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Do linguistically diverse migrants dominate advanced mathematics? Comparing Greater Sydney with the rest of New South Wales

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Abstract
This study uses ethnic capital theory to explore access to secondary mathematics education among linguistically diverse (LD) migrants in metropolitan and regional New South Wales, Australia. Administrative data from over 50,000 students who completed their Higher School Certificate in 2017 were analysed using multilevel logit regressions and marginal effects. The results indicate that, in Greater Sydney, all linguistically diverse first-generation youth took mathematics courses at higher rates than their peers. So did second-generation migrants from Asian backgrounds. Furthermore, considerably larger proportions of students who spoke East Asian, Indo-Aryan, or Arabic languages studied advanced mathematics. Even when only parents spoke these languages at home, their Australian-born children took advanced mathematics more often. Yet, these second-generation students were less overrepresented than those fluent in parental languages. The paper discusses the potential consequences of LD migrant concentration in Greater Sydney, stressing the importance of equitable mathematics education in metropolitan and regional areas.

Keywords Linguistically diverse students · Mathematics education · Migrant students · Urban education · Ethnic segregation

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Introduction

Teenage migrants in English-speaking countries often differ markedly from their peers in their upper-secondary mathematics achievement and course uptake (Clarkson, 2007; Han, 2016; Lee & Zhou, 2015; Levels et al., 2008). While migrants lag behind other youth in some locations, Australia's selective migration policy favours highly-skilled workers, contributing to immigrant advantage. Many immigrant children grow up in homes of highly-educated professionals who have completed science-related degrees. Consequently, many excel in education, partly due to parental support and expectations to outstrip others in numeracy (Ho, 2020).

Not all migrants have fared equally well in Australian secondary education. Nonetheless, similar to research in the United States and Canada, most attention has focused on East Asian heritage students as visible high-performers (Adamuti-Trache & Sweet, 2014; Pang & Mu, 2019; Zhu & Leung, 2011). In particular, studies of Sydney's selective high schools point to the success of Asian migrants across several learning domains (for a review, see: Ho, 2020). In this context, mathematics has received special attention from policymakers and academics due to its perceived importance for social and economic mobility, technological development and Australia's environmental sustainability (Law, 2018a). Yet, student participation in mathematics has been falling in Australia (Hodgen et al., 2010), with consistently lower rates among females nationwide and in NSW (Forgasz, 1998; Law, 2018b; Sikora & Pitt, 2019).

In contrast to several other countries, since 2001, Australian secondary students have been able to not take mathematics and still enter university (Hodgen et al., 2010; Sikora & Pitt, 2019). Thus, the share of New South Wales (NSW) students who do not study secondary mathematics has increased over the last two decades (Nicholas et al., 2015). For instance, in 2001, 92% of NSW students studied a Higher School Certificate (HSC) mathematics course; in our 2017 data, this has declined to 77%. Concerns about this trend, labelled as a crisis, have inspired reflections that university-educated Australians will be unable to compete in globalising labour markets (Wilson, 2015).

In this context, the experiences of immigrant students in Australia, particularly those of Asian descent, have received considerable attention. To this literature, the current paper contributes an analysis of data broad in scope yet with some fine-grained detail. We examined administrative records available for all NSW students who obtained their Higher School Certificates in 2017. In doing so, we distinguished several migrant groups by country of birth and languages spoken by parents and children at home. We compared three groups of Asian migrants with other ethnic groups. Moreover, our analyses of mathematics uptake contrast the situation in Greater Sydney and the rest of New South Wales to extend previous quantitative studies which could not address the potential differences between metropolitan and regional settings (Roberts et al., 2022). The paper highlights the issues of access to and achievement in mathematics in regional areas (Halsey, 2018) as they intersect with spatial and related community characteristics.

Mathematics participation and achievement among migrant students in Australia

Since its inception, the research on Australian migrant students contrasted first-generation and second-generation with other youth, often without accounting for their diverse cultural and ethnic origins (Akther & Robinson, 2014; Forgasz, 1998). Ethnicity differs from migration status as the former depends on the spoken languages, region of origin, shared cultural history and, occasionally, religion, whereas the latter is a legal category (Knowles, 2010). However, economic, political and educational outcomes depend on both because, as Knowles points out, consequences of ethnicity are socially produced in the migration process (2010). Accounting for potential ethnic advantages and disadvantages requires understanding migrant origins and destinations in the geographic and sociocultural sense.

When the Program for International Student Assessment (PISA) enabled large-scale cross-national comparisons, it became evident that teenage migrants' educational outcomes differed by culture and ethnicity (OECD, 2006). First-generation youth whose parents experienced diverse education systems varied in how much academic success they had in the host country (Levels et al., 2008). School performance depended not only on the characteristics of their family, such as its scholarly culture or socioeconomic status but also on the typical social and economic characteristics of populations in their countries of origin, as well as the features of the education system in their host country (Dockery et al., 2020). PISA studies also revealed that in countries with migration policies focused on attracting skilled workers, such as Australia, Canada, and New Zealand, many adolescent migrants outperformed their classmates in mathematics (OECD, 2006). However, the Australian PISA includes mainly Year 10 students before they decide which subjects to pursue in Years 11 and 12. Subject choices reflect prior achievement but also a range of other factors. Therefore, later participation patterns are more consequential for access to tertiary education than earlier school achievement.

Consequently, patterns of participation in upper-secondary mathematics attracted attention in Australia. Most studies focused on gender differences (Forgasz, 2006; Kirkham & Chapman, 2022; Sikora & Pitt, 2019). Yet, some noted the importance of ethnicity and sociocultural factors (Kirkham et al., 2020) or Asian culture (Ho, 2020).

More recently, PISA analysts turned their attention to the high mathematics performance of East Asian students arguing that familial culture was crucial for children's achievements (Jerrim, 2015). Middle-class parents can purchase homes in desirable school districts, pay tuition fees to provide access to non-government schools and expose their children to peer networks conducive to academic competition (Ho, 2020). Jerrim (2015) found that in Australia, second-generation migrants from East Asian countries, which topped PISA's mathematics rankings, outperformed their peers, irrespective of school environments or family socioeconomic status. Parental influence accounted for half of the explained achievement advantage, while school effects accounted for the other half. East Asian parents fostered cultural values that included hard work ethos, ambitious occupational aspirations, time devoted to out-of-school mathematics activities and an instrumental attitude to educational attainment. Indeed, in Australia, bilingual teenage migrants expect to work in higher-status occupations than other students, including monolingual migrants (Sikora & Pokropek, 2021). Linguistically diverse (LD) migrant youth are more likely to plan careers in science, which require above-average numeracy skills (Sikora & Pokropek, 2021).

To better understand these cultural influences, Jerrim (2015) contrasted students of Chinese, Korean and Japanese ancestry who represented PISA's higher-performing East Asian countries (HP East Asian) with students born to parents from Malaysia, Philippines, Indonesia, Thailand, Cambodia, Vietnam, Laos and North Korea, dubbed Lower Performing East Asian Countries (LP East Asian). Other migrant groups included in the comparison were students of 'Indian origin' whose parents were born in India, Pakistan, Nepal or Bangladesh and second-generation migrants from the United Kingdom. Additional trend analysis showed that the advantage in PISA's performance of students of East Asian HP origins over their peers has been increasing in younger cohorts. While insightful, Jerrim's (2015) study concerned low-stake outcomes, did not consider the potential role of students' linguistic backgrounds and left out some sizeable migrant groups, such as Arabic speakers. Moreover, so far, no analyses of Australian data contrasted and compared specific ethnic groups with regard to Year 12 mathematics course uptake, which is a later and potentially more consequential outcome of ethnic capital. Our paper fills this void for metropolitan and regional NSW.

