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ORIGINAL ARTICLE

School location and socioeconomic status and patterns of participation and achievement in senior secondary mathematics

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Abstract
In many countries, there is pressure for schools to increase student engagement and skills in mathematics, in particular for disadvantaged students. This is certainly true in Australia. This study repurposes school level data to examine patterns of participation and achievement in senior secondary school mathematics in Victoria, Australia. It confirms that school socioeconomic status (SES) is strongly tied to participation and achievement in these subjects, and that nonmetropolitan schools tend to perform more poorly than metropolitan schools in these areas. It shows that nonmetropolitan schools are less likely to offer advanced mathematics subjects than metropolitan schools, and where they do, their students are less likely to choose those options. This study also reveals that correlations between mathematics performance and SES are far weaker in the nonmetropolitan school population than the metropolitan school population. This suggests that a nonmetropolitan location has a moderating effect on the impact of SES, pointing the way for potentially fruitful lines of future inquiry.

Keywords Mathematics · Achievement · Engagement · Equity · Disadvantage · Rural · Socioeconomic status

Introduction

In an increasingly technocentric world, it is argued that deep understanding of mathematics is a critical right for all, and there is a need to equip citizens with increasingly sophisticated mathematical skills (Center for Curriculum Redesign 2013). The rise of the Science, Technology, Education and Mathematics (STEM) movement over the past

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decade has seen mathematics positioned as the essential foundation underpinning all aspects of STEM and contributing to the betterment of society (Office of the Chief Scientist 2013). STEM is seen as important for ensuring national security, economic growth, food and water supply and sustainable resource management, all in the face of a rapidly changing global environment. There is therefore a call to develop a workforce with strong STEM skills, particularly in mathematics and related fields such as data analysis, coding and engineering (Australian Industry Group 2015; Morgan and Kirby 2016).

However, as the global emphasis on mathematics has grown, achievement and participation in secondary school mathematics education in many countries have waned. The results of the Programme for International Student Assessment (PISA) revealed that 13 nations showed a significant decline in mathematics literacy from 2003 to 2015 while only six countries showed significant improvement (Thomson et al. 2017a). These results, as well as poor participation rates in senior mathematics and other STEM studies, have fuelled significant concerns in many English-speaking countries (Marginson et al. 2013). Further, significant equity issues are noted internationally in mathematics engagement and performance. On average, students from lower socioeconomic backgrounds report lower self-efficacy in mathematics the world over, and that self-efficacy correlates strongly with mathematical achievement (OECD 2013). The Trends in Mathematics and Science Study (TIMSS) shows that internationally, students attending schools with students from higher socioeconomic backgrounds had higher mathematics achievement (Mullis et al. 2013).The impact of socioeconomic status (SES) on mathematics achievement internationally is also reflected in PISA data (Kalaycioglu 2015).

Australia is one of the nations experiencing a decline in mathematics achievement and participation. Since 2003, the PISA reveals a downward trend in the mathematical literacy of Australian 15-year-olds, both relative to other nations and in absolute terms (Thomson et al. 2017a). Moreover, McPhan et al. (2008) point to a worrying trend of senior secondary students turning away from higher-level mathematics subjects, preferring instead to study the more basic mathematics courses. Australia also shows differences in the mathematical performance of students from families of different SES. PISA testing suggests that in Australia the difference between the average mathematical literacy scores of students from each SES quartiles is the equivalent of approximately 1 year of schooling (Thomson et al. 2017a). A further equity issue apparent in Australia is disparity in mathematical achievement of students from different locations. PISA testing suggests that on average Australian students from metropolitan areas outperform students from nonmetropolitan areas by a year or more.

The present study sought to determine if similar patterns of inequity are seen in the participation and achievement of senior secondary students in mathematics in government secondary schools in Victoria, Australia. Further, it sought to explore any interactive effect of SES and location on mathematics participation and achievement. This study was part of a wider research programme repurposing enrolment and assessment data routinely collected from all government secondary schools offering the Victorian Certificate of Education (VCE) to measure the success of schools in various aspects of STEM education. Murphy (in press) presents findings from this programme as they relate to senior Science education. This paper focuses on mathematics education and addresses three research questions:

1. What is the relationship between school SES (the status of families sending children to the school) and student participation and achievement in senior secondary mathematics?
2. What is the relationship between the location of a school (metropolitan or non-metropolitan) and student participation and achievement in senior secondary mathematics?
3. Is there an interactive effect of socioeconomic status and location on student participation and achievement in senior secondary mathematics?

