Access to level of mathematics study in high school: social area and school differences

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Using detailed information from the certificate records of 5,825 Year 10 students in Tasmania, this study found that the level of mathematics students access -- advanced, intermediate, or low -- is strongly related to socioeconomic background and school attended. Differences across schools, measured using multilevel modelling techniques, are related to the type of school (government, Catholic or independent), enrolment size and social composition. Residential segregation, the uneven distribution of selective schools, and school-level policies are the mechanisms discussed in explaining the origins of social area and school differences.

Introduction

Social inequalities in many areas of school participation have been declining, but social differences in access to mathematics courses persist. A study of mathematics participation in the state of Victoria has shown that access to university preparatory mathematics in the senior years retained substantial social class differences over the last forty years despite general improvements in the take up of mathematics as rates of school completion grew (Teese, 1994). The social trends are not confined to Victoria. A recent national study found a strong relationship between the social background of Year 11 and Year 12 students and the rates of participation in mathematics-science type courses: students from the highest socioeconomic group were more than twice as likely to take a mathematics-science course type than students from the lowest group (Ainley, et al, 1994). Other work has also shown large social differences in rates of mathematics participation (Lamb, 1996; Ainley et al., 1990; Teese, 1994). The evidence is a strong reminder that at a time when there are weakening social trends on some broad indicators of educational participation, such as school retention rates, large social differences in the use of school continue.

This paper reports original information on the levels of mathematics study of Year 10 students to explore the interactions between social background, school and access to the mathematics curriculum. Studies on curriculum access in the past have tended to focus on students in the senior year-levels (Years 11 and 12) where differences are more apparent because it is at this level that the curriculum is most differentiated. However, mathematics in the junior years of secondary school often involves pupil grouping practices such as setting or even more formal streaming. It is important to examine differences in the more junior grades because it is these year levels which operate as a staging period where differences in access to level and type of mathematics study lay the groundwork for trends in subject selection that emerge in the senior years.

To look at the relationships among social background, school and mathematics the study draws on information gathered from a statewide study of secondary schools in Tasmania. It will be argued that social class, mediated through the processes of residential segregation and selective schooling, and school policy are major influences shaping patterns in levels of mathematics study. Analysis of socio-economic patterns shows that students from higher socioeconomic backgrounds are far more likely than their peers to continue to access the most profitable streams of mathematics study. After controlling for student background, there are important differences in patterns of course enrolments across schools. These differences reflect the influence of school organisation and local school policies.

Data and analysis

The information on mathematics participation used in this paper was collected as part of a broader study investigating patterns of curriculum access and achievement in Tasmanian secondary schools. For that work, a data base was generated from records held by the Tasmanian Schools Board. The data base contains information on the subject enrolments and subject results for all School Certificate (Year 10), Higher School Certificate (Years 11 and 12) and, more recently, Tasmanian Certificate of Education (Years 9, 10, 11 and 12) students from 1970 to 1995.

In this paper we focus on the mathematics courses taken by students in Year 10 in 1994 (N=5825). In Tasmania at this year level compulsory mathematics is provided as four separate syllabuses designed for students of different levels of mathematics ability. The top-level is designed for students planning to continue the study of mathematics into the senior years of secondary school and university. It includes the study of algebra, geometry, trigonometry, and measurement. The other three levels represent a decreasing order of difficulty with increased attention given to business and consumer mathematics and mathematical life skills.

The aim of this paper is to examine patterns of social and school differences in enrolments across the different levels of mathematics study. To do this the analysis will build on the tradition of social area research in Australia used to examine socioeconomic and regional differences in education. Over the last two decades various researchers have studied the links between residential segregation, uneven school provision, and various measures of educational activity and achievement (Fisher et al, 1973; Claydon, 1975; Teese, 1991). This is commonly done by means of census information relating to occupations, incomes, housing and other characteristics of the population of each geographical area in which schools are located, or the populations which schools serve are located.

In the present study the Census Collection District was used as the geographical area. Since the home address for each student was available, it was possible to identify the collection district in which he or she lived using a digitised electronic street directory on desktop mapping software. A socioeconomic index score, calculated at the level of the collection district, was then assigned to the record for each student. The socioeconomic index scores were those derived by the Australian Bureau of Statistics (1994) and known as the Socioeconomic Indexes for Areas (SEIFA). The ABS provides five indexes. The one used in the present investigation was the index of education and occupation.

