% respectively in 2015. On the other hand, elementary mathematics participation rate has shown a steady increase over the past decade stabilising at 52% for the past few years. These trends were consistent in the majority of states in Australia especially for calculus based subjects. The decline in participation rates in calculus based mathematics is a cause for concern (Engineers Australia, 2016).

6. Trends in Student Participation in Mathematics Subjects in Queensland

The latest literature of trends in students' participation in Queensland was part of Ainley et al's (2008) research on national trends in advanced mathematics which was 12 years ago. This is in contrast to states such as New South Wales where more current research has been undertaken to analyse trends in student participation in mathematics (Jaremus et al., 2018). From 2008 to 2019 Queensland offered Mathematics A, B, C and Prevocational Mathematics which were replaced by General, Methods, Specialist and Essential Mathematics respectively (Queensland Tertiary Admissions Centre [QTAC], 2018). Mathematics A is considered Elementary Mathematics, Mathematics B – Intermediate and Mathematics C – Advanced (Forgasz; 2006b). Mathematics C is a recommended companion subject to Mathematics B and they offer more diverse and better career opportunities (Queensland Studies Authority [QSA], 2014). Although Mathematics C provides an additional preparation, both Mathematics B and C cater for students interested in university courses with high demands in mathematics such as science, medicine, mining, engineering, information technology, mathematics, finance, business and economics (QCAA, 2008). This is different from the categories that have been used in previous analyses of participation trends nationally as only Mathematics C was regarded as a prerequisite of such courses. Mathematics A is for students who want to pursue studies and training in courses with moderate demand in mathematics such as carpentry, plumbing, auto mechanics, tourism, hospitality and administration (QCAA, 2008). Prevocational

Mathematics can be classified as background elementary mathematics (Kennedy et al., 2014) as it does not prepare students for any further tertiary studies hence it is a terminal option. Prevocational mathematics was never considered in any previous participation trends analysis hence there is no literature on the subject.

The following section includes discussion of raw data as well as percentages to identify research gaps due to the limited availability of literature on Queensland. Raw enrolment numbers of mathematics participation in Year 12 increased marginally from 46517 in 2000 to 47465 in 2004 apart from a decline of 694 students in 2001 (Forgasz, 2006b). Since early 1990s to 2005 there was a significant decline in the proportion of Year 12 students studying mathematics B and C in Queensland. However, participation rates seemed to have stabilised by 2013 after a marginal increase (QSA, 2014).

Elementary Mathematics

A marginal increase from 66.0% in 2000 to 67.5% in 2004 characterised students' participation in elementary mathematics (Forgasz, 2006b). Raw Year 12 data show that student participation increased from 26 298 in year 2000 to 27415 in 2004 which was an increase of 4.2% (Forgasz, 2006b). Females dominated participation year by year from 2000 up to 2006 (McPhan et al., 2008). Between 2000 and 2004, male participation rates trailed female as male enrolments increased by 3.5% compared to 4.9% for females (Forgasz, 2006b). In addition, female enrolment compared to all Year 12 females increased from 67.3% to 69.8% while male enrolment as a proportion of all Year 12 males was stable at around 65% in the same period (Forgasz, 2006b).

Intermediate Mathematics

A steady decline in participation was witnessed from 1992 to 2008 which was followed by a steady but marginal increase until 2013 (QSA, 2014). The mean percentage enrolment rate among the Year 12 cohorts was 41.5%, however, intermediate mathematics (Mathematics B) participation rate fell by 2.1% for the period 2000-2004 (Forgasz, 2006a, 2006b). Female participation rate declined by 4.8% while male participation rate increased by 0.3% from 2000 to 2004 (Forgasz, 2006a, 2006b). In the same period both male and female enrolment rates as proportions of their Year 12 gender declined, with male rate declining from 46.2% to 44.7% and females from 39.3% to 37.0% (Forgasz, 2006b).