Theoretically, the notion of ethnic capital, which extends Bourdieu's concept of cultural capital (1986), discussed by Modood (2004), provides a coherent framework for understanding immigrant schooling outcomes. Such capital involves those ethno-racial characteristics embedded within family relationships that Jerrim (2015) identified as familial influences. Modood (2004) notes that this form of capital always contains the triad of adult–child relationships, transmissions of aspirations and attitudes, and norm enforcement to facilitate the academic success of minorities. Ethnic capital is a comprehensive theoretical approach compatible with strategic adaptation theory (for a more detailed discussion, see: Sikora & Pokropek, 2021). The latter proposes that many immigrants view educational success as their main pathway to upward mobility. Because some first-generation migrants lack confidence in their language competencies, they turn to science and technology for academic advancement. Mathematics appears to be a level playing field, a universalist domain in which personal characteristics such as ethnicity or social origins are unlikely to lead to educational assessment bias (Xie & Goyette, 2003). In a US study of academic success, one migrant mother summarised this attitude by saying, 'In math, there is always a right answer; one plus one always equals two. It's not that way in the arts' (Lee & Zhou, 2015, p. 58). Second-generation migrants are usually less concerned about cultural or language competencies (Feliciano & Lanuza, 2016). Still, they may view science and mathematics as universalist disciplines that promise greater geographical mobility and transferability of credentials and skills.

This paper extends the applications of the ethnic capital theory to participation in mathematics, given the importance of this domain for social and economic mobility.

The present paper builds upon Ho's (2020, p. 188) extensive study of Sydney's elite high schools and her conclusion that many Asian parents saw their children's educational success as 'the foundation for the family's future security and prosperity'. The Australian model of neoliberalist education enables intense academic competition through material and non-material means, such as understanding how to utilise shadow tutoring to do well in high-stake tests (Ho, 2020). While Ho's work did not focus on mathematics per se, it discussed the experiences of students whose backgrounds relate to what Jerrim (2015) labelled HP East Asian languages.

The ethnic capital theory also transpires in other extensions of Bourdieu's social reproduction argument, investigating how the values of Confucianism drive academic success in mathematics (Mu, 2014). Several cultural tropes, including conceptions of fundamental skills (Liuyi Six Skills), underpin the cultural construction of the educational gold standard in which mathematical knowledge takes a central place. Mu contended that it permeated Chinese students' habitus at subconscious levels, leading them to report affinity with the study of mathematics without comprehending its origins (2014).

These studies have contributed crucial insights to understanding why some linguistically and ethnically diverse student groups elect to study mathematics and become high performers in the Australian education system. However, they focused on one specific ethnic group at a time, a small snapshot of the educational landscape or low-stake achievement outcomes, such as the PISA tests. We have taken a comparative approach by contrasting ethnic groups residing in metropolitan and regional areas, and we studied mathematics participation rather than achievement. One compelling reason to consider the uptake of different Higher School Certificate (HSC) courses is that they equip students for entry to university programs, which may be essential in later career-making. Students who opt out of secondary mathematics might lock themselves out of pathways into more secure and versatile employment (Law, 2018a). Achieving top results in Year 10 mathematics is thus arguably not as crucial as continuing its study into Year 12.

Furthermore, we provide an overview of mathematics participation not of Asian students as a monolith category but with more subtle ethnic and legal distinctions. We have distinguished between first and second-generation migrants who do and do not speak their parental language, as sharing a common language with parents might be critical to internalising familial guidance and aspirational direction (Modood, 2004). Most educational studies of Australian migrants had no data to compare linguistically diverse students in metropolitan and regional areas. Yet, access to ethnic capital resources might vary dramatically by location and spatial concentration of co-ethnics (Knowles, 2010; Modood, 2004). For these reasons, we considered separately the situation of students who reside in Greater Sydney and the rest of New South Wales.

Research questions

We addressed three research questions.

First, is the uptake of mathematics HSC courses among LD migrants and other students similar between Greater Sydney and the rest of NSW?

Second, are LD migrants more likely to take at least one mathematics course that counts for the Australian Tertiary Admission Rank (ATAR) than their non-migrant peers?

Finally, are LD migrants more likely to study advanced mathematics than other students? If so, which migrant groups are most overrepresented?

In addressing these questions, we compared several groups. We contrasted Australian-born students with those born in what Jerrim (2015) labelled as PISA higher-performing East Asian countries (HP East Asian) and youth born in the PISA lower-performing East Asian countries (LP East Asian). Furthermore, we considered students born in India, Pakistan, Nepal and Bangladesh versus migrants born in all other countries. In terms of languages spoken at home, we grouped migrants into those who speak only English; those who, in addition to English, speak Chinese, Korean or Japanese (HP East Asian); speakers of Vietnamese, Tagalog, Indonesian, Malay and related languages (LP East Asian); those who speak Indo-Aryan languages and Arabic speakers versus everybody else (see Appendix 1 for the detailed list of languages in each group). Our goal was to distinguish as many different backgrounds as possible. The groupings are based on prior literature but also on student numbers, as we needed several per cent per cluster to make the estimates with appropriate precision.

Methods

Data

We used the administrative data from the NSW Education Standards Authority (NESA) for the cohort who completed their HSC in 2017. We first considered 74,230 youth who took at least one HSC course. We excluded 458 cases for whom we had no information on Year 12 School ACARA[1] identification and 3504 without information on whether their coursework was ATAR-eligible. We also disregarded 3062 records lacking home residential Statistical Area Level 1 information, which is required to categorise students into those living in Greater Sydney and the rest of NSW (Australian Bureau of Statistics, 2021). This left us with 67,206 students in the analysis, but we focus here on 53,970 ATAR-eligible students and 42,712 youth who took mathematics, using subject eligibility as appropriate in 2017.

Measurement

There are two dependent variables. The first is a zero/one indicator of whether a student took at least one mathematics ATAR course. In NSW in 2017, students could

[1] The Australian Curriculum, Assessment and Reporting Authority.

take four mathematics options contributing to their university entry rank. The first two were General Mathematics or Mathematics. Students who studied Mathematics could also choose further mathematics in the form of Extension Mathematics 1 and Extension Mathematics 2. Also available was a non-ATAR-eligible mathematics option which we did not consider. The second dependent variable is a zero/one indicator of whether a student took Mathematics Extension 2. This course targets students with a strong mathematics achievement background (NSW ESA, 2016; Sikora & Pitt, 2019).

The critical contrast in our analysis is between students whose homes are located in Greater Sydney and the rest of NSW (Australian Bureau of Statistics, 2021). Greater Capital City Statistical Areas, which Greater Sydney exemplifies, extend to Newcastle and Wollongong as they have population density and accessibility to services similar to the central city. Furthermore, populations in these Greater Sydney areas are intimately connected to the capital city through access to services and where they typically commute for work, recreation and commerce. Their school environments are closely related to a city habitus and associated with higher levels of academic achievement. Specifically, including this distinction is significant as, despite the perennial challenge of non-metropolitan student achievement (Halsey, 2018), educational research rarely includes a specific non-metropolitan focus (Roberts et al., 2022).