To measure social area differences in mathematics participation, the collection districts were divided into ten equal groups based on their order on the scale of socioeconomic status. The Year 10 students were then divided into the ten groups according to the social status of the census collection district in which they lived. It was then possible to examine the social distribution of mathematics participation.

To measure the relationships with school the multilevel modelling technique, *hierarchical linear modelling* (HLM), was used. The technique is a relatively recent development within regression analysis and permits researchers to model student-level outcomes within schools and then to identify and model any between-school differences that exist (Bryk and Raudenbush, 1992). The technique is now widely accepted among educational researchers as the most appropriate for looking at school effects. Because categorical (dummy) predictor variables were used (e.g. studying top-level mathematics or not), nonlinear HLM analysis was performed.

Patterns of mathematics participation

Figures 1, 2 and 3 present the mathematics enrolment rates of Year 10 students in Tasmanian secondary schools. The vertical axis in each figure records the percentages of males and females taking part in the level of mathematics study. The horizontal axis records the student population divided into ten groups based on the SES decile grouping of collection districts. At the low end of the scale (1) are the students who live in the collection districts of low social status. At the upper end of the scale (10) are the students living in districts of high social status. Three rather than four levels of mathematics study are presented because of very small numbers in the fourth (bottom) level. These students have been included in the third mathematics (Figure 3).

In 1994 social area differences in maths participation were a feature of junior secondary schooling in Tasmania. Access to the top level of mathematics varied according to the social status of a student's district (Figure 1). Children living in lower socioeconomic areas were far less often taking advanced level mathematics than children living in higher SES areas. For example, only 15% of boys in the lowest SES group were taking advanced-level mathematics in 1994 compared to 45% of boys in the highest SES group. The social gradient in participation is steep and largely consistent. Apart from some small falls in the middle groups, rates of participation rise sharply moving from the bottom to the top of the SES scale.

