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Trends in Calculus-Based Mathematics in the New Senior Secondary Queensland Certificate of Education

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Abstract: The new Queensland Certificate of Education (QCE) curricula was introduced in 2019, offering senior secondary students four mathematics options to study: Essential Mathematics, General Mathematics, Mathematical Methods and Specialist Mathematics. Methods and Specialist are calculus-based options, and provide broader and diverse career opportunities post-secondary. This paper investigated senior secondary students' enrolment in calculus-based mathematics options between 2019 and 2020 in Queensland state schools from different districts. Quantitative methods were applied to analyse student participation using data from the Queensland Curriculum and Assessment Authority (QCAA), Socio-Economic Indexes for Areas (SEIFA) from the Australian Bureau of Statistics (ABS); schools' Index of Community Socio-Educational Advantage (ICSEA) values from the Australian Curriculum, Assessment and Reporting Authority (ACARA); and schools transfer ratings from the Department of Education (DoE).Results show a high dropout rate in calculus-based options as students progressed into their initial course/s of study. Trends show that the SEIFA Indexes, schools' ICSEA Indexes, schools transfer ratings positively correlate with student dropouts. The study argues for resources to be made available to promote continued students' participation and achievement. Targeted support for schools located in low socioeconomic areas and having high transfer ratings is significant to promote the uptake and continued participation in calculus-based mathematics.

Keywords: Calculus-based mathematics, Socioeconomic status, School transfer rating, Students participation, Dropout.

Introduction

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Mathematics plays a central role in innovation, scientific, technological, economic and social knowledge development (Watt et al., 2017). The sciences, digital technologies and innovation, in particular, are regarded as the economic drivers and main jobs of the future (Black et al., 2021; PwC, 2013), and mathematics is regarded as a significant enabler of these fields (Australian Academy of Science, 2016). In Australia, "innovation and digital technologies have the potential to increase Australia's productivity and raise GDP by $136 billion in 2034, and create close to 540,000 jobs" (PwC, 2013, p13), hence mathematics is pivotal in reshaping the future (Chubb, 2012). Australia, and especially Queensland needs graduates with advanced mathematics skills to promote innovation, data synthesis and technology if it is to remain competitive in the global scenario.

Indeed, enhancing participation and achievement in advanced mathematics in schools is a focus of most governments all over the world (Noyes & Adkins, 2016; Treacy et al., 2020), because mathematics drives STEM (Shaughnessy, 2013). Similar to other countries such as the United Kingdom, Australia also offers bonus points at university entry for students who pass advanced mathematics as an incentive to motivate uptake (Prendergast et al., 2020; Treacy et al., 2020). The distinct advantage of studying advanced mathematics in high school is not only important to achieve individual goals but is recognised as being of value to society.

Developing advanced mathematics skills results in high economic value, since "strong mathematical skills are critically important for a thriving and competitive knowledge-based economy" (Adkins & Noyes, 2016, p. 94). Studies have shown that students who pursue advanced mathematics are interested in pursuing high impact jobs (Gijsbers et al., 2020). Indeed, people with advanced mathematics skills progress to earn about 11% more than those without by the time they reach 34 years of age (Adkins & Noyes, 2016). Similarly, choosing advanced mathematics is generally regarded as a pathway to high paying jobs (Light & Rama, 2019). The link between economic development, prosperity and advanced mathematics makes it a key transformational focus for governments, hence understanding trends in students' participation in advanced mathematics can inform policy makers.

The purpose of this research is to determine trends in enrolment and participation in calculus-based mathematics under the new curriculum introduced in Queensland in 2019. In addition, the relationship between the participation trends, school location, area's socio-economic status and schools' transfer ratings are explored. The study builds on prior research on students' participation in calculus-based mathematics in Queensland (Chinofunga et al.,2022). This study further expands the focus to the relationship between participation, dropout rates, SES, school location and teacher mobility and transfer ratings. The study will contribute to limited literature available on the impact of social and economic factors and school location on participation in calculus-based mathematics.

Importance of calculus-based mathematics

Calculus is built on the foundations of the analysis of changing phenomenon. Therefore, "calculus is essential for developing an understanding of the physical world" (Queensland Curriculum and Assessment Authority (QCAA), 2018 p.1). Calculus-based mathematics introduces differentiation and integration at high school which provides students with the opportunity to model quantities that undergo change and a portal for deeper theoretical growth (Maltas & Prescott, 2014). In Queensland, graduates with either Specialist Mathematics and or Mathematical Methods have a pathway to pursue tertiary courses that are mathematics intensive such as natural sciences, health sciences and engineering (QCAA, 2018). However, students who opt for Specialist Mathematics also have to study Mathematical Methods but have a distinct advantage at tertiary levels as it is regarded as more advanced. Thus, studying these subjects is critical as students prepare for careers in a competitive world.