Our independent variables of interest are students' linguistic background and migration status. Many studies employ parental country of birth to distinguish not only migrant status but also ethnicity. However, NESA does not collect detailed information on the parental country of birth. Therefore, to depict ethnic diversity, we relied on parental and student languages. To categorise first and second-generation migrants, we used students' country of birth. Students born outside of Australia are first-generation. The second generation comprises those born in Australia who speak or whose parents speak a non-English language.

Student language is a six-category variable. The Australian Standard Classification of Languages (ASCL) codes, provided in the original data, were recoded into six categories. Appendix 1 lists detailed ASCL codes for each language category. The six categories used in this analysis are (1) students speaking English, and (2) HP East Asian students, i.e. those who speak Japanese or Korean, Chinese, Cantonese, Hakka, Wu, Min Nan or other languages predominantly used in China. The third category is LP East Asian students who speak Malay, Tagalog, Filipino, Lao, Khmer, Vietnamese, Indonesian and related languages (Jerrim, 2015). Students in the fourth group speak Bengali, Hindi, Nepali, Sinhalese, Gujarati, Punjabi, and associated languages. We labelled them 'Indo-Aryan' following the ASCL. The fifth group comprises Arabic-speaking students, while the sixth category involves all other Non-English languages.

Parental languages were grouped into the same six clusters for consistency. Initially, we kept the languages spoken by Parent 1 and Parent 2 separately but subsequently merged these into one variable. The substance of our conclusions does not differ, regardless of whether we code the languages of Parent 1 and Parent 2 separately or in conjunction, so we opted for the latter approach for the sake of parsimony. If only one parent spoke a non-English language, both parents were put into that language group. In assigning codes, we began with HP East Asian languages, then proceeded to code LP East Asian, Indo-Aryan, Arabic, and other non-English languages, with English at the end. This coding order means that a student with one Chinese and one English-speaking parent was treated as HP East Asian.

The student's country of birth is a five-category variable. Preliminary analyses showed no differences between students born in Australia and other English-speaking countries, identified in Appendix 1. Thus, the first category includes those born in Australia, the United Kingdom, the United States, New Zealand, Canada and Ireland. The second group are HP East Asian countries, while the third is LP East Asian countries. We also distinguish India and nearby countries, as defined by Jerrim (2015). The fifth group is all other countries, as we could not identify Arabic-speaking countries as a separate category.

Because familial economic and social capital might enhance the educational advantage of migrants, we controlled for parents' education and occupation. Other control variables are students' sex, Aboriginal or Torres Strait Islander self-identification (ATSI) and Year 9 NAPLAN numeracy score. When the goal is to separate the impact of ethnic culture from the influence of prior academic achievement and other effects, these control variables are essential.

NESA collects information about parents' school and nonschool qualifications in several broad categories. Following preliminary analyses where all these categories were retained, the qualifications were expressed in years of education based on the approximate number of years each credential takes to acquire in Australia. We next averaged years of schooling for Parent 1 and Parent 2. This transformation reduced the degrees of freedom, resulting in more parsimonious and interpretable models (Marks, 2013). For instance, parents with a bachelor's degree or higher were assumed to have completed 17 years of education. If only one parent's information was available, we used it instead of the average.

Information on parental occupation was collected in several categories, not detailed enough to be expressed as occupational status scores (McMillan et al., 2009). Therefore, following preliminary analyses, parental occupation was recoded to a three-category variable to simplify models without losing information (Marks, 2013). While Parent 1 and Parent 2 occupations were available, we did not have an indicator of parental gender. Thus we did not know whether respondents whose parents form opposite-sex couples reported their mother or father consistently as Parent 1 or Parent 2. In this situation, and given our ethnic capital framework, which emphasises the influence of the entire family over an individual parent, combining parental occupation was optimal. The first category includes students in families where neither parent worked as a professional or manager. The second comprises students with at least one parent working as a professional or a manager, while teenagers in the third group have both parents employed as professionals or managers. Ideally, we would like to control for family structure, but this information was not available in the data.

School type is vital in the Australian marketised education system, so our final set of controls depicts school characteristics. We distinguished between students who completed Year 12 in coeducational, boys-only or girls-only schools. Furthermore, we accounted for attendance of partially and fully selective schools or government non-selective, Catholic and independent schools. Partially or fully selective schools are a subset of the government school system where entry requires an aptitude test. In 2017, they comprised 21 fully selective schools and 27 schools with selective streams, i.e., partially selective schools.

Analytical strategy

The data are hierarchical in that students (level one units) are nested in schools (level two units). Therefore we used two-level logistic models to estimate group probabilities of taking ATAR-eligible mathematics and the advanced Mathematics Extension 2.

To achieve transparency and focus in reporting many ethnic and linguistic dimensions with multiple odds ratio coefficients, we present our results using marginal effects, henceforth margins, and the *mimrgns* procedure (Klein, 2014; Williams, 2012). Margins are derived by solving regression equations for fixed values of focal independent variables while other independent variables are held at mean values. This strategy produces typical mathematics participation rates for comparable student groups that differ only by ethnolinguistic characteristics of interest.

Missing data

Administrative data are affected by some missing records; thus, we used multiple imputations by chained equations (MICE) (Royston & White, 2011). This approach minimises the potential exclusion bias. The details of what we imputed are in Appendix 2. Our data are more likely to be missing at random (MAR) rather than missing completely at random (MCAR) (Little & Rubin, 2002); thus, for us the MICE is optimal (Newman, 2014; Schafer & Graham, 2002). We generated ten versions of the dataset, computing each estimation ten times and averaging the results using the Rubin rule.

Results

The overview of the student characteristics in Greater Sydney and the rest of NSW begins in Table 1, where we list the information for all ATAR-eligible students. While, in both locations, about one-fifth of youth in HSC courses did not study mathematics, those regional students who did, leaned towards units with little or no calculus content. About 45% of city students elected General Mathematics, the only course with no calculus, compared to 56% in the rest of NSW. The proportions of students in Mathematics, which contains some calculus, were comparable at 17 and 16%, respectively. Mathematics Extension 1 attracted 10% of students in Greater Sydney but only 6% in the rest of the state. Finally, Mathematics Extension 2, the most demanding unit, was taken by 7% of students in Greater Sydney but only 2% in the rest of the state (Table 1).

Table 1 Descriptive statistics

	Greater Sydney	Rest of NSW
Dependent Variables		
Mathematics Courses		
No ATAR Mathematics	21%	20%
General Mathematics	45%	56%
Mathematics	17%	16%
Mathematics Extension 1	10%	6%
Mathematics Extension 2	7%	2%
Demographics		
Sex		
Male	48%	44%
Female	52%	56%
Ethnicity		
ATSI	1%	4%
Student Country of Birth		
Australia Canada NZ UK USA	82%	93%
HP East Asian	3%	0.4%
LP East Asian	2%	1%
Indian	2%	0.4%
Other	12%	6%
Student Language		
English	58%	94%
HP East Asian	10%	1%
LP East Asian	7%	1%
Indian	6%	1%
Arabic	6%	0%
Other	12%	3%
Parents		
Parent Language		
English	51%	92%
HP East Asian	11%	1%
LP East Asian	8%	1%
Indian	7%	1%
Arabic	7%	0.4%
Other	16%	5%
SES		
Parents' Education		
Mean Years	13.98	13.23
Parents' Occupation		
Neither Prof Manager	36%	39%
One Prof Manager	35%	34%
Both Prof Manager	29%	27%
Mathematics Achievement		
Year 9 NAPLAN mean score	629.98	607.21

Table 1 (continued)