Advanced Mathematics

A decline in participation in advanced mathematics was witnessed from the early 1990s until 2000 (Ainley et al., 2008). Participation rates declined from 15.8% in 1991 to 7.8 % in 2007 even though there were marginal increases in 1995 and 2004 (Ainley et al., 2008). From year 2000 to 2003 raw data show a decline in enrolment from 3242 to 3175 respectively, however a significant increase to 3430 was welcomed in 2004 (Forgasz, 2006b). The sum of all advanced mathematics enrolments from year 2000 to 2004 was only 8% of all Year 12 students (Forgasz, 2006b). However, the increase in enrolment have been credited to the 'bonus' points system Queensland offered to students which incentivised students to enrol (Maltas & Prescott, 2014).The bonus points entails a student with a pass in Mathematics C to receive two adjustments to boost the selection mark for tertiary courses.

Between 2000 and 2004, female participation rate in advanced mathematics was slightly lower than male participation with females at 5.5% and males at 6% (Forgasz, 2006b). In fact, percentage rates of participation were fairly stable for both genders over the same period, although male dominance has not been challenged (Forgasz, 2006b).

No analysis of trends in student participation in mathematics options has been undertaken for Queensland since Ainley et al's (2008) study from 12 years ago. This constitutes a significant gap in literature which this study aims to fill by reporting on an analysis of student participation trends for the period 2010 to 2019 for Queensland, Australia.

7. Study Methods and Results

The study investigated students' options and trends of participation in Mathematics A, B, C and Prevocational mathematics between 2010 and 2019 using data from Queensland Curriculum and

Assessment Authority (QCAA). Quantitative methods were applied to analyse trends of student options. Consent to use the data in this study was provided by QCAA. The data included number of schools, gender, indigenous or non-indigenous and number of students in different options. Table 2 below shows raw data of student numbers in the year levels from 2010 to 2019.

Raw data showing student numbers

Year	Year level	Gender		Non-Indigenous	Indigenous	Total
		Male	Female			
2010	11	30571	28856	56866	2561	59427
	12	28534	28143	54666	2011	56677
2011	11	30600	29261	57243	2618	59861
	12	29319	28444	55647	2116	57763
2012	11	30920	29769	57951	2738	60689
	12	29728	29353	56821	2260	59081
2013	11	31770	30560	59278	3052	62330
	12	30378	29724	57724	2378	60102
2014	11	32445	30581	59848	3178	63026
	12	31132	30457	58829	2760	61589
2015	11	32520	30868	60112	3276	63388
	12	31844	30519	59489	2874	62363
2016	11	33314	31556	61389	3481	64870
	12	31964	31116	60005	3075	63080
2017	11	32090	31334	60019	3405	63424
	12	33032	31829	61639	3222	64861
2018	11	24351	21494	43586	2259	45845
	12	31613	31582	60016	3179	63195
2019	11	Introduction of new curriculum				
	12	24247	21868	43912	2203	46115

Table 2: Raw data showing student numbers

To perform the analysis, a descriptive quantitative method was employed using Microsoft Excel. Microsoft Excel offers a suite of statistical analysis functions that can be used to run descriptive statistics, to perform several different and useful inferential statistical tests and process data through using formulas (Abbott, 2011). Descriptive statistics and graphical representations of data can be useful when making comparisons between sets (Carr, 2008). Descriptive statistics (e.g. calculation of the measures of central tendency such as the mean, mode and median), were used to analyse the data using the Microsoft Excel software. According to Aldrich and Rodriguez (2013) multiline graphs can be used to identify trend changes in one or more variables over time. The following section describes the trend changes in: (1) Average percentage enrolment; (2) Schools not offering calculus based mathematics; (3) Gender enrolment in Mathematics A, B and C; (4) Indigenous Students Enrolment; and (5) Dropout Rates in Mathematics B and C.

The average percentage enrolment

An analysis of the average percentage of student enrolment in Mathematics A, B, C and Prevocational mathematics between 2010 and 2019 was conducted. The analysis ranked the mathematics enrolment in the different options as follows:

Mathematics A: 42.55% at Year 11 and 43.44% at Year 12

Mathematics B: 30.41% at Year 11 and 29.53% at Year 12

Mathematics C: with 7.82% at Year 11 and 7.62% at Year 12

Prevocational Mathematics (PVM): 19.22% at Year 11 and 19.21% at Year 12

Figure 1 below is a graph of student enrolment in all the four mathematics options: Mathematics A, B, C and Prevocational mathematics between 2010 and 2019. The Mathematics A, B, C and Prevocational syllabi terminated at the end of 2019 hence Year 11 data ended in 2018.