Several scholars have highlighted the importance of advanced mathematics that include providing better and diverse career opportunities, (Chinnappan et al., 2008; Chinofunga et al., 2022; Maltas & Prescott, 2014; Noyes & Adkins, 2017) and facilitate skills for STEM workforce (Kennedy et al., 2014). Moreover, calculus-based mathematics is critical in "developing students' logical thinking and reasoning abilities" (Prendergast et al., 2020, p. 753). A country's economic status and social wellbeing is enhanced by having a workforce that possess advanced mathematics skills as they are critical for research, industry and business to thrive (Black et al., 2021). A projected increase of school enrolments of 20.4% by 2026 in Queensland must prompt policy makers to also find ways of boosting calculus-based graduates by the same margin (O'Connor & Oam, 2019). Calculus based mathematics offers distinct advantages for graduates as it enhances critical thinking and decision making, thus prepares them for individual growth and flexible but critical career options.

High school calculus-based mathematics increases the chances of entry into highly sought-after courses in higher education (Cogan et al., 2019). Hence,

> "students need a good measure of rigorous, formal mathematics in order to be literate, prepared for whatever career path students choose upon completion of their secondary education whether they choose to enter immediately the work force; to enter a technical, trade or vocational career path, or to continue their formal education at a college or university" (Cogan et al., 2019, p. 531).

Furthermore, calculus-based mathematics enhances the chances of success in STEM courses at tertiary level (Cohen & Kelly, 2020; Gottfried, 2015; Nicholas et al., 2015; Redmond-Sanogo et al., 2016). Research also indicates that students who graduate from high school with advanced mathematics subjects do well in health sciences at university with a high-grade point average (Ryan et al., 2017). High school graduates with non-calculus options who want to pursue tertiary courses where calculus-based mathematics is a pre-requisite are required to take up bridging or remediation courses (Nicholas et al., 2015; Redmond-Sanogo et al., 2016; Varsavsky, 2010). Undoubtably, the role that calculus-based mathematics plays in STEM tertiary courses cannot be underestimated.

Socio-economic background and participation in calculus-based mathematics

Social and economic background largely determines access to resources. Students from high SES families or schools have access to better resources that can provide opportunities for success compared to those from lower socio-economic backgrounds (Bornstein & Bradley, 2014). Consequently, students' participation and achievement are significantly influenced by "school characteristics such as location and socio-economic background of the students it serves." (ACARA, 2013 p.1). Additionally, differences in students' achievement are often influenced by students' SES (Broer et al., 2019). "In Australia, the magnitude of the socio-economic gap in mathematics achievement at age 10 is about 65% as large as the gap observed among 15-year-olds, and about 58% as large as the gap in numeracy proficiency among 25-29-year-olds" (OECD, 2018, p. 2). Consequently, the limited educational opportunities and experiences students from low SES are more likely to encounter do not promote social equality and better educational outcomes (Peggy, 2018). Moreover, financial and human capital complemented by resources accessed through networking play an important role in shaping students' choices and beliefs (Bradley & Corwyn, 2002). Better and diverse opportunities calculus-based mathematics offer are skewed towards students from high SES families or who go to high SES schools.

Socio-economic factors also influence students' mathematics subject choices and achievement (Valero et al., 2015). Consequently, students from high SES background have better chances of participating in and achieving well in mathematics, especially in advanced options compared to those from low SES background (Valero et al., 2015). Moreover, parents of students from high SES background have high expectations and encourage their children to take advanced mathematics (Hascoët et al., 2021). In contrast, students from lower SES communities may not interact much with knowledgeable and experienced adults who can act as role models and provide stimulating and motivating experiences, thus limiting opportunities and options for such students (Bradley & Corwyn, 2002). This is because, the immediate social network around students that include parents, teachers, siblings and friends plays a key role in influencing students' mathematics choices (Kirkham et al., 2019). The critical role parents, and the social background plays in influencing students' mathematics choices emphasise the importance of school location, school choice and the social network a student is exposed to. On average, a student who attends a higher SES school enjoys higher educational outcomes compared to a student from a similar social background who attends a lower SES school (Perry & McConney, 2013, p. 125). This is because, high status peers are significantly influential to other peers within a social group (Choukas-Bradley et al., 2015). Schools with high SES are strongly associated with high academic expectations, competition and achievements (Perry & McConney, 2013), hence students' mathematics choices are influenced by the school environment, which is expected to be highly stimulative, productive and positive (Willms, 2010). Clearly, the interaction between students from different levels of SES in high SES schools provides an opportunity for networking among peers that will boost mathematics achievement, especially to those from low SES (Perry & McConney, 2013). Hence, school SES plays a critical role in students mathematics choices regardless of the students' family SES.