Figure 1: Participation in advanced-level mathematics:Year 10 students,

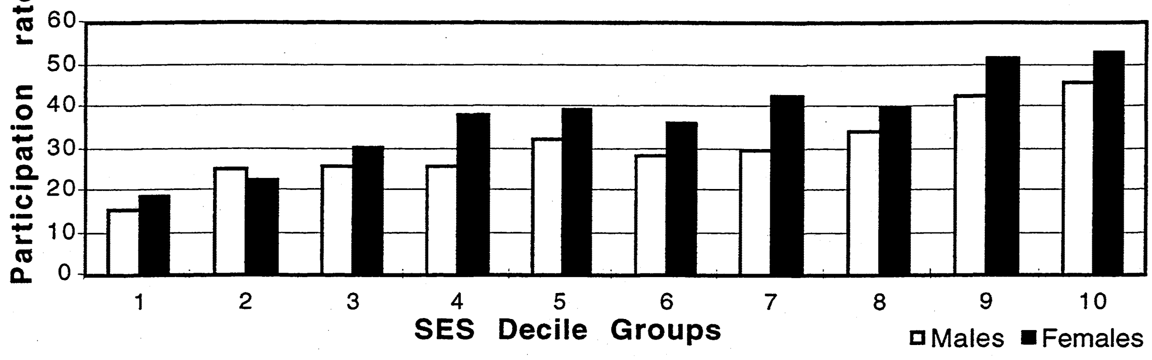


Figure 2: Participation in middle-level mathematics: Year 10 students,

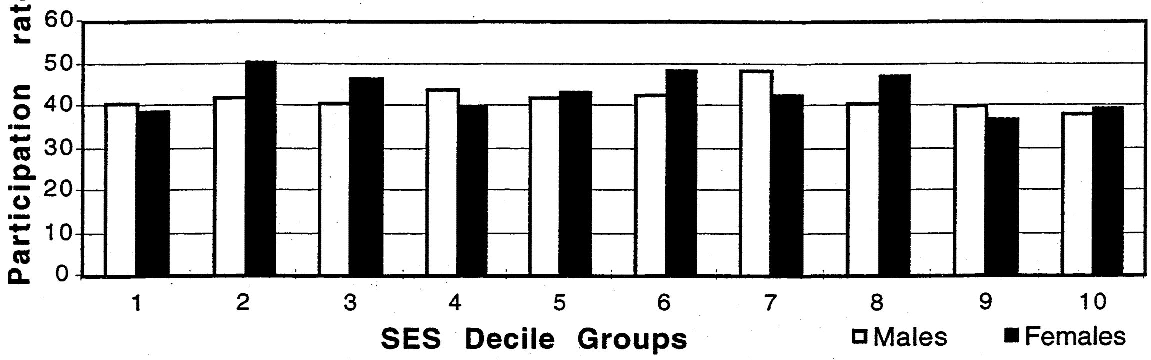
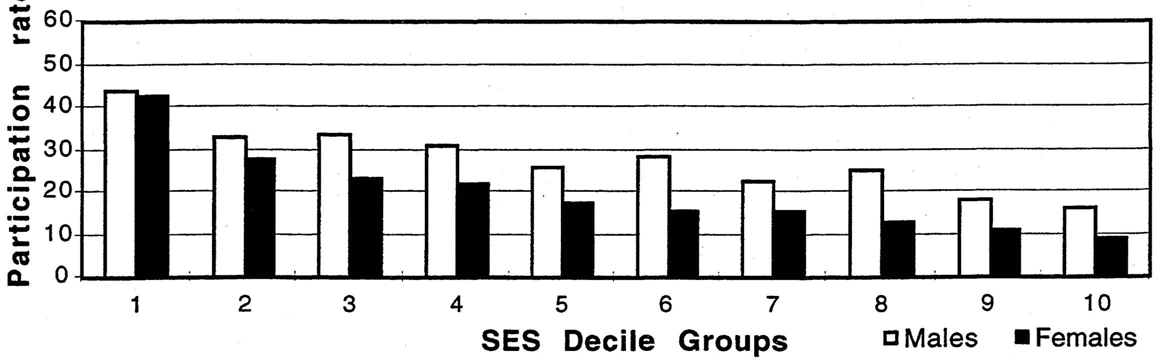


Figure 3: Participation in low-level mathematics: Year 10 students, 199



A point worth noting is that there are gender differences in the rates of participation in advanced maths, but these run against the patterns reported elsewhere (eg Lamb, 1996; Teese, 1991). At almost every point, as we ascend the SES scale, females are more often taking the top-level mathematics. The one exception is the second lowest SES group where the rate for males is slightly higher. The average gap between females and males is seven per cent. It would seem that in Year 10 mathematics girls are outperforming boys, if access to the most difficult level of mathematics is any guide. But the size of the gender gap does not alter the general social trends. For both males and females rates of participation increase as SES rises.

The reverse social trends are apparent when considering participation in the bottom-level mathematics (Figure 3). Participation in this level of mathematics is dominated by children from low SES backgrounds. Over 40% of boys and girls from the lowest SES group are taking the least difficult mathematics. Alternatively, fewer than 10% of girls and 15% of boys from the highest SES group are enrolled in this level of mathematics. Again there is a sizeable gender gap. On average, across the groups, eight per cent more boys than girls are enrolled in the least difficult mathematics. Gender differences are weakest at the lower end of the SES scale, where the gap is negligible, and largest in the middle groups. However, despite these differences, for both males and females social differences are large, with steep falls in participation as the SES scale rises.

Enrolments in middle level mathematics do not vary much according to SES (Figure 2). However, it is important to view participation in the middle level mathematics in conjunction with enrolment rates in the other levels. Taken together the figures reveal that students from the lowest SES groups are predominantly studying either the middle-level or bottom-level mathematics. This is the case for over 80% of boys and girls from the lowest SES group. Alternatively, the vast majority of children from the upper end of the social status scale are studying either middle-level or the advanced-level mathematics (over 80% of males and females from the two highest SES groups).

It is clear from the results that there are social area differences in access to levels of mathematics study. But do these differences vary across schools? To address this question nonlinear HLM analysis is used to predict the likelihood of participation in mathematics across schools controlling for the effects of key background attributes of students. Gender and SES were the main student-level factors included in the analysis while school type (Catholic, independent, government), mean SES of the school, and enrolment size were the main school level factors. The results from the analyses are presented in Table 1. Estimates for middle-level mathematics are excluded because there were no significant school differences. Two models are reported for top-level mathematics and bottom-level mathematics. The first model for each analysis includes only the level one variables. The second model includes student-level and school-level variables.

The level one models show that SES and gender exert strong independent effects on the likelihood of studying top-level mathematics and bottom-level mathematics. Other things equal, students from higher SES backgrounds have a significantly higher likelihood of doing the most difficult level of mathematics compared to their lower SES peers, and significantly lower likelihood of being relegated to the least difficult level of mathematics study. Being male significantly increases the likelihood of studying the bottom-level mathematics and not accessing the top-level of mathematics study, all else equal.