	Greater Sydney	Rest of NSW
Year 12 school		
Coeducational		
Coeducational	64%	95%
Girls only	20%	3%
Boys only	16%	2%
Sector		
Government	52%	57%
Catholic	28%	27%
Independent	20%	16%
Selective		
Not selective	89%	96%
Partially selective	4%	2%
Fully selective	7%	3%
N	38,961	15,009

Percentages might not sum up to exactly 100% due to rounding

Aboriginal and Torres Strait Islanders tended to live outside of Greater Sydney, where they made up 4% compared to only 1% in the city. The regional areas have lower proportions of first-generation migrants and are strikingly homogeneous with respect to a lack of linguistic diversity. Some 93% of students in regional NSW were born in Australia or other English-speaking countries, compared to 82% of city-dwellers. Moreover, 94% of regional students spoke only English, compared to 58% in Greater Sydney. Parental languages were also considerably more diverse in Greater Sydney, with only 51% of parents speaking solely English versus 92% in the rest of the state. As expected, more socioeconomic advantage was evident in parental educational and occupational profiles, and above-average academic performance was typical among Greater Sydney students (Table 1). The ethnic segregation between metropolitan and regional student populations is remarkable. In mathematics, it appears to be an essential issue of spatial inequity, warranting further investigation into its influence on subject selection and career pathways in contemporary Australian society. We understand ethnic segregation as unequal opportunities in the two residential areas for ethnic and cultural minority students to interact and share social spaces with similar youth. Given the lack of ethnic diversity in the regional population, the learning environments for minority students may differ dramatically from metropolitan areas in the availability of culturally affirmative peer networks and supportive ethnic communities. Furthermore, if, as our analysis suggests, mathematics participation is associated with non-Anglo heritage, the socio-spatial distribution of populations across the state creates unique challenges for initiatives to enhance participation.

While Table 1 shows that students in the metropolitan part of NSW had more access to selective and independent schools, higher Year 9 NAPLAN mathematics scores and parents with more education and higher occupational status, our focus was on highlighting the relative opportunities available to ethnically diverse students. Firstly we considered how likely they were to study some ATAR-eligible mathematics.

Opting in and out of mathematics study

Table 2 shows odds ratios from a two-level logistic model predicting the likelihood of taking at least one HSC mathematics course. Odds ratios above one denote positive effects, while those below one denote negative effects.

Factors contributing to the uptake of HSC mathematics varied between students whose homes were located in the two areas (Table 2). Nevertheless, as found by prior research, females in both locations were less likely than males to study mathematics for their HSC (Kirkham & Chapman, 2022; Sikora & Pitt, 2019). In Greater Sydney, students born in one of the HP East Asian countries were 59% more likely to take mathematics (odds ratio of 1.59) than those born in one of the English-speaking countries, who were a reference group for this comparison. Rather than examining odds ratios from Table 2, we turned to a more interpretable way of presenting the results. Figures 1, 2 and 3 show probabilities expressed as margins computed for three linguistically diverse (LD) migrant groups and monolingual, English-speaking students. Bars have error lines representing 95% confidence intervals, and margins do not differ where lines overlap.

Margins in Figs. 1, 2 and 3 illustrate typical mathematics participation levels for students, assuming they do not differ from their peers in Year 9 NAPLAN mathematics performance or any control variables in Table 2 apart from languages or country of birth. We obtained margins for youth in each of our country, student language and parental language groups. Our reference or benchmark group for comparison are monolingual English speakers born to English-speaking parents in Australia or another English-speaking country. We first compared them to first-generation migrants, who were born in a non-English-speaking country and spoke their parental language at home (Fig. 1). Then we compared them to the second generation, i.e. students born in Australia or some other English-speaking country who speak their parents' non-English language (Fig. 2). Finally, we contrasted them with second-generation migrants whose parents could communicate in a language other than English, but the youth did not speak it themselves (Fig. 3).

While linguistically diverse migrants took up mathematics at higher rates than all others in Greater Sydney, similar differences could not be established in the rest of NSW. In other words, so few diverse students lived outside of Greater Sydney that even when coefficients depicting the differences between them and their peers were similar to those in Greater Sydney, they failed to reach statistical significance.

Among city students, first-generation linguistically diverse migrants were more likely to study secondary mathematics (Fig. 1). The typical participation for English monolinguals in the benchmark group was 74%. It rose to 91% for the HP East Asian first generation and 86% for students born in LP East Asian countries. Similarly high was the rate of 91% for those overseas-born who spoke an Indo-Aryan language. The average participation for all other first-generation youths from non-English

Table 2 Two-level logistic regression predicting taking at least one ATAR eligible mathematics course in 2017 (1 = yes, 0 = no)

	Greater Sydney		Rest of NSW	
	Odds ratio	t statistic	Odds ratio	t statistic
Female	0.54**	−17.14	0.62**	−9.50
ATSI	0.77	−2.09	0.79	−2.06
Student born in Australia Canada NZ UK USA	Reference		Reference	
HP East Asian	1.59**	3.02	1.07	0.13
LP East Asian	1.10	0.83	1.30	0.65
India, Pakistan +	1.63**	3.35	4.00	2.01
Other countries	1.30**	4.85	0.99	−0.08
Student language: English	Reference		Reference	
HP East Asian	1.61**	3.02	0.71	−0.48
LP East Asian	1.54**	3.78	1.22	0.44
Indo-Aryan	1.67**	3.37	1.11	0.16
Arabic	1.15	1.39	2.45	1.01
Other languages	1.10	1.27	1.62	2.01
Both parents speak English at home	Reference		Reference	
HP East Asian	1.71**	3.66	2.16	1.10
LP East Asian	1.54**	4.33	1.38	0.88
Indo-Aryan	1.81**	4.17	1.01	0.02
Arabic	1.08	0.87	0.58	−0.66
Other languages	1.11	1.57	0.91	−0.55
Parents' education	1.01	1.08	0.97	−2.24
Parental occupation: Neither prof manager	Reference		Reference	
One prof manager	1.03	0.74	0.97	−0.50
Both prof manager	0.94	−1.22	0.96	−0.49
Coeducational school in Year 12	Reference		Reference	
Girls only	0.91	−0.77	0.78	−1.09
Boys only	0.95	−0.42	1.23	0.60
Government school	Reference		Reference	
Catholic	1.30	2.33	1.18	1.55
Independent	1.33**	2.75	0.82	−1.78
Not selective school	Reference		Reference	
Partially selective	1.08	0.37	2.36	2.48
Fully selective	0.43**	−3.74	0.30**	−3.44
NAPLAN Year 9 Numeracy score	1.01**	45.71	1.01**	26.83
Intra-class correlation rho	15%		24%	
N of schools	470		427	
N of students	38,961		15,009	