A school reflects the demography of the community within its catchment area and those located in communities with low SES have students who are in some way disadvantaged (Hernández, 2014). In fact, "schools that are in the same district, but located in neighbourhoods of differing SES display a large disparity in opportunities and quality of education offered to students" (Hernández, 2014, p1). Students who attend schools in high SES neighbourhoods have access to relevant information and experiences that help them set high expectations and above all better educational resources (Ireneusz, 2020; Pritchett, 2001). Schools in affluent areas have better physical and material resources that differentiate them from other schools. In fact, differences in educational opportunities are influenced by accessibility to well-resourced schools (Broer et al., 2019). "It is not just the relative wealth of parents that holds large numbers of bright kids back: it is postcode inequality too. What part of the country a child grows up in has a real impact on their life chances" (Nick Clegg (UK former leader of the Liberal Democrats), 2016). In contrast, students from low SES who attend high SES schools score 86 points higher than their counterparts in low SES schools (OECD, 2018). Students from low SES families and communities have limited options to pursue because of the social and financial capital which is needed to enter reputable and well-resourced schools.

Student participation and achievement in advanced mathematics is linked to school resources that include discipline trained teachers and family social economic status (Chiu, 2010). Importantly, mathematics teachers' expertise in teaching the subject and making it more engaging and understandable to students plays a critical role in student participation in calculus-based mathematics (Kirkham et al., 2019). In fact, "the likelihood of a student pursuing further studies in mathematics would be influenced by their experiences in mathematics classes at secondary school" (Chinnappan, 2008). For example, past mathematics achievement directly influences students' attitude towards mathematics (Birgin et al., 2010; Hascoët et al., 2021; Sikora et al., 2019). Clearly, "attitudes concerning mathematics show significant impact on one's decisions about the amount and nature of mathematics one will study in the future" (Recber et al., 2017). As a result, students' choices of schools influence the mathematics options they select (Sikora et al., 2019). Students from low SES families have limited options in terms of school choices as they are more likely to enrol in schools within their communities.

Location of a school is a major contributor of resources and opportunities a school offer as it contributes to teacher mobility and transfer rate. Queensland state schools are allocated transfer ratings from 1 to 7 depending on remoteness, access and level of amenities in the area, complexity of school environment and staffing requirements (Department of Education [DoE], 2019). Remoteness is determined by distance from Brisbane or Toowoomba or any coastal city of more than 8000 people (DoE, 2019). In fact, school transfer ratings are the bases of the transfer points teachers accrue (Department of Education, 2020). Therefore, "teachers who elect to work for longer periods in schools of rating 3 to 7 increase their prospects of securing a transfer to a preferred location where they choose to return, while schools benefit from the greater stability and stronger community integration." (DoE, 2020, p. 5). Teachers who are attached to a school for a longer period perform better than those who have a short stint at the school and this pattern is more apparent in disadvantaged schools (Hanushek & Rivkin, 2010). Teachers at a school with rating 7 are due for transfer after 2 years while others are expected to serve 3 years at a school to qualify (DoE, 2020). However, any other personal, social, professional circumstances and transfers from a school with a lower rating to one with a higher rating may also lead to approved transfers (DoE, 2020). The higher the school transfer rating, the more transfer points teachers accrue which may result in unintended consequences of high teacher turnovers in such schools.

High teacher turnover in schools is also a key factor in hindering quality education and better options for students in disadvantaged communities (Barbieri et al., 2011). Teachers may target schools with high transfer ratings because they “are simply waiting to move on to a desired location, putting low effort into their current work duties and disregarding any longer-term plans for their students” (Barbieri et al., 2011, p. 1430). Therefore, a substantial number of teachers tend to be more effective and more focused on delivery after a voluntary transfer (Jackson, 2013). Contrastingly, teachers who teach students who are keen to engage or are high achievers are less likely to transfer (Boyd et al., 2011). This means that teachers in low transfer rated schools may serve longer in a school which will provide stability, consistency, and confidence for students to participate in calculus-based mathematics if other factors like socio-economic disadvantages are minimised.

Socio-economic measures in the study

A significant number of researchers (Anastasiou et al., 2020; Avan & Kirkwood, 2010; Broer et al., 2019) have linked family and neighbourhood socio-economic status (SES) with educational outcomes. SES differences mainly involve accessing material (financial, assets) and social (community networking, neighbourhood) resources that impact wellbeing and development of individuals, families and neighbourhoods (Bornstein & Bradley, 2014; Bradley & Corwyn, 2002). However, obtaining family SES is very difficult considering the sensitivity of the subject to society (Broer et al., 2019). Nevertheless, SES of an area can be determined using the socio-economic Index for areas (SEIFA) which indicates the relative advantage and disadvantage of a neighbourhood (Australian Bureau of Statistics [ABS], 2018b). This study seeks to determine the correlation between the school districts’ SEIFA Indexes, schools’ ICSEA Indexes, teacher mobility and transfer ratings with students’ dropout in the calculus-based mathematics subjects in Queensland state schools.