Literature review

This study positions both senior school participation rates and academic achievement as measures of an Australian school's success in mathematics education. It then considers the impact of two contextual factors that research suggests impacts these metrics: school SES, and school location.

Mathematics achievement and participation

Both international and national testing raise concerns about the mathematical literacy of Australian students. The TIMSS shows that Australian year 8 students' achievement in mathematics did not improve significantly from 1995 to 2015 (Thomson et al. 2017b). In contrast, of the 16 other countries with TIMSS data for the same period, nine showed significant improvement in mathematics achievement, four (including Australia) showed no improvement and three showed decreases. PISA mathematical literacy testing describes a similarly worrying story. In 2003, Australian year 9 students scored an average of 524 points in mathematical literacy performance, 25 points above the OECD average; however, in 2015 this score had shrunk to 494, only four points ahead of the OECD average (Thomson et al. 2017a). Australia's own National Assessment Program—Literacy and Numeracy (NAPLAN) also suggests a stagnation in the numeracy performance of Australian secondary school students (Australian Curriculum Assessment and Reporting Authority 2017). At a time when mathematics is being internationally positioned as fundamental to innovation and development, Australian secondary students' lack of growth in mathematical ability is particularly concerning.

Parallel to the issue of achievement are problems of participation in senior mathematics. From 1995 to 2010 there was a steady decrease in the number of year 12 students enrolling in intermediate or advanced mathematics, with a concomitant increase in the numbers enrolling in elementary mathematics subjects (Office of the Chief Scientist 2012). This trend has continued well into this decade (Barrington and Evans 2016; Kennedy et al. 2014). This shift is not limited to Australia, with other countries, including the USA, experiencing similar changes in participation in senior secondary mathematics (Marginson et al. 2013). McPhan et al. (2008) explored the reasons behind this shift in participation, suggesting that student experience in junior secondary mathematics, student self-efficacy in mathematics and student knowledge of careers involving advanced mathematics are among the most significant influences on student uptake of senior school mathematics. Further, research demonstrates that student engagement with mathematics deteriorates significantly in early secondary school

(Attard 2013; Plenty and Heubeck 2011). Combined, this suggests that secondary schools have the opportunity and potential to address this concerning shift in participation in senior mathematics.

SES and mathematics

The 2015 PISA testing showed year 9 students from the highest SES quartile were on average 3 years ahead of those from the lowest SES quartile (Thomson, De Bortoli, et al. 2017). The TIMSS uses several indicators of SES, including the number of books in the home, the education resources in the home and the educational level of parents, and found that all three correlated strongly with achievement (Thomson et al. 2017a). A similar association between SES and achievement was revealed through the National Assessment Programme's (NAP) numeracy testing. Year 9 students achieve better in numeracy testing if their parents have higher levels of education and if their parents work in higher occupation levels (Australian Curriculum Assessment and Reporting Authority 2017). These findings reflect the relationship between SES and mathematics achievement that has been well-researched internationally (Grootenboer and Hemmings 2007; Kalaycioglu 2015; Rothman 2003; Weber et al. 2010).

Not only does SES correlates with achievement, it also impacts on student participation in mathematics. As parental education and occupation levels increase, so does the number of students enrolling in advanced mathematics courses (McPhan et al. 2008). Studies shed some light on why SES may have this impact by considering engagement with mathematics in the early years of secondary schooling. TIMSS attitudinal surveying shows that by year 8, lower SES students report not liking learning mathematics in significantly higher proportions than other students. PISA measurements of student motivation to learn and succeed in mathematics suggest that year 9 students from high SES backgrounds were far more motivated to achieve in mathematics than other students. Martin et al. (2015) suggest that students from lower SES schools are more likely to self-handicap, become disengaged and to have reduced class participation in mathematics.

Location and mathematics

International and national testing also suggests that school location correlates with mathematics achievement in Australia. The TIMSS demonstrates that metropolitan year 8 students significantly outperform students from provincial schools who, in turn, outperform students from remote areas (Thomson et al. 2017b). PISA testing shows metropolitan year 9 students' mathematical literacy is significantly higher than the OECD average and nonmetropolitan year 9 students' is significantly lower, with the gap between the two being the equivalent of more than a year of learning (Thomson et al. 2017a). This pattern is also borne out by national numeracy testing (Australian Curriculum Assessment and Reporting Authority 2017).

