

School location and socio-economic status and patterns of participation and achievement in Year 12 enabling mathematics

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There is national and international pressure for schools to increase student engagement and skills in more challenging mathematics, in particular for disadvantaged students. This study repurposes school level data to examine patterns of participation and achievement in advanced year 12 mathematics. It confirms that school socio-economic status (SES) is strongly tied to participation and achievement in these subjects, and that non-metropolitan schools tend to perform more poorly than metropolitan schools in these areas. However, it suggests that a non-metropolitan location mitigates against the apparent impact of SES, pointing the way for potentially fruitful lines of future inquiry.

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 all citizens with increasingly sophisticated mathematical skills (Center for Curriculum Redesign, 2013). The rise of the Science, Technology, Education and Mathematics (STEM) movement 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). There is a call to grow a workforce with strong STEM skills, particularly in mathematics and related fields such as data analysis, coding and engineering (Australian Industry Group [AIG], 2015; Office of the Chief Scientist, 2014). A necessary part of achieving this growth is addressing the under-representation of students from disadvantaged or rural backgrounds pursuing STEM career pathways. In response, Australia has set national goals to increase participation and achievement in the more challenging STEM subjects, including mathematics, with a particular focus on addressing equity issues (Education Council, 2015).

Unfortunately, as the global and national emphasis on mathematics has grown, achievement and engagement in secondary school mathematics education in Australia has waned. Since 2003, the Programme for International Student Assessment (PISA) reveals a downward trend in the mathematical literacy of Australian 15 year olds, both relative to other nations and in absolute terms (Thomson, De Bortoli, & Underwood, 2017). Moreover, McPhan, Morony, Pegg, Cooksey and Lynch (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.

At the same time, there is significant disparity in the mathematical performance of Australian students from families of different SES, and different geographic locations. PISA testing suggests that students from the highest SES quartile are on average three years ahead of students from the lowest SES quartile (Thomson, De Bortoli, & Underwood, 2017) and students from metropolitan areas outperform students from non-metropolitan areas by a year or more. Similar patterns are revealed through the National Assessment Programme's numeracy testing. (Australian Curriculum Assessment and Reporting Authority [ACARA], 2017).

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The present study explored patterns of inequity in the participation and achievement of Year 12 students in enabling mathematics in government secondary schools in Victoria, Australia. Enabling mathematics subjects are defined here as those that are explicitly identified as prerequisites for further study in tertiary mathematics or mathematics related fields. This study was part of a wider research programme repurposing 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. This paper focuses on Year 12 enabling mathematics education and addresses three research questions:

1. What is the relationship between school socio-economic status (the status of families sending children to the school) and student participation and achievement?
2. What is the relationship between the location of a school (metropolitan or non-metropolitan) and student participation and achievement? and
3. Is there an interaction effect of socio-economic status combined with location on student participation and achievement?

Method

. This paper presents analyses of patterns of participation and achievement in Year 12 enabling mathematics subjects offered within the VCE. As part of their VCE, students are required to complete a Year 12 English subject, and at least three other Year 12 subjects (Victorian Curriculum and Assessment Authority [VCAA], 2017). Typically, students complete five or six year 12 subjects. Studying mathematics is not compulsory to earn a VCE. (VCAA, 2016). While many university courses recommend that students complete a mathematics subject at Year 12 level, only Mathematical Methods and Specialist Mathematics are listed explicitly by any Victorian tertiary institution as a pre-requisite for entry into any of their courses (Victorian Tertiary Admissions Centre [VTAC], 2016) so these were categorised as enabling mathematics subjects for this study. Mathematical Methods includes the study of calculus, probability and statistics. Specialist Mathematics is designed to be taken in conjunction with Mathematical Methods, extending its content to look at topics such as complex numbers, vectors, and statistical inference

Study Data

Location and demographic information, enrolment numbers and median study scores were obtained from the Victorian Department of Education and Training (DET), for every Victorian government secondary school offering a VCE program during 2014, 2015 and 2016 (N=286). Sampling across these three recent years mitigates against cohort effects while also producing contemporary baseline findings on which to base future comparisons.

Outcome Variables

Schools from different locations and serving communities of different socio-economic status were compared using three outcome variables: Subjects Provided, Enrolment Proportion, and Achievement Level.

Subjects Provided. The Subjects Provided variable tracks which of the Year 12 enabling mathematics subjects schools had students studying across the three years.

Enrolment Proportions. Enrolment Proportions for each enabling mathematics subject were calculated for each school providing that subject by dividing the number of enrolments in a particular mathematics subject by the total number of Year 12 enrolments and then averaging this result across the three years.

Achievement Levels. Achievement Levels were calculated for each subject in each school running that subject in all three years by averaging the median school Year 12 study scores from each of the three years. These study scores are standardised by the VCAA by ranking student performance in each subject and then allocating normalised student study scores according to rank, with a maximum of 50, a set mean of 30 and standard deviation of 7 (VCAA, 2017). Given this, it is legitimate to compare study scores from school to school and year to year.