The Australian Bureau of Statistics census data can be used to infer important school information such as relative advantage and disadvantage of a neighbourhood (Gibson & Asthana, 2000). The SEIFA index is developed after a census and the current index is from 2016. The data includes SES index in percentiles and name of area. This data was corelated with school data, obtained from QCAA, which included name of district, postcode, and enrolment per unit. The period under study is of particular interest because Queensland changed to a new senior curriculum in 2019 and the first external examination was in 2020. Importantly, the analysis will help to determine the impact of school postcodes and SES on participation in calculus-based mathematics.

The SEIFA value is used to better understand the relationship between socio-economic advantage and disadvantage to social and educational outcomes (ABS, 2018a). ABS broadly define "relative socio-economic advantage and disadvantage in terms of people's access to material and social resources, and their ability to participate in society" (2018a, p6). The percentile value on the SEIFA index is meant to indicate where the area sits in terms of SES within the whole nation (ABS, 2018a), but this study is only focused on Queensland. Importantly, socio-economic status of an area is mainly attributed to collective income, education, employment, and occupation of people in a neighbourhood (ABS, 2018a). Thus, a low score on the index indicates a high proportion of relatively disadvantaged people in an area (ABS, 2018a, p. 6). This index is used comparatively in the trend analyses.

To better understand the impact of socio-economic factors in relation to different schools and their location, the Australian Curriculum, Assessment and Reporting Authority (ACARA) developed an Index of Community Socio-educational Advantage (ICSEA). ICSEA values are developed using students' family background data, location of school and demography of indigenous and non-indigenous students (ACARA, 2013). It enables "comparisons between schools based on the level of educational advantage or disadvantage that students bring to their academic studies." (ACARA, 2013, p.1). Similarly, it can be used as a measure of social economic advantage in education (Callingham, 2017). The ICSEA values range from 500 representing schools with students from hugely underprivileged educational backgrounds to 1300 for schools with students from very highly privileged educational backgrounds and a benchmark average of 1000 (ACARA, 2013). This study analyses trends in participation in calculus-based mathematics using ICSEA values of all Queensland government secondary schools to investigate if school location and socio-economic background plays a role in students' participation in the subjects.

Study methods and results

The study used data from a range of institutions (ABS, ACARA, DoE, QCAA) to investigate the impact of social and economic factors on participation in calculus-based mathematics. Quantitative methods were used to analyse trends from within and across data sets to establish a comprehensive picture of how socioeconomic status and school location affect participation. QCAA provided consent for the use of its data which included school name, subject name, postal code and enrolment per unit. Each school and district were matched to SEIFA index (ABS), ICSEA value (ACARA) and transfer points (DoE). Descriptive quantitative methods were applied to analyse trends using Microsoft Excel suite of functions because it "provides a comprehensive approach to quantitative data analysis" (Johri, 2020, p. 4). It is especially ideal for descriptive quantitative statistical analysis and data management through its use of functions and data organisation tools (Rubin & Abrams, 2015). Measures of central tendency such as mean (average) and mode together with Excel in-built functions were used to determine trends in students' participation. Specifically, data analysis explored (i) students' participation and dropout rates per district (ii) school location SEIFA index and students' participation (iii) school ICSEA value and students' participation (iv) transfer ratings and students' participation. The next section reports the data analysis using the SEIFA index, ICSEA value, school transfer rating and student enrolment to determine trends in students' participation in calculus-based mathematics.

Students' participation and dropout rates per QCAA district

Firstly, an analysis of the average percentage of student enrolment in Mathematical Methods and Specialist Mathematics in state schools per QCAA district between 2019 and 2020 was carried out. Distance education schools were considered separately because their catchment area can span more than one district. In both Tables 1 and 2, enrolment in Unit 1, was considered for 2019 because it is the first unit students engage with in Year 11. Similarly, Unit 4 enrolment was considered in 2020 because it is the last unit before students sit for the external examination. Hence students' enrolments in Unit 4 indicates the number of students who completed Year 12 calculus-based mathematics.

Mathematical Methods enrolment per QCAA district

Table 1: Enrolment in Mathematical Methods in state schools per district

QCAA District	Unit 1 Enrolment	Unit 4 Enrolment	Dropout	% dropout
Brisbane-Ipswich	563	405	158	28.1
Brisbane Central	950	718	232	24.4
Brisbane East	619	405	214	34.6
Brisbane North	829	513	316	38.1
Brisbane South	625	334	291	46.6
Cairns	451	267	184	40.8
Gold Coast	731	457	274	37.5
Mackay	247	134	113	45.7
Rockhampton	337	179	158	46.9
Sunshine Coast	661	390	271	41.0
Toowoomba	388	223	165	42.5
Townsville	364	209	155	42.6
Wide Bay	354	208	146	41.2
Distance education	88	53	35	39.8
Totals	7207	4495	2712	

Table 1 shows raw data on enrolment and dropout rates in Mathematical Methods in state schools per district at the beginning of Year 11. The data shows that 7207 state schools students opted for Mathematical Methods. However, state school students who were still enrolled for Unit 4 in Year 12 were 4495 representing a percentage drop out of 37.6%. This means that the total number of students in state secondary schools who opted out of Mathematical Methods from the start of Year 11 to the end of Year 12 was 2712. That is, for every

14 students who chose this subject 5 did not complete it. Brisbane Central and Ipswich are the only districts with less than 30% dropout rate while Brisbane South, Mackay and Rockhampton are over 45%. Due to the high dropout in Brisbane South, Mackay and Rockhampton districts, for every 20 students who choose Mathematical Methods in Year 11, about 9 of the students dropped out by the end of Year 12.