This author was unable to locate studies comparing participation rates in mathematics by remoteness. The link between mathematics engagement and school remoteness has been explored but this does not suggest a definitive relationship. PISA testing shows that relationship between motivation and remoteness is not linear, suggesting that rural students have the highest motivation to learn mathematics, followed by metropolitan students, with provincial students testing as having the lowest motivation (Thomson et al. 2013). Hardre (2011) reviews the scant international research into student motivation in mathematics in rural schools and presents conflicting evidence, with some studies suggesting high motivation in mathematics in rural settings, while other studies found low motivation.

Method

This paper presents analyses of patterns of participation and achievement in mathematics subjects offered within the VCE. The VCE is designed to be completed over 2 years, and is made up of semester long units of study, with unit 1 and unit 2 studies benchmarked at a year 11 level and unit 3 and unit 4 studies benchmarked at a year 12 level (Victorian Curriculum and Assessment Authority 2017). Students are awarded the VCE after completing a minimum of 16 units, including three English units and three unit 3–4 sequences in addition to English. However, students typically complete more units than this, with most schools encouraging students to take 12 units at year 11 level and 10 units at year 12 level. Year 11 level units are assessed only as satisfactory or unsatisfactory. Year 12 level units allow students to earn a study score by completing a combination of school-based and external assessments, for year 12 level units. These study scores are used to determine a student's Australian Tertiary Admission Rank (ATAR) which Australian tertiary institutions use as a key element of their candidate selection process for most of their courses.

Studying mathematics is not compulsory to earn a VCE. There are several mathematics subjects on offer in the VCE and students may elect to take none, one, or more of these (Victorian Curriculum and Assessment Authority 2016). Foundation Mathematics units 1 and 2 are for students not intending to study mathematics at a year 12 level. General Mathematics units 1 and 2 and Further Mathematics units 3 and 4 are designed to be widely accessible. Both of these involve the study of non-calculus-based topics such as geometry, statistics and algebra. Mathematical Methods units 1–4 involve more advanced mathematics, including the study of calculus, probability and statistics. Specialist Mathematics units 1–4 are the most advanced mathematics subjects offered in the VCE. They are designed to be taken in conjunction with Mathematical Methods, extending its content to look at topics such as complex numbers, vectors and statistical inference. Expected pathways of mathematical units that students may study are shown in Table 1. While many university courses recommend that students complete a mathematics subject at year 12 level, only Mathematical Methods Unit 3–4 and Specialist Mathematics units 3–4 are ever listed explicitly by any Victorian tertiary institution as a possible prerequisite for entry into any of their courses (Victorian Tertiary Admissions Centre 2016). In this paper, these two mathematics subjects are discussed as the 'enabling mathematics subjects'.

Study data

Location and demographic information, VCE mathematics enrolment numbers and median study scores in mathematics subjects were obtained for every Victorian government school offering a VCE program from 2014 to 2016 ($N = 286$). This school

Table 1 Expected pathways of VCE mathematics units

Year 11 level (units 1 and 2)		Year 12 level (units 3 and 4)
Foundation Mathematics		
Foundation Mathematics plus supplementary study; or	leads to	Further Mathematics
General Mathematics		
Mathematical Methods; or	leads to	Mathematical Methods and/or Further Mathematics
General Mathematics and Mathematical Methods		
Mathematical Methods plus supplementary study; or	leads to	Mathematical Methods and Specialist Mathematics
Mathematical Methods and General Mathematics; or		
Mathematical Methods and Specialist Mathematics		

level data is routinely collected by the Victorian Department of Education and Training (DET) and was shared with the author in a de-identified form. Sampling across these three recent years mitigates against cohort effects, while also producing contemporary baseline findings on which to base future comparisons. Cohort effects are especially likely in rural schools with small numbers of students completing the VCE.

Outcome variables

Schools from different locations and serving communities of different socioeconomic status were compared using three outcome variables: subjects provided, enrolment proportion and achievement level.

Subjects provided

The Subjects Provided variable tracks which of the four year 11 and three year 12 mathematics subjects any particular school had students studying across 3 years (2014–2016).

Enrolment proportions

Enrolment proportions for each mathematics subject were calculated for each school delivering that subject by dividing the number of enrolments in a particular mathematics unit by the total number of VCE enrolments at that particular level and then averaging this result across the three years (2014–2016). It should be noted that it is likely that some students may have enrolled in more than one mathematics subject; however, there is no way to identify this in the data used for this analysis.