**$p < 0.01$

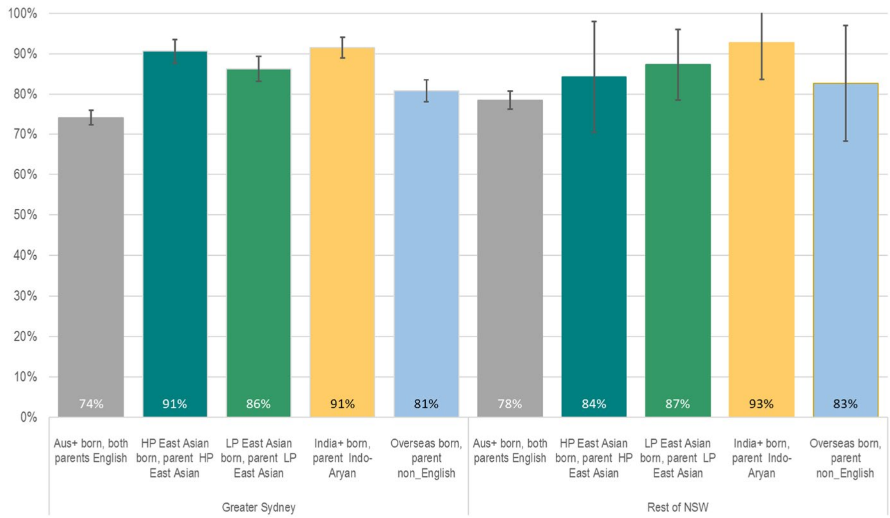

Fig. 1 At least one ATAR mathematics course: margins based on Table 2. LD first-generation migrants who speak parental language versus monolingual students born in Australia and similar countries

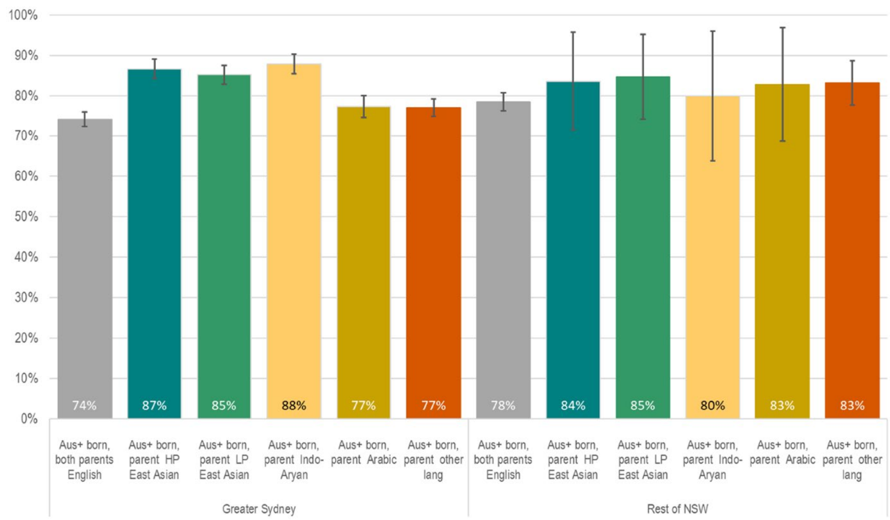

Fig. 2 At least one ATAR mathematics course: margins based on Table 2. LD second-generation migrants who speak parental language versus monolingual students born in Australia and similar countries

backgrounds was 81%. Thus, all first-generation linguistically diverse migrants took mathematics at rates higher than English monolinguals.

Among second-generation students, shown in Fig. 2, Asian youth in three groups, HP, LP and Indo-Aryan, also studied mathematics more often than their peers. Compared to the 74% for the benchmark group, 87% of comparable HP

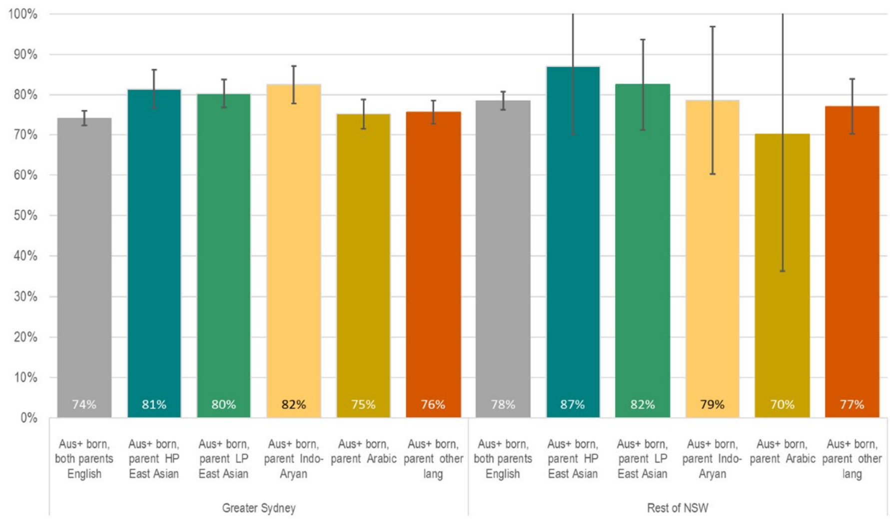

Fig. 3 At least one ATAR mathematics course: Margins based on Table 2. LD second-generation migrants who do not speak parental language vs monolingual students born in Australia, similar countries

East Asian language speakers born in Australia took mathematics, compared to 85% LP East Asians and 88% of students speaking Indo-Aryan languages. Among Arabic-speaking second-generation migrants and youth speaking other languages, 77% elected a mathematics subject. This proportion was comparable to the reference group.

The participation rates for the second generation who do not speak their parents' language were also higher among Asians than in the benchmark category (Fig. 3). The HP East Asian group rate was 81%, with 80% for LP East Asians and 82% for youth whose parents spoke an Indo-Aryan language. These rates are higher than those of English monolinguals born in English-speaking countries. But the two groups of second-generation non-Asian migrants did not differ from English speakers.

In the rest of NSW, the estimates for the tiny groups of ethnically diverse students were indistinguishable from the comparison group due to small numbers and large confidence intervals (Figs. 1, 2 and 3). Nevertheless, they suggest that ethnic minority students did not lag behind their peers. Statistical insignificance of these effects reinforces the salience of the small number of ethnically diverse students in regional areas for any potential examinations of non-metropolitan students' takeup and perceptions of secondary mathematics.

Overall, all first-generation linguistically diverse migrant groups in Greater Sydney opted for HSC mathematics more often than English speakers. Among the second generation, all Asian students did so.

Advanced mathematics

We next examined the uptake of the most specialised mathematics unit, Mathematics Extension 2. In preliminary analyses, we considered the distributions of students in General Mathematics, Mathematics and Mathematics Extension 1. As mathematics units in NSW are tiered, we found it economical to focus on patterns in the study of Mathematics Extension 2 only as they were the reverse of those in General Mathematics with other units in between.

As per our previous estimation, the numbers of ethnically diverse students were too small to achieve credible estimates in regional NSW, again suggesting more research is required to understand the influence of spatial geographies on students' mathematics perceptions. Therefore, we focus our discussion on the metropolitan students using the same margin-informed approach to the odds ratios in Table 3.

Mathematics Extension 2 (ME 2) is a specialised unit for students who wish to pursue intensive mathematics programs at university. The overall participation rate in Greater Sydney was 7% among ATAR-eligible youth (Table 1). But in the comparison group of English monolinguals, this proportion was only 4%, all else being equal (Fig. 4). In contrast, among the HP East Asian first-generation migrants, 15% completed ME 2, one in six students, compared to less than one in 20 for the reference group. The uptake among first-generation LP East Asian students was slightly lower, at 9%, over twice more than 4%. Interestingly, the participation rate for first-generation Indo-Aryan language speakers and all other students who spoke some foreign language at home was also very high at 14% (Fig. 4). Thus HP East Asian students born overseas took ME2 more often than their peers from LP East Asian but not Indo-Aryan or Arabic-speaking countries.