Explanatory Variables

Two explanatory variables are considered in this study: Student Family Occupation and Education Index (SFOE) and School Location.

SFOE. SFOE is the DET measure of SES (DET, 2016). SFOE is calculated for each school by DET using both parental education levels and occupation categories as recorded in school enrolment details. The higher the SFOE, the lower the SES, and the greater the disadvantage of families at the school. In some analyses the SFOE is analysed in quartiles, with the first SFOE quartile including the higher SES schools and the fourth SFOE quartile the lower 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 non-metropolitan (N=122), if located in a LGA in any other region in Victoria (Victorian Government, 2017). Consequently, schools classified as non-metropolitan include schools in regional cities as well as rural and remote locations.

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, Manion, & Morrison, 2011).

Descriptive statistics were used to summarise patterns of participation and achievement in the enabling mathematics subjects across location and SES categories. The proportions of schools providing the two enabling mathematics subjects, and the means and ranges of enrolment proportions and achievement levels 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 non-metropolitan schools respectively to examine differences in these relationships based on location.

Results

Year 12 Enabling Mathematics Subjects Provided

Tables 1 and 2 show that almost all schools, independent of location or SES, delivered Mathematical Methods during the three years. However, there is a significant difference in

the proportion of schools providing Specialist Mathematics. Metropolitan schools and high SES schools delivered Specialist Mathematics at a rate of 86% (141 out of 164 schools) and 94% (68 out of 72 schools) respectively. For non-metropolitan and low SES schools this rate dropped to 70% (86 out of 122 schools) and 66% (47 out of 71 schools) respectively.

Enrolment Proportions

Table 1 shows that the enrolment proportion for each of the VCE mathematics subjects varies with location. It shows that the enrolment proportion in Mathematical Methods is 0.051 in metropolitan schools compared to 0.037 in non-metropolitan schools. There is also a large difference in enrolment proportions in Specialist Mathematics, being 0.017 in metropolitan schools and 0.010 in non-metropolitan schools. Table 2 shows that the highest SES schools also have greater enrolment proportions compared to the lowest SES schools in Mathematical Methods (0.064 compared to 0.039 respectively) and Specialist Mathematics (0.022 compared to 0.014 respectively).

Table 1

Enrolments in VCE Mathematics Subjects as a Proportion of all VCE Subject Enrolments by School Location.

	All Schools		Metropolitan Schools (N=164)		Non-Metropolitan Schools (N=122)	
	N	Mean (Range)	N	Mean (Range)	N	Mean (Range)
Mathematical Methods	280	0.045 (0.004 – 0.155)	162	0.051 (0.004 – 0.155)	118	0.037 (0.004-0.103)
Specialist Mathematics	227	0.014 (0.001 – 0.075)	141	0.017 (0.001 – 0.075)	86	0.010 (0.001-0.028)

Table 2

Enrolments in VCE Mathematics Subjects as a Proportion of all VCE Subject Enrolments by SFOE Quartile.

	1 st Quartile SFOE Schools (Highest SES) (N=72)		2 nd Quartile SFOE Schools (N=71)		3 rd Quartile SFOE Schools (N=72)		4 th Quartile SFOE Schools (Lowest SES) (N=71)	
	N	Mean (Range)	N	Mean (Range)	N	Mean (Range)	N	Mean (Range)
Mathematical Methods	72	0.064 (0.012- 0.155)	70	0.040 (0.004- 0.098)	70	0.037 (0.004- 0.103)	68	0.039 (0.006- 0.094)
Specialist Mathematics	68	0.022 (0.001- 0.075)	55	0.011 (0.002- 0.030)	57	0.009 (0.001- 0.024)	47	0.014 (0.002- 0.055)

As can be seen in Table 3, there is a weak negative correlation between enrolment proportions and SFOE in both the enabling mathematics. However, when calculating

coefficients using data from only metropolitan schools, the strength of these correlations increases. Conversely, in non-metropolitan schools, these correlations become negligible.

Table 3

Spearman's rho correlation coefficients for SFOE and Year 12 Mathematics Subject Enrolment Proportions by all Schools, Metropolitan Schools and Non-Metropolitan Schools

	All Schools	Metropolitan Schools	Non-Metropolitan Schools
	rho (N)	rho (N)	rho (N)
Mathematical Methods	-0.34 (284)	-0.5 (162)	-0.02 (122)
Specialist Mathematics	-0.29 (227)	-0.33 (141)	-0.08 (86)

Achievement Level

Table 4 shows that metropolitan schools outperform non-metropolitan schools in both Mathematical Methods and Specialist Mathematics, however the average difference was only 1.67 and 1.82 study score points respectively. In contrast, Table 5 shows the difference in achievement levels between highest and lowest SES schools was starker. On average, the highest SES schools outperformed the lowest SES schools by 4.01 and 3.54 points in Mathematical Methods and Specialist Mathematics respectively.