Achievement levels

Study scores are only available for the year 12 subjects so achievement levels were calculated only for each year 12 subject. They were calculated for each school running a particular subject in all three years (2014, 2015 and 2016) by averaging the median school year 12 study score from each of the three years. Study scores have been standardised by the VCAA to allow them to be compared from school to school and year to year. This is done by first ranking each student's performance against all others in that subject in that year. Students are then allocated study scores according to their rank so that the distribution of scores is normalised, with a maximum of 50, a set mean of 30 and standard deviation of 7 (Victorian Curriculum and Assessment Authority 2017).

Explanatory variables

Two explanatory variables are considered in this study: student family occupation and education index (SFOE) and school location.

Student family occupation and education index

Student family occupation and education index (SFOE) is calculated for each school by DET using both parental education levels and occupation categories as recorded in school enrolment details. SFOE is a measure of socioeconomic disadvantage, where the higher the SFOE, the lower the SES, and the greater the disadvantage of families at the school (Department of Education and Training 2016). In some analyses, the SFOE is analysed in quartiles, with the first SFOE quartile including the highest SES schools and the fourth SFOE quartile the lowest SES schools.

School location

Schools were categorised as either metropolitan ($N = 164$), if located in a local government area (LGA) within the Greater Melbourne area, or nonmetropolitan ($N = 122$), if located in a LGA in any other region in Victoria (Victorian Government 2017). This coarse granularity of location categories was a limitation of the de-identified data used in this study. Consequently, schools classified as nonmetropolitan include schools in regional cities as well as rural and remote locations.

The distribution of schools by SFOE and school location is shown in Table 2.

Analysis

As this study used data from the entire population of interest, sampling error was not a risk and therefore calculations of statistical significance were not required. The focus was on the practical significance of the statistics only (Cohen et al. 2011).

Table 2 Distribution of schools by SFOE and school location

	SFOE				
School location	Quartile 1	Quartile 2	Quartile 3	Quartile 4	Total
Metropolitan schools	61	28	29	46	164
Nonmetropolitan schools	11	43	43	25	122
Total	72	71	72	71	286

Descriptive statistics were used to summarise patterns of participation and achievement in mathematics subjects across location and SES categories. The proportions of schools providing the different mathematics subjects, and the means and ranges of enrolment proportions, and the achievement levels in the year 12 subjects, were compared by school location and SFOE quartile. The relationships between both enrolment proportions, achievement level, and SFOE were further investigated using Spearman's rho correlation coefficients. Coefficients were calculated for all schools, for metropolitan schools and for nonmetropolitan schools respectively to examine differences in these relationships based on location.

Results

VCE mathematics subjects provided

Table 3 shows that almost all schools provided General Mathematics and Mathematical Methods at year 11 level, and Further Mathematics and Mathematical Methods at year 12 level, independent of location. It shows that nonmetropolitan schools were slightly more likely than metropolitan schools to run year 11 Foundation Mathematics, but far less likely to run year 11 or year 12 Specialist Mathematics.

Table 4 shows the lowest SES schools were more likely to offer year 11 Foundation Mathematics than the highest SES schools. The inverse is true for Specialist Mathematics, with the highest SES schools running this subject in far higher proportions than the lowest SES schools at both year 11 and 12 levels.

Enrolment proportions

Table 5 shows that the enrolment proportion for each of the VCE mathematics subjects varies with location. Enrolment proportions are only calculated using data from schools providing each subject. Table 5 shows the enrolment proportion for the year 11 level subjects of Foundation Mathematics and General Mathematics is slightly higher in nonmetropolitan schools compared to metropolitan schools. It also shows that

Table 3 Proportion of schools providing VCE mathematics subjects by location (2014–2016)

	Metropolitan schools ($N = 164$)	Non-metropolitan schools ($N = 122$)
Year 11 Foundation Mathematics	53%–59%	57%–62%
Year 11 General Mathematics	98%–99%	99%–100%
Year 12 Further Mathematics	96%–98%	98%–99%
Year 11 Mathematical Methods	97%–100%	96%–98%
Year 12 Mathematical Methods	95%–98%	89%–93%
Year 11 Specialist Mathematics[a]	63%	34%
Year 12 Specialist Mathematics	73%–80%	51%–53%

[a] Year 11 Specialist Mathematics was only offered in 2016

Table 4 Proportion of schools providing VCE mathematics subjects by SFOE quartile (2014–2016)