Considering second-generation migrants who speak their parent's language in Fig. 5, we note that students in all three Asian groups were about three times (12, 12 and 11%) as likely to take Mathematics Extension 2 as the reference group with its 4%. Interestingly, students with comparable prior mathematics achievements who spoke Arabic were also much more likely to take advanced mathematics (9%). Yet, youth from other language backgrounds did not differ from the comparison group. Notably, Arabic-speaking students have received no attention in the literature on academic performance and ethnic capital. Our data suggest that although they choose mathematics at rates similar to other migrants, they target the most advanced course significantly more often.

This pattern of higher uptake among Asian and Arabic-speaking students also transpires among second-generation youth who do not speak parental languages. Figure 6 shows that in all comparison subgroups, about 8% of these students completed Mathematics Extension 2, compared to only 5% of youth from other linguistic backgrounds.

Summary and discussion

Our analysis shows that ethnic capital (Modood, 2004) is associated with higher rates of advanced mathematics participation and that youth from particular linguistic and cultural backgrounds are overrepresented in advanced secondary mathematics.

Table 3 Two-level logistic regressions: Mathematics Extension 2 in 2017 (1 = yes, 0 = no)

Mathematics Extension 2	Greater Sydney		Rest of NSW	
	Odds ratio	t statistic	Odds ratio	t statistic
Female	0.69**	−4.87	0.43**	−5.15
ATSI	0.62	−0.65	0.82	−0.33
Student born in Australia, Canada, NZ, UK, USA	Reference		Reference	
HP East Asia	1.54**	4.22	2.46	1.17
LP East Asia	0.67	−2.01	2.62	1.09
India, Pakistan +	1.46	2.22	2.4	1.32
Other countries	2.09**	7.87	1.12	0.32
Student language: English	Reference		Reference	
HP East Asian	1.81**	4.03	1.3	0.26
LP East Asian	1.89**	3.07	1.33	0.27
Indo-Aryan	1.81**	3.68	3.29	1.71
Arabic	1.25	0.92	1.71	0.29
Other non-English languages	0.98	−0.14	1.77	1.04
Both parents speak English at home	Reference		Reference	
HP East Asian	2.45**	5.99	0.95	−0.06
LP East Asian	2.33**	4.02	1.04	0.05
Indo-Aryan	2.34**	5.13	1.79	0.87
Arabic	2.39**	3.94	1.43	0.19
Other non-English languages	1.34	1.83	0.72	−0.65
Parents' education	1.05**	2.8	1.13**	2.87
Parental occupation: Neither prof manager	Reference		Reference	
One prof manager	0.98	−0.23	0.94	−0.3
Both prof manager	1.04	0.4	0.95	−0.23
Coeducational school in Year 12	Reference		Reference	
Girls-only	1.04	0.3	0.71	−0.47
Boys-only	0.93	−0.53	0.65	−0.71
Government school	Reference		Reference	
Catholic	1.07	0.49	0.81	−0.69
Independent	1.40**	2.74	1.06	0.2
Not selective school	Reference		Reference	
Partially selective	0.73	−1.46	1.89	0.94
Fully selective	1.16	0.85	1.03	0.04
NAPLAN Year 9 Numeracy score	1.02**	41.07	1.02**	18.77
Intra-class correlation rho	9%		29%	
N of schools	458		409	
N of students	30,692		12,020	

**$p < 0.01$

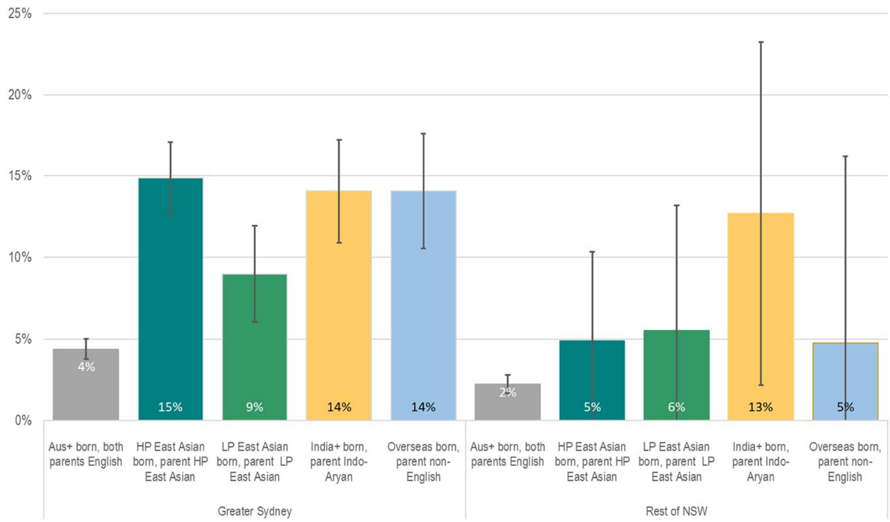

Fig. 4 Mathematics extension 2: margins based on Table 3. LD first-generation migrants who speak parental language versus monolingual students born in Australia and similar countries

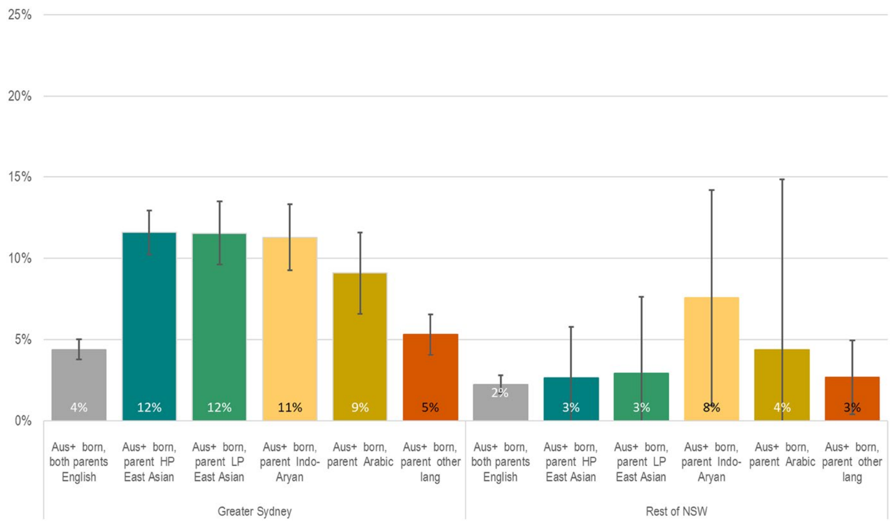

Fig. 5 Mathematics extension 2: margins based on Table 3. LD second-generation migrants who speak parental language versus monolingual students born in Australia and similar countries

This is undoubtedly the case for Greater Sydney. At least four significant conclusions follow from our analysis of mathematics participation among ethnically diverse students with comparable ability levels, family backgrounds and school characteristics. First, monolingual English-speaking students, migrants and Australian-born are, in relative terms, considerably less likely to take up secondary mathematics, inclusive of specialised units. Second, where participation is concerned, first-generation HP