Table 4

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

	All Schools		Metropolitan Schools		Non-Metropolitan Schools	
	N	Mean (Range)	N	Mean (Range)	N	Mean (Range)
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 5

Comparison of Schools' Achievement Levels in VCE Year 12 Mathematics Subjects, where Results were available for 2014, 2015 and 2016, by SFOE Quartile

	1 st Quartile SFOE Schools (Highest SES) (N=72)		2 nd Quartile SFOE Schools (N=71)		3 rd Quartile SFOE Schools (N=72)		4 th Quartile SFOE Schools (Lowest SES) (N=71)	
	N	Mean (Range)	N	Mean (Range)	N	Mean (Range)	N	Mean (Range)
Mathematical Methods	68	28.75 (18.80-	54	26.36 (21.21-	52	25.59 (16.96-	47	24.74 (18.44-

		37.32)		33.09)		32.34)		31.00)
		28.32		26.14		26.73		24.78
Specialist Mathematics	68	(17.00- 36.31)	54	(17.71- 33.00)	53	(18.00- 46.00)	47	(17.08- 35.00)

Table 6 shows there is a negative correlation between SFOE and achievement across all schools in both subjects. However, the strength of these correlations increases when considering only metropolitan schools, with a strong negative and moderate negative correlation in Mathematical Methods and Specialist Mathematics respectively. Conversely, in non-metropolitan schools there is only a weak negative correlation in Specialist Mathematics, and a negligible correlation in Mathematical Methods.

Table 6

Spearman's rho correlation coefficients for SFOE and VCE Year 12 Mathematics Subject Achievement Levels for all Schools, Metropolitan Schools and Non-Metropolitan Schools

	All Schools	Metropolitan Schools	Non-Metropolitan Schools
	rho (N)	rho (N)	rho (N)
Mathematical Methods	-.482 (280)	-.613 (162)	-.193 (118)
Specialist Mathematics	-.390 (226)	-.453 (141)	-.242 (85)

Discussion and Conclusion

This study explored the impact of school SES and school location on the provision of, enrolment in, and achievement in, Year 12 enabling mathematics subjects. It did this using school-level data from all Victorian government secondary schools offering either subject across the three years of 2014, 2015 and 2016.

On average, students from lower SES schools were less likely to have access to enabling mathematics subjects, were less likely to enrol in these subjects, and achieved less well in these subjects, compared with students attending higher SES schools. Similar patterns were observed in the participation and achievement levels of non-metropolitan schools versus metropolitan schools, with metropolitan schools generally attracting more students to, and on average achieving better results in, enabling mathematics subjects than schools outside the greater Melbourne metropolitan area. These results mirror the findings of previous studies of the impact of SES and geographic location on the mathematical literacy of secondary school students (ACARA, 2017; McConney & Perry, 2010; Thomson, De Bortoli & Underwood, 2017).

More revelatory is that this study suggests that a non-metropolitan location can mitigate the apparent influence of school SES. In metropolitan schools, as school SES decreased, participation and achievement in enabling mathematics tended to decrease. However, in the non-metropolitan schools, SES appeared to have little to no impact on the enabling mathematics subjects delivered, nor the proportions of students enrolling in these subjects, nor the average achievement levels in enabling mathematics. Importantly, some non-metropolitan schools dramatically outperformed other schools. While non-metropolitan schools on average underperformed relative to the metropolitan schools, their performance was more varied and SES did not appear to explain that variability.

So, what are the factors, independent of SES, influencing non-metropolitan school performance in the enabling mathematics? Past research hints at possible explanations.

Many researchers, including Marginson (2013), highlight the difficulties of recruiting qualified mathematics teachers to rural and remote areas. 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 (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 non-metropolitan 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 non-metropolitan 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 & Beesley, 2007; Semke & Sheridan, 2012). Possibly the high-performing non-metropolitan schools identified in the current study have been able to exploit their location and perhaps smaller size to better foster such relationships. Related to this may be that some non-metropolitan schools are better able to make use of rich local community resources afforded non-metropolitan 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 non-metropolitan 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 (VTAC, 2016), all of which lead to careers with growing demand for workers (AIG, 2015).

This study re-purposed 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, De Bortoli & Underwood, 2017). Finally, while this study reveals relationships between school SES and location and enabling mathematics participation and achievement, the data analysed in this study do not explain why these relationships exist.

Further research is needed to seek an explanation for these relationships. In particular, developing an understanding as to why some non-metropolitan schools perform much better than expected in mathematics education promises to not only provide a model for improving enabling mathematics education in other non-metropolitan 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 non-metropolitan 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.

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