	1st quartile SFOE schools (highest SES) ($N=72$)	2nd quartile SFOE schools ($N=71$)	3rd quartile SFOE schools ($N=72$)	4th quartile SFOE schools (lowest SES) ($N=71$)
Year 11 Foundation Mathematics	43%–47%	56%–68%	54%–56%	66%–70%
Year 11 General Mathematics	99%–100%	99%–100%	99%–100%	99%–100%
Year 12 Further Mathematics	99%–100%	99%–100%	96%–97%	97%–97%
Year 11 Mathematical Methods	99%–100%	97%–100%	94%–99%	96%–97%
Year 12 Mathematical Methods	96%–99%	92%–97%	88%–93%	92%–96%
Year 11 Specialist Mathematics[a]	72%	54%	38%	39%
Year 12 Specialist Mathematics	85%–88%	59%–72%	53%–61%	54%–56%

[a] Year 11 Specialist Mathematics was only offered in 2016

nonmetropolitan schools have a slightly higher enrolment proportion for year 12 level Further Mathematics than metropolitan schools. However, in the enabling subjects, the pattern is reversed with the enrolment proportion in year 11 Mathematical Methods being greater in metropolitan schools than nonmetropolitan schools. This gap widens further for year 12 Mathematical Methods. The enrolment proportion in the recently introduced year 11 Specialist Mathematics is greater in metropolitan schools than nonmetropolitan schools. This gap widens for year 12 Specialist Mathematics.

Table 6 shows that the enrolment proportion for each of the VCE mathematics subjects varies with SES. The proportion of enrolments for year 11 General Mathematics and year 12 Foundation Mathematics are slightly lower in the highest SES schools (1st SFOE quartile) compared to all other schools. However, the enrolment proportion for year 11 Foundation Mathematics in the lowest SES schools in nearly twice that of the enrolment proportion in the highest SES schools. This trend is reversed for the uptake of Mathematical Methods and Specialist Mathematics. The highest SES schools have greater enrolment proportions in all both enabling mathematics studies at year 11 and year 12 levels, compared to the lower SES schools.

The relationship between SFOE and enrolment proportions was investigated by calculating Spearman's rho correlation coefficients for each subject across all schools, metropolitan schools and nonmetropolitan schools. It should be noted, as SFOE is a measure of disadvantage a negative correlation indicates a positive relationship

Table 5 Enrolments in VCE mathematics subjects as a proportion of all VCE subject enrolments by school location

	All schools	Metropolitan schools	Nonmetropolitan schools
	Mean (range)	Mean (range)	Mean (range)
Year 11 Foundation Mathematics	0.028 (0.000–0.112)	0.027 (0.000–0.112)	0.030 (0.000–0.083)
Year 11 General Mathematics	0.106 (0.005–0.196)	0.100 (0.005–0.177)	0.115 (0.058–0.196)
Year 12 Further Mathematics	0.122 (0.008–0.200)	0.114 (0.008–0.171)	0.133 (0.071–0.200)
Year 11 Mathematical Methods	0.051 (0.004–0.172)	0.057 (0.007–0.172)	0.045 (0.004–0.103)
Year 12 Mathematical Methods	0.045 (0.004–0.155)	0.051 (0.004–0.155)	0.037 (0.004–0.103)
Year 11 Specialist Mathematics	0.007 (0.000–0.037)	0.008 (0.000–0.037)	0.005 (0.001–0.026)
Year 12 Specialist Mathematics	0.014 (0.001–0.075)	0.017 (0.001–0.075)	0.010 (0.001–0.028)

between SES and enrolment proportions. As can be seen in Table 7, there is a weak positive correlation between SFOE and enrolment proportions in year 11 Foundation Mathematics ($\rho = 0.24$), and a moderate positive correlation in year 12 Further Mathematics ($\rho = 0.34$). However, there is a moderate negative correlation between SFOE

Table 6 Enrolments in VCE mathematics subjects as a proportion of all VCE subject enrolments by SFOE quartile