After controlling for the level one factors there are strong school differences. Analyses using unconditional models predicting level of mathematics study show that over 30% of variance is due to differences across schools. Some of the factors contributing to this variation are included in the full models presented in Table 1.

Previous research has pointed to the importance of the social composition of schools as an influence on achievement and other outcomes (e.g. Coleman et al., 1966; Lee & Bryk, 1989; Rumberger, 1995). In the present study, the mean SES of schools was not related to the study of advanced-level mathematics. However, the social intake of schools did have an influence on rates of participation in the least difficult mathematics. Other things equal, schools with a higher mean SES intake significantly reduced the likelihood of students studying the bottom-level mathematics.

Table 1: Non-linear HLM estimates of level of mathematics study

	Advanced-level maths		*Low-level maths*	
	Level 1 model	Full model	Level 1 model	Full model
School-level Variables				
Base rate	-0.572***	-0.673***	-1.399***	-1.419***
Student composition				
Mean SES		-0.024		-0.097**
School type				
Catholic		0.667***		-0.759***
Independent		1.236***		-1.209***
School size				
Enrolments		0.005***		-0.003*
SES differential				
Base rate	0.108***	0.070***	-0.125***	-0.097***
Catholic		-0.046*		0.027
Independent		0.064*		0.044
Enrolments		0.001**		-0.000
Gender differential				
Base rate	-0.286***	-0.251**	0.432***	0.492***

N (students) = 5825; N (schools) = 72
*Significant at the .10 level; **Significant at the .05 level; ***Significant at the .01 level
NOTE: Only variables which are significant predictors have been reported.

School type has an important independent effect on level of mathematics study. Other things equal, attending a Catholic school significantly increased the likelihood of studying advanced-level mathematics and reduced the chances of relegation to the bottom-level of mathematics study. The effects for non-Catholic private schools were even stronger. The results suggest that attending a private school improves students' chances of accessing the advanced-level of mathematics. These results support other research showing strong independent effects of private schools on educational activity (Coleman, Hoffer and Kilgore, 1982; Williams and Carpenter, 1990; Lamb, 1989, 1994a).

School type also influences the relationships between SES and level of mathematics study. Research from the high school and beyond study in the United States has shown consistently that the social distribution of academic achievement is more equal in Catholic schools than in other schools (Lee and Bryk, 1989; Bryk, Lee and Holland, 1993). The findings in this study also show an effect of Catholic schools on the social distribution of level of mathematics study (at least in terms of accessing the top-level mathematics). The size of the effect for rates of participation in the advanced-level mathematics, presented in the figures on the SES differential, is small (significant at the .10 level rather than .05) but suggests that the social distribution of participation is weaker in Catholic schools than in other schools. This does not hold for participation in the bottom-level mathematics, however. Furthermore, the figures for non-Catholic private schools suggest that, in contrast to the Catholic sector, there is an increase in social differences in top-level mathematics participation. In other words, non-Catholic private schools increase rather than reduce social differences. This trend did not hold for patterns of participation in the least difficult level of mathematics.

Another school factor related to level of mathematics study is enrolment size. Other things equal, the larger the school the greater the likelihood of students studying advanced-level mathematics. This may be because in smaller schools separate classes of the advanced level mathematics are not possible due to small student numbers. Enrolment size also has an interactive effect with SES at level two. The figures suggest that the social distributions of participation in advanced-level mathematics are less equal in larger schools than in smaller secondary schools. This may reflect differences in the provision of classes related to student numbers. It suggests that in smaller schools where classes in advanced mathematics are made available they tend to involve a broader social mix of students.