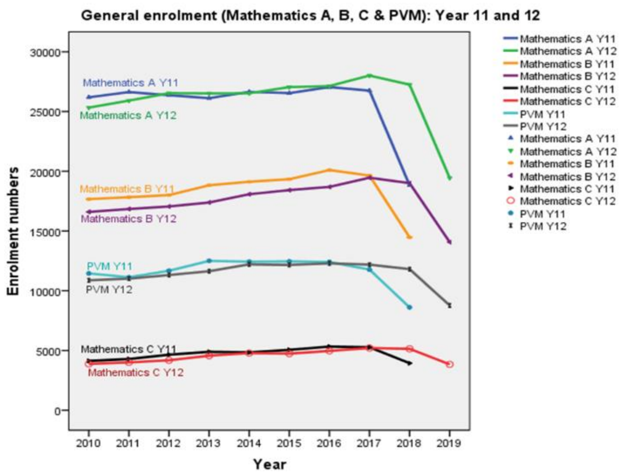

Figure 1: Enrolment Summary from 2010 to 2019

Schools without Students Participating in Calculus Based Mathematics

Figure 2 below is a graph of the number of schools that did not register any student for Mathematics B and C between 2010 and 2019. The yearly average number of schools that did not have students participating in calculus based mathematics, which is Mathematics B is 13 and Mathematics C is 83. The difference between schools offering Mathematics A and B or C gave the number of schools that did not have students participating in calculus based mathematics.

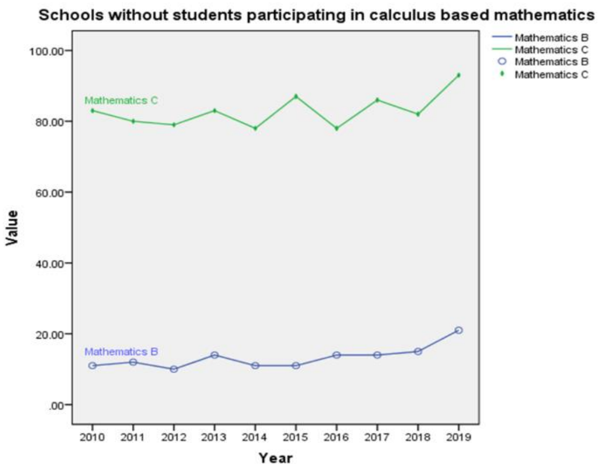

Figure 2: Schools without students participating in calculus based mathematics from 2010 to 2019

Gender enrolment in Mathematics A, B and C

Table 3 shows the average percentage enrolment in Mathematics A, B and C from 2010 to 2019 in the gender groups. The table also shows the gender distribution in calculus based (Mathematics B and C) and non-calculus Mathematics A.

Year Level	Subject	Gender	Average Percentage
11	Mathematics A	Males	46.61
		Females	53.39
	Mathematics B	Males	52.54
		Females	47.46
	Mathematics C	Males	64.71
		Females	35.29
12	Mathematics A	Males	46.30
		Females	53.70
	Mathematics B	Males	52.37
		Females	47.63
	Mathematics C	Males	64.89
		Females	35.11

Table 3: Average Percentage Gender enrolment in Mathematics A, B and C from 2010 to 2019

The results show that male enrolments in calculus based mathematics was higher compared to females. The average percentage of males enrolled in Mathematics B compared to the total Mathematics B enrolment was 52.54% in Year 11 and 52.37% in Year 12.This means for every 13 males enrolled in Mathematics B, there were 12 females. Similarly, in Mathematics C males constituted 64.71% of the Year 11 cohort and 64.89% in Year 12. For every 13 males enrolled for Mathematics C, there were 7 females. In contrast, females dominated participation in the non-calculus option of Mathematics A. At Year 11, females surpassed males by an average percentage of 6.78% which increased to 7.4% at Year 12. There was a slight increase in the ratio from every 12 males to 13 females in Year 11 to 6 males to 7 females in Year 12.