	1st quartile SFOE schools (highest SES)	2nd quartile SFOE schools	3rd quartile SFOE schools	4th quartile SFOE schools (lowest SES)
	mean (ange)	mean (range)	mean (range)	mean (range)
Year 11 Foundation Mathematics	0.018 (0–0.062)	0.028 (0–0.058)	0.029 (0.001–0.112)	0.035 (0–0.086)
Year 11 General Mathematics	0.095 (0.047–0.158)	0.108 (0.005–0.180)	0.114 (0.051–0.171)	0.109 (0.020–0.196)
Year 12 Further Mathematics	0.103 (0.026–0.169)	0.127 (0.008–0.200)	0.133 (0.086–0.191)	0.125 (0.039–0.181)
Year 11 Mathematical Methods	0.074 (0.012–0.172)	0.049 (0.007–0.090)	0.042 (0.017–0.096)	0.041 (0.004–0.092)
Year 12 Mathematical Methods	0.064 (0.012–0.155)	0.040 (0.004–0.098)	0.037 (0.004–0.103)	0.039 (0.006–0.094)
Year 11 Specialist Mathematics	0.010 (0.001–0.037)	0.005 (0.001–0.013)	0.006 (0–0.026)	0.005 (0.001–0.017)
Year 12 Specialist Mathematics	0.022 (0.001–0.075)	0.011 (0.002–0.030)	0.009 (0.001–0.024)	0.014 (0.002–0.055)

Table 7 Spearman's rho correlation coefficients for SFOE and VCE mathematics subject enrolment proportions by all schools, metropolitan schools and nonmetropolitan schools

	All schools rho (*N*)	Metropolitan schools rho (*N*)	Nonmetropolitan schools rho (*N*)
Year 11 Foundation Mathematics	0.24 (204)	0.24 (113)	0.22 (91)
Year 11 General Mathematics	0.19 (286)	0.28 (164)	0.01 (122)
Year 12 Further Mathematics	0.34 (284)	0.50 (162)	0.02 (122)
Year 11 Mathematical Methods	− 0.47 (285)	− 0.51 (164)	− 0.43 (121)
Year 12 Mathematical Methods	− 0.36 (280)	− 0.40 (162)	− 0.26 (118)
Year 11 Specialist Mathematics	− 0.38 (145)	− 0.47 (103)	0.02 (42)
Year 12 Specialist Mathematics	− 0.29 (227)	− 0.33 (141)	− 0.08 (86)

and enrolment proportions across all schools in year 11 Mathematical Methods ($\rho = -0.47$), a weaker moderate negative correlation in year 11 Specialist Mathematics ($\rho = -0.38$) and year 12 Mathematical Methods ($\rho = -0.36$) and a weak negative correlation in year 12 Specialist Mathematics ($\rho = -0.29$). However, when calculating coefficients using data from only metropolitan schools, the strength of all of these correlations increases. Conversely, in nonmetropolitan schools, these correlations weaken significantly, with most becoming negligible.

Achievement level

Table 8 shows that achievement levels in each of the VCE mathematics subjects varies with location. Metropolitan schools outperform nonmetropolitan schools in all three year 12 VCE mathematics subjects. Metropolitan schools' average (mean) study scores are 0.83, 1.67 and 1.82 points higher than that of nonmetropolitan schools' in Further Mathematics, Mathematical Methods and Specialist Mathematics respectively. This table also flags a further equity issue. As the mean for each VCE subject is fixed at 30 and the means reported in this table are well below this, it points to the disparity of average achievement of students attending government schools compared to those enrolled at independent schools.

Table 8 Comparison of schools' median achievement levels in VCE year 12 mathematics subjects, where results were available for 2014, 2015 and 2016, by location

	All schools		Metropolitan schools		Nonmetropolitan schools	
	N	Mean (range)	*N*	Mean (range)	*N*	Mean (range)
Further Mathematics	222	27.97 (18.36–41.21)	139	28.52 (19.60–41.21)	83	27.06 (18.36–32.33)
Mathematical Methods	221	26.57 (16.96–37.32)	139	27.19 (18.44–37.32)	82	25.52 (16.96–33.09)
Specialist Mathematics	222	26.66 (17.00–46.00)	139	27.34 (17.08–46.00)	83	25.52 (17.00–37.00)

Table 9 Comparison of schools' achievement levels in VCE year 12 mathematics subjects, where results were available for 2014, 2015 and 2016, by SFOE quartile

	1st quartile SFOE schools (highest SES)		2nd quartile SFOE schools		3rd quartile SFOE schools		4th quartile SFOE schools (lowest SES)	
	N	Mean (range)	*N*	Mean (range)	*N*	Mean (range)	*N*	Mean (range)
Further Mathematics	68	30.264 (23.00–41.21)	54	27.73 (21.11–32.33)	53	27.12 (18.36–31.99)	47	25.88 (19.50–35.67)
Mathematical Methods	68	28.75 (18.80–37.32)	54	26.36 (21.21–33.09)	52	25.59 (16.96–32.34)	47	24.74 (18.44–31.00)
Specialist Mathematics	68	28.32 (17.00–36.31)	54	26.14 (17.71–33.00)	53	26.73 (18.00–46.00)	47	24.78 (17.08–35.00)

Table 9 also shows that achievement levels in each of the VCE mathematics subjects also varies with SFOE. Year 12 VCE mathematics performance decreases across the SFOE quartiles in all three subjects. In Further Mathematics, Mathematical Methods and Specialist Mathematics, first quartile SFOE schools' average study scores are 4.52, 4.55 and 3.54 points higher than that of fourth quartile schools in these subjects respectively.