Specialist Mathematics enrolment per QCAA district

Table 2: Enrolment in Specialist Mathematics in state schools per district

QCAA District	Unit 1 Enrolment	Unit 4 Enrolment	Dropout	% Dropout
Brisbane-Ipswich	113	88	25	22.1
Brisbane Central	330	280	50	15.2
Brisbane East	168	131	37	22.0
Brisbane North	225	170	55	24.4
Brisbane South	196	139	57	29.1
Cairns	101	67	34	33.7
Gold Coast	191	147	44	23.0
Mackay	33	23	10	30.3
Rockhampton	91	59	32	35.2
Sunshine Coast	191	141	50	26.2
Toowoomba	99	60	39	39.4
Townsville	68	49	19	27.9
Wide Bay	100	77	23	23.0
Distance education	55	34	21	38.2
Totals	1961	1465	496	

Table 2 shows raw data on enrolment and dropout rate in Specialist Mathematics in state schools per district. The total number of students who opted to study Specialist Mathematics in Year 11 at the beginning of 2019 was 1961 (Table 2). Nonetheless, only 1465 enrolled for Unit 4; hence, 496 students opted out. The dropout rate of participation or enrolment was 25.3% from Unit 1 (beginning of Year 11 in 2019) to Unit 4 (end of Year 12 in 2020). That is, for every 20 students who opted for Specialist Mathematics 15 continued until end of year 12. Cairns, Mackay, Rockhampton and Toowoomba districts have greater than 30% dropout rates. Similarly, distance education schools have a 38% dropout rate which is the highest of all the jurisdictions under consideration. Brisbane Central remains the district with the lowest percentage dropout rate of 15.2% followed by Brisbane East and Brisbane- Ipswich at 22%. Similarly, Mackay contributes the smallest number of students studying calculus-based mathematics among all districts.

An analysis of the number of schools offering calculus-based mathematics in each district was also done. Figure 1 shows the distribution and number of schools offering Mathematical Methods and Specialist Mathematics in the thirteen districts.

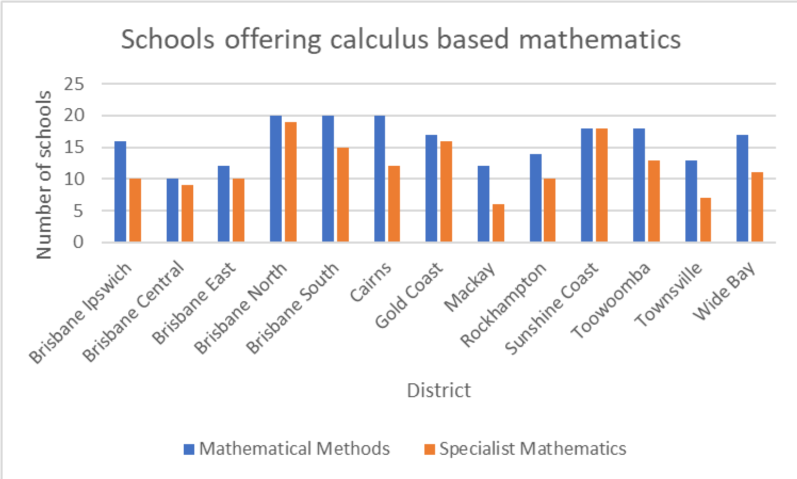

Figure 1: Schools offering calculus-based mathematics per district

An analysis of Figure 1 and Tables 1 and 2 gives a deeper understanding of enrolment and the number of schools offering the options per district. Figure 1 show Brisbane Central having only 10 and 9 schools offering Mathematical Methods and Specialist Mathematics respectively, but the enrolment in this district is the highest in Queensland. Furthermore, it has the lowest percentage dropout rate compared to any other district at 24.4%. Contrastingly, Brisbane East and Mackay districts have 12 schools each offering Mathematical Methods, but Brisbane East has almost three times the enrolment of Mackay and the dropout rate is significantly different. This is also true if a comparison is made between Sunshine Coast and Toowoomba, Brisbane North and Cairns districts in Mathematical Methods. There is also a bigger difference in number of schools offering Mathematical Methods and Specialist Mathematics in Mackay, Brisbane Ipswich, Brisbane South, Cairns, Mackay, Rockhampton, Toowoomba, Townsville and Wide Bay.