Indigenous Students Enrolment

Figure 3 shows trends in Indigenous students' enrolment in the mathematics options. A large number of Indigenous students enrolled in Pre Vocational Mathematics with a very small percentage in Mathematics C. Table 4 below shows how Indigenous students are distributed in the four options. The percentages were calculated as a total of the state Indigenous student population.

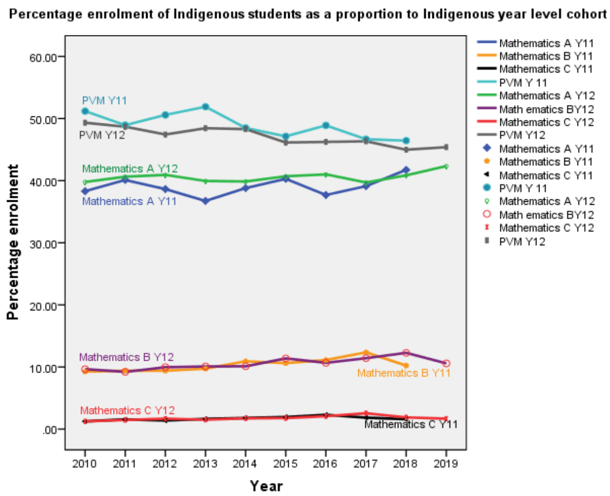

Figure 3: Percentage Enrolment of Indigenous students from 2010 to 2019

Year 11	Year 12
Mathematics A (39.05%)	Mathematics A (40.58%)
Mathematics B (10.33%)	Mathematics B (10.53%)

Mathematics C (1.70%)	Mathematics C (1.76%)
Pre Vocational (48.91%)	Pre Vocational (47.13%)

Table 4: Average percentages of distribution of Indigenous students from 2010 to 2019

Dropout Rates in Mathematics B and C

Figure 4 shows the dropout rate in Mathematics B and C for all students, while Figure 5 shows the dropout rate according to gender. Figure 6 shows the percentage drop out of Indigenous versus non-indigenous students. Additionally, the trends of students' movement between mathematics subject options can also be determined through data analysis. The availability of both Year 11 and 12 data allowed tracking of changes in students' enrolment as they moved from one year to the next.

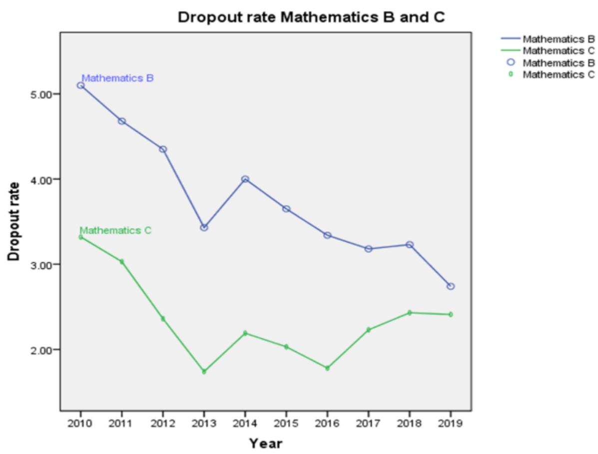

Figure 4: Dropout rate in Mathematics B and C for all students from 2010 to 2019

Consistently, Mathematics B had more students dropping out as they moved from Year 11 to Year 12. On average about 688 students dropped from Mathematics B every year compared to 108 students in Mathematics C. This means that the dropout from Mathematics C, although averaging 2.35%, is calculated on a smaller population than for Mathematics B with an average of 3.77%. For the period under consideration, 2010 to 2019, a total of 3372 females and 4582 males dropped out of calculus based mathematics.

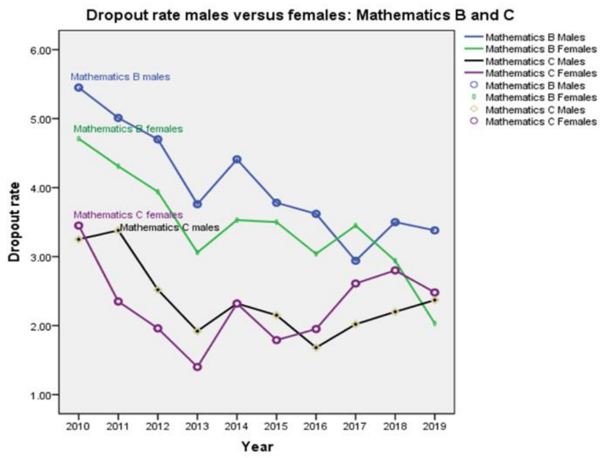

Figure 5: Dropout Rate According to Gender from 2010 to 2019

A larger percentage of males dropped out of Mathematics B and C with an average rate of 4.06% in Mathematics B and 2.38% in Mathematics C. Contrastingly, females were in the minority in both options but their dropout rate was 3.45% in Mathematics B and 2.32% in Mathematics C.