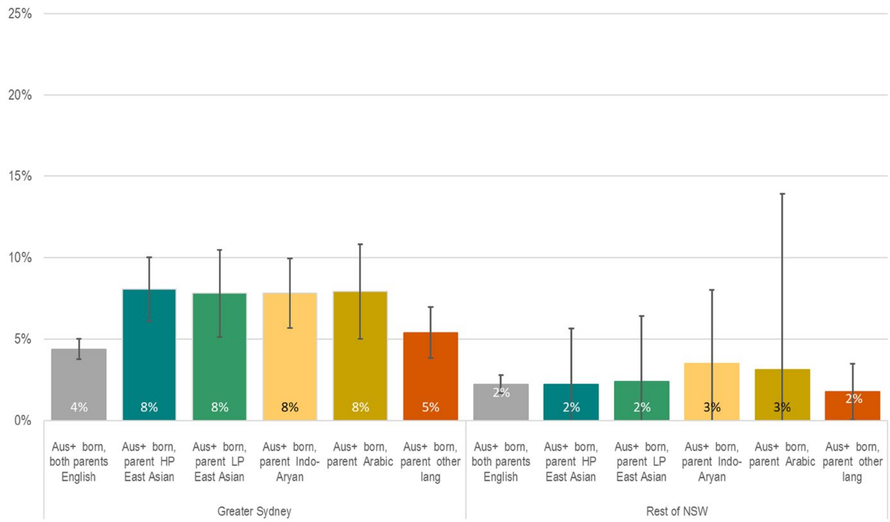

Fig. 6 Mathematics extension 2: margins based on Table 3. LD second-generation migrants who do not speak parental language vs monolingual students born in Australia, similar countries

East Asians are more likely to take mathematics but not ME2 compared to other migrants. Thus, it is vital to recognise the strong participation of non-Asian first-generation youth in advanced mathematics. While, within ethnic groups, first and second-generation students do not differ significantly in their ME2 uptake, speaking parental language boosts specialised mathematics participation among the latter. The final issue concerns the potentially challenging situation of the few ethnically diverse students outside of Greater Sydney and the broader challenge of access to specialist mathematics and mathematics teachers in these regions (Halsey, 2018).

Beyond access to specialist staff, small numbers of ethnically diverse students suggest that the social geography of communities and schools in the rest of NSW may relate to students' mathematics choices. While further research is required here, we hypothesise that there is tension within the social geography characterising the rest of NSW due to the small number of ethnically diverse youth. Low exposure to the cultural habitus of these students may amount to lower incentives for overall mathematics participation through undermining schools' cultures of mathematics due to the relative absence of diverse ethnic values. Either way, our results suggest that the association of mathematics participation with specific ethnic backgrounds (Modood, 2004) may have unintended consequences that need consideration in curricular reforms. School curriculum leaders need to be conscious of the ethnic compositions of their schools and communities when developing curricular offerings. Furthermore, this awareness needs to extend to junior schools to foster a culture of mathematics with an appreciation of the benefits that may be conveyed by various ethnic capitals (Modood, 2004).

Mathematics occupies a powerful place in the history of the senior secondary curriculum in Australia (Teese, 2013). It effectively supports matriculation and is often accessed by students in schools characterised by greater levels of social advantage (Dean et al., 2021; Perry & Southwell, 2014). Previously, no detailed analysis of access and participation concerning student and parent languages and migration experiences existed in Australia. Our study invites more detailed investigations of ethnic capital described by Ho (2020), Jerrim (2015) and Mu (2014) in the context of more diverse ethno-racial backgrounds. For this purpose collecting future data on self-identified race would be invaluable. Moreover, contemporary technological and methodological advances in natural language processing enable systematic analysis of rich narratives from thousands rather than dozens of culturally diverse parents and students on their educational aspirations, motivations and pathways. However, such data collections are yet to be created.

Our inclusion of the non-metropolitan areas of the state addresses the general absence of a specific focus in research on the experiences of youth in non-metropolitan schools (Roberts et al., 2022) and speaks to the cultural context of education in these areas. Rural regions' evident limited cultural diversity may hamper cultural bridging and magnify the problem of accessing mathematics for all students in these communities. While migrants remain a minority, their undisputed overrepresentation in advanced units directly predicates who enters high-status employment fields (such as medicine, Ho et al., 2022). When coupled with broader population characteristics, this segregation may curb professional families' willingness to move to non-metropolitan areas due to perceived limitations of educational accessibility.

As Teese (2013) notes, profound ethnocultural shifts shape education in Australia. This trend sees families seeking competitive advantage through access to selective or non-government schools. Families' linguistic and migration status and residence can matter immensely for access to advanced mathematics education. This amplifies segregation between school types, but also ethnically, and results in divisions in the distribution of schooling outcomes regarding access to university and certain elite professions. This trend needs better understanding as a potential chrysalis of future societal discontent and occupational segregation.

Appendix 1: country and language coding

Student country of birth Standard Australian Classification of Countries (SACC) (Australian Bureau of Statistics, 2008).[2]

English speaking:

1100; 1101 through 1199; 2100; 2102 through 2106; 12; 22; 1201; 2201; 8102; 8104.

[2] Our administrative data include students from some but not all countries listed in SACC or languages listed in ASCL. Countries and languages, which are not represented in the data, are not included in the list of our codes.

HP East Asian:

6102 Hong Kong
6201 Japan
5205 Singapore
6101 China
6203 Republic of Korea (South Korea)
6105 Taiwan.

LP East Asian:

5203 Malaysia
5204 Philippines
5202 Indonesia
5104 Thailand
5102 Cambodia
5105 Vietnam
5103 Laos
6202 Democratic People's Republic of Korea (North Korea).

Indo-Aryan

7103 India
7106 Pakistan
7105 Nepal
7101 Bangladesh

Student and parent language codes Australian Standard Classification of Languages (Australian Bureau of Statistics, 2016).

1201 English.

HP East Asian:

7101 Cantonese
7102 Hakka
7104 Mandarin
7106 Wu
7107 Min Nan
7199 Chinese, not elsewhere classified
7201 Japanese
7301 Korean
7999 Other Eastern Asian Languages, not elsewhere classified.

LP East Asian:

6301 Khmer
6302 Vietnamese
6401 Lao
6402 Thai
6499 Tai, not elsewhere classified
6502 Cebuano
6503 IIokano
6504 Indonesian
6505 Malay
6511 Tagalog
6512 Filipino
6517 Ilonggo (Hiligaynon)
6518 Javanese.

Indo-Aryan:

5103 Tamil
5201 Bengali
5202 Gujarati
5203 Hindi
5204 Konkani
5205 Marathi
5206 Nepali
5207 Punjabi
5208 Sindhi
5211 Sinhalese
5212 Urdu
5213 Assamese
5215 Kashmiri
5216 Oriya
5217 Fijian Hindustani
5299 Indo-Aryan, not elsewhere classified.
Arabic: 4202 Arabic.

Appendix 2: Information about missing data

Variable	Observations	Imputed	% Imputed	Min	Max
Statistical area level 1 (SA1)	67,206	0	0	0	1
ATAR	67,206	0	0	0	1
Mathematics courses	67,206	0	0	0	4
Female	67,206	0	0	0	1

Variable	Observations	Imputed	% Imputed	Min	Max
ATSI	67,206	0	0	0	1
Student's country of birth	67,203	3	0	1	5
Student language	62,350	4856	7	1	6
Parental language	61,734	5472	8	1	6
Parental education	61,036	6170	9	9	17
Parental occupation	59,763	7443	11	0	2
NAPLAN Year 9 Numeracy score	60,673	6533	10	247	920
Coeducational versus other schools	67,206	0	0	1	3
School sector	67,206	0	0	1	3
Selective school	67,206	0	0	0	2

Author contributions JS analyzed and interpreted the student data and drafted the initial version of the manuscript. PR procured the data and was a major contributor in writing and revising the manuscript. Both authors read, edited and approved the final version of the manuscript.

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Data availability The data that support the findings of this study are available from the NSW Education Standards Authority but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available.