School location SEIFA index and students' participation

An analysis of student enrolment in Mathematical Methods and Specialist Mathematics and school location based on their SEIFA index was done. In total, the SEIFA indexes of 203 schools was considered. This excluded 4 distance education schools because their location has no influence on students' enrolment. Since the SEIFA data was in presented as percentiles, 50% and upwards was considered as upper half and thus designated as areas with economic advantage while below 50% was considered as areas that were economically disadvantaged. Although there were 115 schools, with students enrolled in Mathematical Methods in the lower half they only contributed 39.8% of the Unit 1 Mathematical Methods cohort. Schools below the 50% have an average percentage dropout rate of 42%, while those above the 50% economic advantage have a dropout rate of 34.7%. Similarly, in Specialist Mathematics, the group with the 50% economic advantage has a dropout rate of 24% compared to 26.6% with the economic disadvantage. Although, there are 76 schools out of 153 considered to have economic advantage, they contribute 63.1% of all students who studied Specialist Mathematics in Unit 1.

School ICSEA value and students' participation

An analysis of student enrolment in Mathematical Methods and Specialist Mathematics and school ICSEA index was completed. The results indicate that dropout rates are influenced by the school ICSEA index. Schools with an ICSEA value of more than 1100 have a dropout rate of 27%, while those between 1000 and 1100 have a dropout rate of 29.2% and lastly those less with than 1000 have a dropout rate of 43.4% in Mathematical Methods. The trend was the same in Mathematical Methods with schools with ICSEA value of 1000 and above having a dropout rate of 20.3% compared to 29.2% of those with a value less than 1000.

School transfer ratings and students' participation

Lastly, an analysis of the school transfer ratings and student enrolment in Mathematical Methods and Specialist Mathematics was also completed. In 2019 at the end of Unit 1, there were 106 state secondary schools with transfer ratings of 1 and these schools had an enrolment of 4919 students in Mathematical Methods. There were 101 schools with transfer ratings of 2 and above, but they only enrolled 2288 students in the same option. To be precise, only 31.7% of all students who studied Unit 1 of Mathematical Methods were enrolled in schools with transfer ratings of 2 and above. Hence, the total enrolment of all the other schools with a different transfer rating from 1 was less than half of those with rating 1. Despite enrolling 68.3% of all students studying Mathematical Methods, 1691 (34.4%) students dropped out of the subject from schools with ratings 1 compared to 1021 from schools with transfer rating of 2 and above. In fact, 54.5% of the enrolled students in schools with transfer ratings of 7 dropped out. Figure 2 shows the dropout rates in relation to the school transfer ratings.

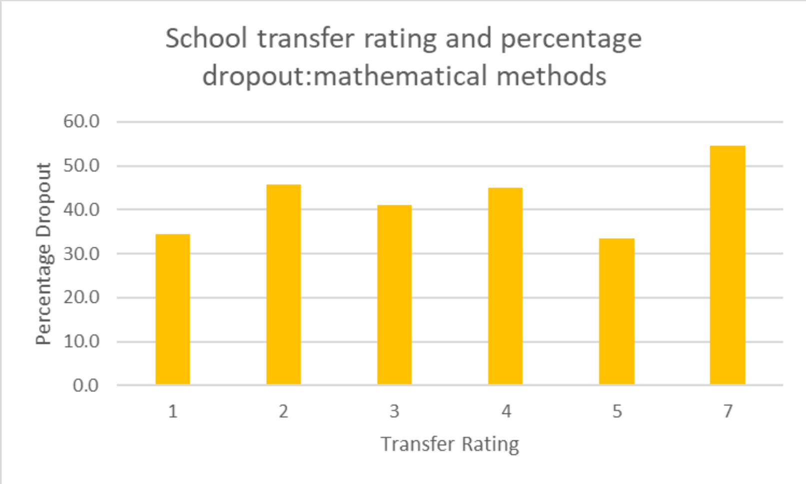

Figure 2: Dropout rates and school transfer ratings

Fewer students in schools with transfer rating above 1 choose to do Specialist Mathematics. Out of 156 schools with students studying the subject, only 61 have a transfer rating of 2 and above. In addition, only some schools with transfer ratings from 1 to 5 have students who enrolled in Specialist Mathematics as shown in Figure 3.