The relationship between SFOE and achievement level was investigated by calculating Spearman's rho correlation coefficients for each subject, across all schools, metropolitan schools and nonmetropolitan schools respectively. Again, note that as SFOE is a measure of disadvantage, a negative correlation indicates a positive relationship between SES and enrolment proportions. As can be seen in Table 10, there is a moderate negative correlation between SFOE and achievement across all schools in Further Mathematics ($\rho = -0.496$) and Mathematical Methods ($\rho = -0.482$), and a weaker moderate negative correlation in Specialist Mathematics ($\rho = -0.390$). However, when calculating coefficients using data from only metropolitan schools, the strength of these correlations increases, with strong negative correlations observed between SFOE and achievement in Further Mathematics ($\rho = -0.611$) and Mathematical Methods ($\rho = -0.613$), and a moderate negative correlation in Specialist Mathematics ($\rho = -0.453$). Conversely, in nonmetropolitan schools there is only a weak negative correlation between SFOE and achievement in Further Mathematics ($\rho = -0.255$) and Specialist Mathematics ($\rho = -0.242$), and a negligible correlation in Mathematical Methods ($\rho = -0.193$).

Table 10 Spearman's rho correlation coefficients for SFOE and VCE Year 12 mathematics subject achievement levels for all schools, metropolitan schools and nonmetropolitan schools

	All schools rho (*N*)	Metropolitan schools rho (*N*)	Nonmetropolitan schools rho (*N*)
Year 12 Further Mathematics	− 0.496 (284)	− 0.611 (162)	− 0.255 (122)
Year 12 Mathematical Methods	− 0.482 (280)	− 0.613 (162)	− 0.193 (118)
Year 12 Specialist Mathematics	− 0.390 (226)	− 0.453 (141)	− 0.242 (85)

Discussion

This study set out to explore the impact of school SES and school location on participation and achievement in VCE mathematics subjects in Victorian government schools. To do this, it used de-identified data from all Victorian government secondary schools offering a VCE mathematics subject across the three years of 2014, 2015 and 2016. Three outcome variables were examined: the VCE mathematics subjects provided by each school, each school's proportional enrolments in each mathematics subject (as a proportion of all VCE subject enrolments) and the average achievement levels of students completing VCE mathematics subjects at year 12 level in each school.

Some findings from this study demonstrated the patterns of participation and achievement in mathematics in the Victorian government sector are consistent with the literature. On average, students from lower SES schools were less likely to have access to higher level mathematics subjects, were less likely to enrol in these subjects and achieved less well in these subjects, compared with students attending higher SES schools. Students from lower SES schools were more likely to enrol in the less challenging VCE mathematics subjects, however they still achieved less well than their high SES counterparts. Rothman (2003) noted similar findings, suggesting significant effects of SES between schools on numeracy achievement. Metropolitan schools achieved better results on average than schools outside the greater Melbourne metropolitan area, mirroring the findings of previous studies of geographic location on the mathematical literacy of secondary school students (Australian Curriculum Assessment and Reporting Authority 2017; Thomson et al. 2017b).

Other findings contribute new knowledge to the field. This study found that students in nonmetropolitan schools were more likely than metropolitan students to enrol in foundational mathematics subjects at years 11 and 12. Conversely, they were less likely to have access to the enabling mathematics subjects, and where they did have access, they were less likely to enrol in those subjects.

Perhaps, more revelatory is that the current study suggests that a nonmetropolitan location has a moderating effect on the influence of school SES. As school family disadvantage increases in Metropolitan schools, participation in challenging mathematics and achievement levels in all mathematics tends to decrease. This is unsurprising given research consistently finds a negative correlation between SES and student mathematics engagement and achievement (Vale et al. 2016). However, in nonmetropolitan schools, SES in this study appeared to have little to no impact on mathematics subjects offered, the proportions of students enrolling in mathematics, or average achievement levels in mathematics. Importantly, some nonmetropolitan schools dramatically outperformed others independent of the background of their students' families. In other words, while the nonmetropolitan schools on average underperformed in relation to the metropolitan schools, their performance was varied and SES did not appear to explain that variability.