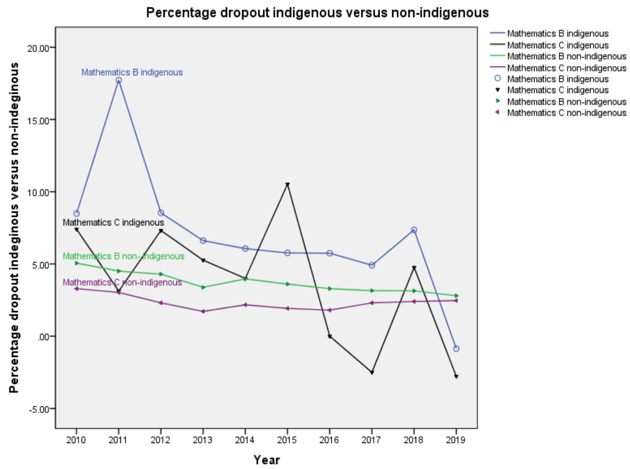

Figure 6: Dropout of Indigenous versus non-indigenous students from 2010 to 2019

The average dropout for Indigenous students was 7.03% for Mathematics B and 3.71% for Mathematics C. This is despite the fact that Indigenous students comprise a very small percentage of enrolments at any year level. In comparison non-indigenous students had an average dropout percentage of 3.72% for Mathematics B and 2.24% for Mathematics C. Raw data show a total of 225 indigenous students dropped out of calculus based mathematics from 2010 to 2019.

8. Discussion

Findings from this research indicate that more male students opted for Mathematics B and C than female students. As highlighted in the data, an average of 47.5 % and 35.2 % of all Mathematics B and C respectively in Years 11 and 12 are females. This is in agreement with Ainley et al., (2008), Forgasz, (2006a), Forgasz, (2006b) earlier findings. This indicates that fewer females opted for calculus based mathematics compared to males for the period 2010 to 2019. The percentage of females choosing advanced mathematics is a concern. On the contrary, the dropout rate of females from these two subjects is 3.45% for Mathematics B and 2.31% for Mathematics C, which is less than the dropout rate for males which is 4.06% for Mathematics B and 2.38% for Mathematics C. This smaller percentage of female dropout in Mathematics B and C suggests that female dropout rate could be further reduced if female enrolment is improved. This indicates that with sustained improvements in female enrolments, the female students have the potential to surpass male students in Mathematics B and C. Females do not prefer competitive environments and avoid uncertainties, but rather opt for more definite settings (Niederle & Vesterlund, 2010). Consequently, the higher enrolments of females in Mathematics A from 2010 to 2019 in Years 11 and 12 indicate that female students opt for choices where they feel that they will perform well. Female students must be encouraged to choose options that offer more STEM opportunities and to perform well in those options. This supports the need for educators to develop strategies that improve female enrolment in these subjects in year 11. While results of trends analysis cannot explain why fewer females choose Mathematics B and C, a closer focus on not only academic but social and cultural factors that enhance female students' participation in Mathematics B and C is essential and this could be a focus of future research.