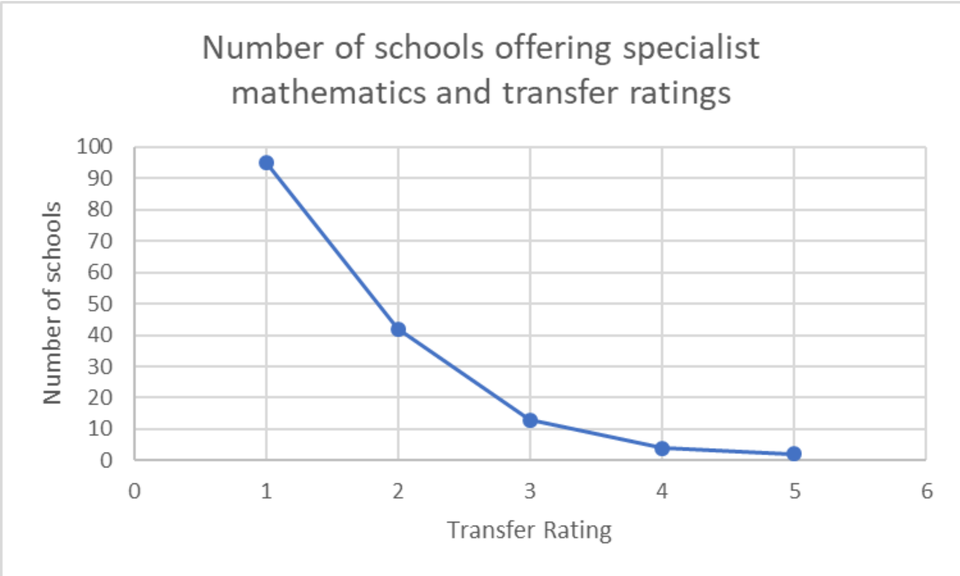

Figure 3: Schools offering Specialist Mathematics and school transfer ratings

Discussion

Education systems all over the world aim to support and nurture students to reach their goals when they have chosen a career path, hence minimising dropout rates in calculus-based mathematics is fundamental. Undoubtedly, dropping out has "considerable social and economic implications," (Goss & Andren, 2014), especially considering the importance of calculus-based mathematics as a key enabler of STEM courses at tertiary institutions (Maltas & Prescott, 2014). Participation in calculus-based mathematics in all districts showed a high dropout rate. In fact, for Mathematical Methods (about equivalent to Mathematics B previously offered), the dropout rate in state schools of 37.6% from 2019 to 2020 is 10 times the average dropout rate of 3.77% of all Queensland secondary schools from 2010 to 2019 (Chinofunga et al., 2022). Similarly, in Specialist Mathematics (about equivalent to Mathematics C previously offered), the dropout rate of 25.3% from 2019 to 2020 is more than ten times the average dropout rate of 2.35% of all secondary schools in the state (Chinofunga et al., 2022). The substantial increase in student dropout rates from calculus-based mathematics from 2019 to 2020 is alarming for these students who initially showed interest and opted studying these subjects and found it hard to continue pursuing them.

Importantly, students who dropout from calculus-based mathematics options are not the same as students who choose to avoid the options at senior secondary school (Hine & Mathematics Education Research Group of Australasia, 2017). These are students with an initial genuine interest in calculus-based mathematics options as they think about and prepare for these options in Year 10 and then enrol in Year 11. If we are to increase the number of students participating in calculus-based mathematics, then the focus should be on retaining the students who dropout. Disrupting this trend would reverse the enrolment and participation numbers in these subjects which have been highlighted as tumbling across Australia (Kennedy et al., 2014; Maltas & Prescott, 2014). Teachers as facilitators of learning can help to retain these students through effective planning and teaching. Calculus-based mathematics teachers' planning must focus on enhancing students' confidence and relationship with their chosen subject options (Grundén, 2020), through providing a coherent and spiral sequencing of mathematical concepts that are anchored on student's prior knowledge and interest to enhance student participation and achievement (ACARA, 2015). Moreover, effective mathematics teaching must enhance the connection of prior knowledge to new knowledge, build, interconnect and expand knowledge and skills from familiar to unfamiliar contexts (Novak, 2010; Stoll et al., 2012). Such an approach is likely to arrest the dropping participation in calculus-based mathematics subjects. This approach might call for new and innovative research focused on enhancing mathematics content sequencing and ways of promoting mathematics knowledge development at all levels in the school curriculum to stop the decline in participation in calculus-based mathematics.

The economic advantage or disadvantage of a school location and students who attend a school can be determined by the SEIFA index and ICSEA value. Considering the initial uptake of Mathematical Methods, Brisbane Central district has the highest enrolment. Importantly, all 10 schools in this district have a SEIFA value of more than 92 and an ICSEA value of more than 1000, demonstrating a high economic advantage enjoyed by the student population. Although it is a district with the least number of schools, it has the highest number of students who participate in calculus-based mathematics in Queensland. Similarly, the Brisbane North district has 10 school locations out of 20 with a SEIFA value of more than 80 and 5 schools with ICSEA value of more than 1000 and it has the second highest enrolment. Contrastingly, from the Mackay district the highest SEIFA value of a school location is 74 and there are only 4 out of 12 schools in areas with values above 50.

There are no schools with ICSEA value of more than 1000. Likewise, 6 school locations out of 13 in the Rockhampton district have a SEIFA value of more than 50 but less than 72 and there are no schools with an ICSEA value of 1000 and above. The Wide Bay district has 17 schools offering Mathematical Methods and there is no school location with a SEIFA value above 50 and ICSEA of 1000 and above. In addition, Townsville and Toowoomba districts have only up to two schools in the top SEIFA index or ICSEA value band with the rest below average. It can be observed that all these districts have low enrolments and a substantial difference between the number of schools offering Mathematical Methods and Specialist Mathematics. This means that potential students who have the interest and capability to participate and achieve well in the calculus-based mathematics subject do not have the option of enrolling in these subjects.