Discussion: explaining social area and school differences

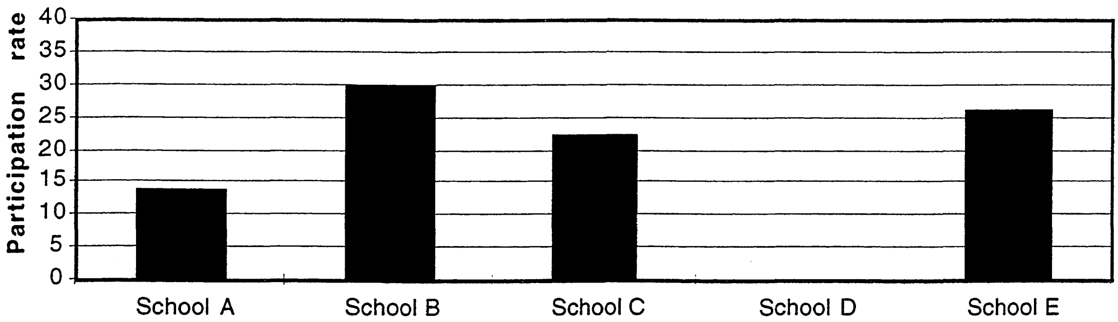
The origins of social area and school inequalities through the mathematics curriculum are partly based on the spatial groupings of the population along social class and cultural lines. Populations across the different suburbs and regions of Tasmania form concentrations differentiated by levels of income, types of occupations, educational qualifications, quality of housing, life styles and wealth. This process of residential segregation, producing unequal distributions of cultural capital and material wealth, means that the families which are the most likely to enjoy mathematics success (measured by level of mathematics study) are concentrated in particular residential areas. These families in high SES areas are able to promote success by exploiting the resources which they have at their disposal. Their knowledge of the school system, more richly developed language skills, high educational and occupational aspirations, aesthetic dispositions, literary and artistic experiences and tastes, and middle class life styles provide substantial advantages for their children in meeting the particular intellectual and behavioural demands associated with the selection, organisation, communication and evaluation of school knowledge (Lamb, 1990).

There are also indirect effects of residential segregation. The concentration of families with high levels of cultural capital, parental education, and income across particular geographical areas contributes to a community pooling of resources and avoidance of socially and culturally mixed environments. The aggregate levels of neighbourhood resources, and the establishment of family and friendship networks in this context, may well account for the neighbourhood or local community effects on mathematics achievement reported elsewhere (Entwistle, Alexander and Steffel-Olsen, 1994). Access to level of mathematics study, in other words, is sensitive to neighbourhood as well as family resources. The separation of populations residentially also means that the resources represented by parental education, cultural capital and employment are concentrated in school catchments. The effects of a pooling of family and neighbourhood resources in particular schools helps contribute to achievement and student progress. In the present study this may help explain why the chances of children being relegated to the lowest-level mathematics were significantly lower in middle class schools than in schools with a predominantly low SES intake.

Overlaying the mechanism of residential segregation is the uneven distribution of selective schools. The main forms of selective secondary schooling in Tasmania are Catholic and private non-catholic schools (in other states it would include selective-entry public high schools and declared language or music schools). There is an unven distribution of private schools across the different suburbs and regions of Tasmania. The uneven pattern of distribution builds on initial inequalities and intensifies effects related to residential segregation. The pooling of children from professional families (thanks to residential segregation, the imposition of fees, academic scholarships) provides private schools with a platform on which to erect elaborate frameworks of pupil management, (e.g. formal systems of pastoral care, more extensive extra-curricular activities in music, drama and art, and more clearly articulated policies on discipline and order), as well as pursue intensive curriculum orientation based on higher education course planning and achieved through a more narrowly focused academic curriculum, formal grouping practices, selective promotions and careful guidance in subject selection (Lamb, 1994b). These are some of the ways in which private schools are able to successfully exploit the advantages of their narrow social intake. The more rarefied teaching environments established in private schools help promote higher achievement in mathematics and, therefore, higher levels of promotion of students to advanced-level mathematics. Many government schools attempt to emulate the practices of private schools. But this must often be ineffectual because these schools cannot provide the same operating conditions thanks to their role in serving much broader populations.

A further layer of influence on social area and school differences is related to local school organisation and school policy (how individual schools manage students and deal with pupil diversity). Figure 4 shows the rates of participation in advanced-level mathematics in five government high schools matched in terms of the social distribution of their student intake (predominantly low SES) and their enrolments (over 60 students in Year 10). It reveals that rates vary substantially across schools serving similar populations. School D had no students in 1994 doing advanced-level maths, whereas the other schools had up to almost a third doing so. Other work suggests that such differences are related to the academic focus of the school, promotion's policies, breadth of curriculum, organisation and attributes of teachers, and policies on entry requirements to levels of study (Lamb, 1996; Bryk, Lee & Holland, 1993; Teese, 1989). Clearly, there are school-level factors influencing access to level of mathematics study.

Figure 4: Participation in advanced-level mathematics: five schools, 199



In conclusion it is important to note that the interactions between the layers of influence on access to level of mathematics take place within the context of a hierarchically organised, centrally controlled curriculum. As long as the curriculum at the Year 9 and Year 10 level continues to be shaped around the needs of selection for senior schooling and university entry then it is likely that mathematics will continue to operate as a major source of social selection.

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