Mathematics is compulsory in Queensland for all students to achieve a Queensland Certificate of Education (QCE). Students decide on which option to pursue in Years 11 and 12. However, findings from this research indicate that not all schools offer all options. As suggested earlier, the Australian Council of Deans of Science in 2006 found that schools in more remote regions struggled to recruit qualified mathematics teachers. While this study did not focus on this issue, Australian Mathematical Sciences Institute [AMSI] (2014) noted that this is a particular challenge for Queensland schools. The data analysis exposed a worrying trend as a significant number of schools across Queensland do not have students participating in Mathematics B and C with a yearly average of 13 and 83 schools respectively. This is in agreement with the AMSI (2014) which suggests that the number of schools able to provide advanced mathematics subjects at Years 11 and 12 is steadily declining and with this the number of students studying advanced mathematics. Additionally, the report suggests that shortages in specialised mathematics teachers has meant that around 40 percent of classes are taught without a qualified mathematics teacher. There is need to develop both material and human resources to empower classroom practise. This may contribute towards addressing the decline in student participation in Mathematics B and C. It is also important to target these resources to enable schools that currently do not offer some of the mathematics options to be able to do so in the future. Significantly, a declining trend of student participation in advanced mathematics subjects may also lead to fewer qualified mathematics teachers for the future.

Results showed that Indigenous students opted mostly for Mathematics A and Prevocational mathematics. Although Indigenous students constitute a very small percentage of enrolments at any year level the dropout rate is worth noting. The average dropout of Indigenous students was 7.03% for Mathematics B and 3.71% for Mathematics C. Indigenous students are mostly enrolled in remote and regional schools which may explain the higher enrolments in Prevocational mathematics compared to Mathematics B and C. Schools in remote regions have difficulty recruiting qualified mathematics teachers (Australian Council of Deans, 2006). This situation may impact Indigenous students more than other student groups. The study argues for an urgent focus to redress these trends and imbalances. The data does not include socio economic status or cultural factors that might also be at play within such settings. Additionally, lack of local STEM career opportunities in remote and regional areas might also play a part in the mathematics subjects students opted for as well as high dropout. This is because graduating at high school may not necessarily translate to starting a high-status career. It would be worthwhile to conduct further research that investigates the views of indigenous students in remote and regional schools to shed further light on their experience of learning Mathematics. However, this is beyond the scope of this study as the aim here is to identify broad trends purely from a statistical viewpoint.

Arresting the dropout rates in calculus based mathematics can be one way to improve the participation rate in the subjects. Results show that a significant number of students who opted for the calculus based mathematics subjects in Year 11 dropped the subjects and enrolled in non-calculus based mathematics in Year 12. Mathematics B had more students dropping out as they moved from Year 11 to Year 12. Data also shows that more students opted for Mathematics B or C at Year 11 than in Year 12, which was the opposite for Mathematics A and Prevocational. As suggested by McPhan et al. (2008), schools can arrest the decline and the high dropout rates in calculus based mathematics if they implement classroom practises that engage students and focus on improving student understanding of important concepts at every level of learning. Arresting this decline becomes imperative to support students' future participation in STEM related careers.

Research is needed to develop teaching and learning strategies that increase student participation in calculus based mathematics subjects. Encouraging all calculus based mathematics students to continue through to Year 12 should be a priority. Furthermore, to satisfy the demand in STEM related careers, more needs to be done to increase participation in calculus based mathematics. One way of doing this would be to focus on improving enrolments in Mathematics B, now Mathematical Methods in Queensland's new syllabus, which has an average percentage enrolment of 30.41% and offers almost the same opportunities as Mathematics C, now Specialist Mathematics. Thus, Queensland has the potential to have more than 31% of all year 12 enrolments eligible for STEM tertiary program and realising the goal of becoming STEM champions.

9. Conclusion

This paper has investigated Years 11 and 12 students' options and trends of participation in calculus based and non-calculus based mathematics subjects between 2010 and 2019 using data from Queensland Curriculum and Assessment Authority. The paper has also looked at the central role that mathematics plays as an enabler of STEM related courses and careers. The study found out that the mathematics trends at Year 12 in Queensland are consistent with previous research at national level. Males dominated in Mathematics B and C and fewer female students opted for the calculus based mathematics. Indigenous students opted mostly for Mathematics A and Prevocational mathematics. However, a significant number of schools do not offer calculus based mathematics options and consequently do not have students participating in the calculus based mathematics. The study argues for an urgent focus to redress these trends and imbalances. The study calls for further research that focus not only on academic factors, but social and cultural factors that enhance all students' participation in calculus based mathematics.

10. Disclosure statement

The author(s) declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

11. Acknowledgements

The author(s) wish to acknowledge the Queensland Curriculum and Assessment Authority (QCAA) for the statistical data.