So, what are the factors independent of SES, influencing nonmetropolitan school performance in the enabling mathematics? Past research hints at possible explanations. Many researchers (Lyon et al. 2006; Marginson et al. 2013; Weldon 2016) highlight the difficulties of recruiting qualified mathematics teachers to rural and remote areas, and of providing these teachers with quality professional development. Without quality mathematics teachers, schools may not be able to offer the more advanced mathematics courses, let alone attract students to enrol in them or adequately prepare students to perform well. McPhan et al. (2008) identified student reticence to participate in composite and distance classes in rural schools as a reason why students do not take up advanced senior mathematics classes, and participating in such class formats may go some way in explaining the lower mathematics achievement levels of students in some nonmetropolitan schools. Other authors have suggested that rural students (and their parents) have lower expectations of continuing on to tertiary study (Centre for Education Statistics and Evaluation 2013), so they may be less motivated to participate and achieve in enabling mathematics subjects. However, while this research may help explain why country schools tend to perform less well in senior mathematics than their city cousins, it does not explain why some nonmetropolitan schools perform unexpectedly well.

Existing research suggests few possible explanations for this aberrant excellence in mathematics. Some research suggests that strong family-school connections and supportive relationships with school communities can positively affect the educational outcomes of rural students (Barley and Beesley 2007; Hardre 2011; Semke and Sheridan 2012). Possibly, the high-performing nonmetropolitan schools identified in the current study have been able to capitalise upon their location and perhaps smaller size to better foster such relationships. Related to this may be that some nonmetropolitan schools are better able to make use of rich local community resources afforded nonmetropolitan schools, such as agriculture, industry and the natural environment, to provide relevant contexts for mathematics learning, thus improving student engagement and achievement.

Whatever the explanation, these findings have concerning practical implications for students attending our low SES and nonmetropolitan schools. Low participation and achievement in enabling mathematics subjects mean that many students from these schools are automatically ruled out of access to some tertiary courses in engineering, computer science and biomedical science (Victorian Tertiary Admissions Centre 2016), all of which lead to careers with growing demand for workers (Australian Industry Group 2015).

This study repurposed school level data from the Victorian DET to uncover broad patterns of participation and achievement in the enabling mathematics subjects and to set a baseline for future research. As such, it does not reveal anything of the role student characteristics, such as gender, indigeneity or ethnicity, may have in moderating the relationships observed in this study, yet these variables are likely to inter-relate with the variables discussed in this paper (Thomson et al. 2017a). Further, while this study reveals relationships between school SES and location and mathematics participation and achievement, the data analysed in this study do not explain why these relationships exist.

The findings highlight the need for further research in a range of areas. It needs to be explored why lower SES schools are less likely to offer the enabling mathematics subjects. Research is also needed to understand why nonmetropolitan students are less likely to enrol in the more challenging mathematics subjects, as the current research offers no conclusive findings around remoteness and engagement (Hardre 2011). While the impact of SES and remoteness on achievement in mathematics is well described in the literature, the findings presented in this paper suggests that location has a moderating effect on the impact of SES. There needs to be more research to understand this relationship. This research also identifies an opportunity to explore why some nonmetropolitan schools perform much better than expected in mathematics education. Such investigation promises to not only provide a model for improving mathematics education in other nonmetropolitan schools, but it could also identify ways in which metropolitan schools might minimise the influence of disadvantage. Case studies should be made of high-performing nonmetropolitan schools at all SES levels, with particular focus on staffing, resourcing, community connection and student and parent expectations. This research could help identify positive school leadership and mathematics education practices for other schools to consider.

Conclusion

This research confirms that the socioeconomic status of the community a school serves impacts on participation and achievement levels in senior mathematics in Victorian secondary schools. This impact is most prominent in the more challenging mathematics subjects which are the same subjects often required for entry into tertiary courses in engineering, computer science, biomedical science and the like. As could be anticipated from previous research, nonmetropolitan schools on average underperformed in comparison to metropolitan schools in mathematics achievement. This study did however reveal that non-metropolitan students are less likely to participate in enabling mathematics subjects and are more likely to take elementary mathematics subjects, than their metropolitan counterparts. Further, this study shows that schools in nonmetropolitan locations somehow largely mitigate against the effects of SES. Importantly, this study reveals there are schools in each SES category that perform notably better than their counterparts, providing potential exemplar case studies for research aimed at addressing the inequities exposed in this paper.

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