A proactive research agenda that supports teachers who teach in low SES areas and less desired schools in relation to the teacher mobility and school transfer ratings must not be limited to financial rewards. The focus should be on planning and pedagogical resources that build a foundation that promotes knowledge and skills development and facilitates independent learning. As argued by some researchers, it is "more meaningful to study what educators can work with to improve students' participation and achievement" (Valero et al., 2015, p. 288). Thus, proactive research that focuses on planning and developing such pedagogical resources should be a priority. These pedagogical resources would need to include multiple representations including visuals as they are easy for students to follow and understand (Raiyn, 2016). This proactive approach may also assist in promoting self-directed learning in students. Importantly, a common framework that can be used by teachers in such schools will help to bring stability in students' learning because it would provide uniformity in concept development and critical delivery resources.

The economic advantage or disadvantage of a school location can be determined by the SEIFA value. Data analysis shows that schools in the top half of SEIFA indexes of 50 and above contribute more than 60% of all students who enrol in calculus-based mathematics despite being less than half of all state schools in Queensland. This is because, school location and the economic advantage significantly influences the knowledge, skills, experiences and other forms of capital students gain (Ireneusz, 2020). The experience may build high expectations from such schools and also parents and students the schools serve (Pritchett, 2001). Resources offered by schools differ mainly because of SES location (Broer et al., 2019). Considering schools in the top half of SEIFA indexes of 50 and above, data analysis shows that the dropout rate is less than the lower half which reinforces the high expectations schools in such locations foster. It is particularly important to pay special attention to schools with lower ICSEA values. The ICSEA value of a school provides a clearer indication of the economic advantage and disadvantage of students enrolled in that school. The relationship between the average dropout rate and a school's ICSEA value supports Perry and McConney's (2013) findings that schools with highly economically advantaged students are strongly associated with high academic expectations and are competitive, compared to schools with economic disadvantage. Thus, the high expectations and competition in schools with high ICSEA values have a substantial influence on students to continue with the subjects.

One of the most critical resource in any school is teachers. Teachers are attracted to different schools based on a range of considerations. School location and resources are key in attracting and retaining teachers which is why schools' transfer ratings are mainly based on these factors. The majority of students, almost 70% of Mathematical Methods cohort, are in the schools that have a transfer rating of 1 and have minimal teacher turnover. This creates stable and predictable school environments. These schools with transfer ratings of 1 have a significantly less dropout rate than schools with transfer ratings above 1. Similarly, the trend is also witnessed in Specialist Mathematics where enrolment is also biased towards schools with ratings of 1, even if they are a smaller number of schools than those with transfer ratings above 1. Barbieri and colleagues (2011) concluded that teachers in schools with high transfer ratings might not have long term plans of teaching in those schools hence they might be less committed and wait for an opportunity to leave. This creates less stable and predictable school environments.

Similarly, the COVID-19 pandemic impacted education systems in different ways across the world. As a result, it might also have affected students physically and psychologically, and might have influenced to some extent the results obtained in this study. However, Queensland experienced minimum disruptions in 2019 and 2020 and the dropout rate is much higher in 2019 before COVID-19 than in 2020. A total of 3117 students had dropped out by the end of 2019, a year the state did not experience lockdowns or restrictions. Likewise, the introduction of external examinations, which contributed towards 50% of the overall calculus based subject result, might also have had an impact on students' confidence and thus their participation.

Conclusion

This paper investigated senior secondary students enrolled to participate in calculus-based mathematics subjects between 2019 and 2020 in Queensland state schools from different socio-economic districts. The QCAA data which included subjects, unit enrolments, school postcodes and districts was matched to SEIFA index (ABS), ICSEA value (ACARA) and transfer points (DoE). The overall high dropout rate in the new calculus-based mathematics subjects is a concern as students who initially choose to study calculus-based mathematics choose not to continue. Consequently, the state is losing a large number of students who could have pursued opportunities that are deemed to be jobs of the future. Socioeconomic factors, school location and transfer rating play a significant role in students' participation in calculus-based mathematics and dropout rates. Indeed, the results show that schools in low socioeconomic locations, enrol students from low SES backgrounds and have high transfer ratings have a low uptake in calculus-based options and high dropout rates. Further research is recommended to identify proactive strategies on how mathematics teachers can improve planning and delivery so as to promote participation and achievement and retain more students in calculus-based subjects. Importantly, there is urgent need for research that focuses on developing pedagogical resources that not only builds a foundation that promotes knowledge and skills development but facilitates more independent learning for the students. Thus, minimising the impact of school location, family SES and teacher turnover.

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