12. Open Access Policy

PRISM is also indexed in the world largest open-access database: DOAJ (the Directory of Open Access Journals). DOAJ is a community-curated online directory that indexes and provides access to high quality, open access, peer-reviewed journals.

13. References

Abbott, M. L. (2011). Understanding educational statistics using Microsoft Excel' and SPSS'. Hoboken, N.J: Wiley.

Ainley, J., Kos, J., & Nicholas, M. (2008). Participation in Science, Mathematics and Technology in Australian Education. ACER Research Monograph No 63. Camberwell: Australian Council for Educational Research.

Aldrich, J. O., & Rodriguez, H. M. (2013). Building SPSS graphs to understand data. Los Angeles: SAGE Publications.

AMSI (2014). Dealing with Australia's mathematical deficit. Australian Mathematical Sciences Institute. Retrieved, from http://amsi.org.au/2014/06/11/dealing-australias-mathematical-deficit/

Australian Council of Deans of Science (2006). The Preparation of Mathematics Teachers in Australia. Meeting the demand for suitably qualified mathematics teachers in secondary schools. Retrieved from: http://www.acds.edu.au/docs/Prep_Math_Teach_Aust.pdf

Barrington, F., & Brown, P. (2014). Update on Year 12 mathematics student numbers. Melbourne, Vic: Australian Mathematical Sciences Institute.

Barrington, F. & Evans, M. (2014). Update on Year 12 mathematics student numbers. Melbourne, Vic: Australian Mathematical Sciences Institute.

Barrington, F. & Evans, M. (2016). Year 12 Mathematics in Australia – the last ten years. Melbourne, Vic: Australian Mathematical Sciences Institute.

Business Tech. (2020). Here's why thousands of South African schools dropped maths as a subject: https://businesstech.co.za/news/government/380697/heres-why-thousands-of-south-african-schools-dropped-maths-as-a-subject/

Carnevale, A. P., Smith, N., and Melton, M. (2011). STEM: Science, Technology, Engineering, and Mathematics. Georgetown University Centre for Education and the Workforce.

Carr, N. T. (2008). Using Microsoft Excel® to Calculate Descriptive Statistics and Create Graphs. Language Assessment Quarterly, 5(1), 43-62. https://doi:10.1080/15434300701776336

Centre for Curriculum Redesign. (2013). The Stockholm declaration: mathematics for the 21st century. Retrieved from Stockholm: http://curriculumredesign.org/wp-content/uploads/Stockholm-Declaration-CCR-FINAL.pdf

Dekkers, J., & Malone, J. (2000). Mathematics enrolments in Australian upper secondary schools (1980- 1999) : trends and implications. Australian Senior Mathematics Journal, 14(2), 49-57.

Engineers Australia Policy Note (2016). High school retention and participation in STEM subjects. Available from www.engineersaustralia.org.au

Forgasz, H. J. (2006a). Australian Year 12"Intermediate" level mathematics enrolments 2000–2004 : trends and patterns. In Identities, Cultures and Learning Spaces (Vol. 1). Canberra, ACT. http://www.merga.net.au/documents/RP222006.pdf

Forgasz, H. J. (2006b). Australian Year 12 mathematics enrolments: patterns and trends, past and present. Melbourne, Vic: Australian Mathematical Sciences Institute.

Hodgen, J., Marks, R., & Pepper, D. (2013). Towards universal participation in post-16 mathematics: Lessons from high-performing countries. London: Nuffield Foundation.

Hodgen J., Pepper D., Sturman L. and Ruddock G., (2010a). Is the UK an outlier? An international comparison of upper secondary mathematics education. London.

Hodgen J., Pepper D., Sturman L. and Ruddock G., (2010b). An international comparison of upper secondary mathematics education. London.

Evershed, N & Safi M (2014). The Guardian. Australia's science and maths are slipping says chief scientist: https://www.theguardian.com/science/2014/dec/01/australias-science-and-maths-are-slipping-says-chief-scientist

Jaremus, F., Gore, J., Fray, L., & Prieto-Rodriguez, E. (2018). Senior secondary student participation in STEM: Beyond national statistics. Mathematics Education Research Journal, 31(2), 151-173. https://doi.org/10.1007/s13394-018-0247-5

Kennedy, J., Lyons, T., & Quinn, F. (2014). The continuing decline of science and mathematics enrolments in Australian high schools. Teaching Science, 60(2), 34-46.

Kennedy, J., Quinn, F., & Lyons, T. (2018). Australian enrolment trends in technology and engineering: putting the T and E back into school STEM.

International Journal of Technology and Design Education, 28(2), 553-571. https://doi.org/10.1007/s10798-016-9394-8

Lee, S. (2016). Understanding the UK mathematics curriculum pre-higher education. A guide for academic members of staff. Sigma. mei.org.uk › pdf › pre-university-mathematics-guide-2016

Lemaire, L. (2003). Interview with Philippe Tondeur. European Mathematical Society Newsletter. Issue 49.

Lyakhova, S., & Neate, A. (2019) Further Mathematics, student choice and transition to university: part 1 - Mathematics degrees, teaching mathematics and its applications: An International Journal of the IMA, Volume 38, Issue 4, December 2019, Pages 167–190, https://doi-org.elibrary.jcu.edu.au/10.1093/teamat/hry013

Maltas, D., & Prescott, A. (2014). Calculus-based mathematics : An Australian endangered species? Australian Senior Mathematics Journal, 28(2), 39-49.

Mather, Joanna & Tadros, Edmund, (2014), Australia's mathematics crisis, Australian Financial Review http://www.afr.com/news/policy/education/australias-mathematics-crisis-20140606-iwfn1

McPhan, G., Morony, W., Pegg, J., Cooksey, R., & Lynch, T. (2008). Mathematics? Why not?: Final report. Canberra: Department of Education, Employment and Workplace Relations (DEEWR).

National Science Board. 2018. Science and Engineering indicators 2018. NSB-2018-1. Alexandria, VA: National Science Foundation. Available at https://www.nsf.gov/statistics/2018/nsb20181/assets/nsb20181.pdf

Niederle, M., & Vesterlund, L. (2010). Explaining the Gender Gap in Math Test Scores: The Role of Competition. The Journal of Economic Perspectives, 24(2), 129-144. https://doi:10.1257/jep.24.2.129

Noyes, A., & Adkins, M. (2016). Reconsidering the rise in A-Level Mathematics participation. Teaching Mathematics and its Applications: An International Journal of the IMA, 35(1), 1-13. https://doi.org/10.1093/teamat/hrv016

Peters, E., Shoots-Reinhard, B., Tompkins, M. K., Schley, D., Meilleur, L., Sinayev, A., . . . Crocker, J. (2017). Improving numeracy through values affirmation enhances decision and STEM outcomes. PloS one, 12(7) https://doi:10.1371/journal.pone.0180674

Queensland Curriculum and Assessment Authority QCAA (2008). Senior Syllabus. Mathematics B: https://international.qcaa.qld.edu.au/offshore_downloads/senior/snr_maths_b_08_syll.pdf

Queensland Studies Authority (QSA) (2014). Trends and Issues in curriculum and assessments. Identifying enrolment trends in senior mathematics and science subjects in Queensland schools.

Queensland Tertiary Admissions Centre (QTAC) (2018). OP to ATAR – Queensland 2021.

Rasmussen, C. L., Heck, D. J., Tarr, J. E., Knuth, E., White, D. Y., Lambdin, D. V., Barnes, D. (2011). Trends and issues in high school mathematics: Research insights and needs. Journal for Research in Mathematics Education, 42(3), 204–219.

Vernon, L. (2020), No STEM success without way more mathematics. Campus Morning Mail. https://campusmorningmail.com.au/news/no-stem-success-without-way-more-mathematics/

Watt, H. M. G., Watt, H. M. G., Hyde, J. S., Hyde, J. S., Petersen, J., Petersen, J., Morris, Z. A., Morris, Z. A., Rozek, C. S., Rozek, C. S., Harackiewicz, J. M., & Harackiewicz, J. M. (2017). Mathematics—a critical filter for STEM-related career choices? A longitudinal examination among Australian and U.S. Adolescents. Sex Roles, 77(3), 254-271. https://doi.org/10.1007/s11199-016-0711-1