Declarations

Competing interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

Ethical approval The data use for this article was approved by the University of Canberra Human Ethics Protocol Number 20170077.

References

Adamuti-Trache, M., & Sweet, R. (2014). Science, technology, engineering and math readiness: Ethnolinguistic and gender differences in high-school course selection patterns. *International Journal of Science Education, 36*(4), 610–634. https://doi.org/10.1080/09500693.2013.819453

Akther, A., & Robinson, J. (2014). Immigrant students' academic performance in Australia, New Zealand, Canada and Singapore. *Australian Association for Research in Education*. Retrieved from https://files.eric.ed.gov/fulltext/ED596765.pdf

Australian Bureau of Statistics. (2008). Standard Australian classification of countries (SACC), 2nd edn., Cat No 1269.0 Australian Bureau of Statistics.
Australian Bureau of Statistics. (2016). Australian Standard classification of languages (ASCL) Cat No 1267.0 Australian Bureau of Statistics
Australian Bureau of Statistics. (2021). Greater capital city statistical areas. Retrieved from https://www.abs.gov.au/statistics/standards/australian-statistical-geography-standard-asgs-edition-3/jul2021-jun2026/main-structure-and-greater-capital-city-statistical-areas/greater-capital-city-statistical-areas#cite-window1
Bourdieu, P. (1986). *The forms of capital*. Greenwood.
Clarkson, P. C. (2007). Australian Vietnamese students learning mathematics: High ability bilinguals and their use of their languages. *Educational Studies in Mathematics, 64*(2), 191–215.
Dean, J., Roberts, P., & Perry, L. B. (2021). School equity, marketisation and access to the Australian senior secondary curriculum. *Educational Review*, 1–21.
Dockery, A. M., Koshy, P., & Li, I. W. (2020). Culture, migration and educational performance: A focus on gender outcomes using Australian PISA tests. *The Australian Educational Researcher, 47*(1), 39–59.
NSW ESA, (2016). *HSC Course descriptions—Mathematics*. Retrieved from http://www.boardofstudies.nsw.edu.au/syllabus_hsc/course-descriptions/mathematics.html
Feliciano, C., & Lanuza, Y. R. (2016). The immigrant advantage in adolescent educational expectations. *International Migration Review, 50*(3), 758–792. https://doi.org/10.1111/imre.12183
Forgasz, H. (1998). The typical Australian university mathematics student: Challenging myths and stereotypes? *Higher Education, 36*(1), 87–108. https://doi.org/10.1023/A:1003183217302
Forgasz, H. (2006). *Australian Year 12 mathematics enrolments: Patterns and trends—Past and present*. International Centre of Excellence for Education in Mathematics, University of Melbourne.
Halsey, J. (2018). *Independent review into regional, rural and remote education—Final report*. Retrieved from https://www.education.gov.au/quality-schools-package/resources/independent-review-regional-rural-and-remote-education-final-report
Han, S. (2016). Staying in STEM or changing course: Do natives and immigrants pursue the path of least resistance? *Social Science Research, 58*, 165–183. https://doi.org/10.1016/j.ssresearch.2015.12.003
Ho, C. (2020). *Aspiration and anxiety: Asian migrants and Australian schooling*. Melbourne University.
Ho, C., Hu, W., & Griffin, B. (2022). Cultures of success: How elite students develop and realise aspirations to study medicine. *The Australian Educational Researcher*. https://doi.org/10.1007/s13384-022-00548-x
Hodgen, J., Pepper, D., Sturman, L., & Ruddock, G. (2010). *An international comparison of upper secondary mathematics education: 24 Country profiles*. Retrieved from http://www.nuffieldfoundation.org/sites/default/files/files/Country_profiles_outlier_NuffieldFoundation18_04_11.pdf
Jerrim, J. (2015). Why do East Asian children perform so well in PISA? An investigation of western-born children of East Asian descent. *Oxford Review of Education, 41*(3), 310–333.
Kirkham, J., & Chapman, E. (2022). Gender, achievement level and sociocultural factors in the mathematics course choices of year 10 students in Western Australia. *The Australian Educational Researcher, 49*(1), 97–114. https://doi.org/10.1007/s13384-020-00425-5
Kirkham, J., Chapman, E., & Wildy, H. (2020). Factors considered by Western Australian year 10 students in choosing year 11 mathematics courses. *Mathematics Education Research Journal, 32*(4), 719–741. https://doi.org/10.1007/s13394-019-00277-y
Klein, D. (2014). *MIMRGNS: Stata module to run margins after mi estimate.* Retrieved from https://EconPapers.repec.org/RePEc:boc:bocode:s457795
Knowles, C. (2010). Theorising race and ethnicity: Contemporary paradigms and perspectives. In P. H. Collins & J. Solomos (Eds.), *The SAGE handbook of race and ethnic studies* (pp. 23–42). Sage.
Law, H. (2018a). Gender and mathematics: Pathways to mathematically intensive fields of study in Australia. *Advances in Life Course Research, 37*, 42–56. https://doi.org/10.1016/j.alcr.2018.07.002
Law, H. (2018b). Why do adolescent boys dominate advanced mathematics subjects in the final year of secondary school in Australia? *Australian Journal of Education, 62*(2), 1–23.
Lee, J., & Zhou, M. (2015). *The Asian American achievement paradox*. Russell Sage Foundation.
Levels, M., Kraaykamp, G., & Dronkers, J. (2008). Immigrant children's educational achievement in western countries: Origin, destination, and community effects on mathematical performance. *American Sociological Review, 73*(5), 835–853. https://doi.org/10.1177/000312240807300507
Little, R. J. A., & Rubin, D. B. (2002). *Statistical analysis with missing data* (2nd ed.). Wiley.
Marks, G. N. (2013). *Education, social background and cognitive ability: The decline of the social*. Routledge.

McMillan, J., Beavis, A., & Jones, F. L. (2009). The AUSEI06: A new socioeconomic index for Australia. *Journal of Sociology, 45*(2), 123–149.
Modood, T. (2004). Capitals, ethnic identity and educational qualifications. *Cultural Trends, 13*(2), 87–105.
Mu, G. M. (2014). Chinese Australians' Chineseness and their mathematics achievement: The role of habitus. *The Australian Educational Researcher, 41*(5), 585–602.
Newman, D. A. (2014). Missing data: Five practical guidelines. *Organisational Research Methods, 17*(4), 372–411. https://doi.org/10.1177/1094428114548590
Nicholas, J., Poladian, L., Mack, J., & Wilson, R. (2015). Mathematics preparation for university: Entry, pathways and impact on performance in first year science and mathematics subjects. *International Journal of Innovation in Science and Mathematics Education, 23*(1), 37–51.
OECD. (2006). *Where immigrant students succeed—A comparative review of performance and engagement in PISA 2003*. OECD.
Pang, B., & Mu, G. M. (2019). *Interpreting the Chinese diaspora: Identity, socialisation, and resilience according to Pierre Bourdieu*. Taylor and Francis.
Perry, L. B., & Southwell, L. (2014). Access to academic curriculum in Australian secondary schools: A case study of a highly marketised education system. *Journal of Education Policy, 29*(4), 467–485.
Roberts, P., Downes, N., & Reid, J. A. (2022). Engaging rurality in Australian education research: Addressing the field. *The Australian Educational Researcher*. https://doi.org/10.1007/s13384-022-00587-4
Royston, P., & White, I. R. (2011). Multiple imputation by chained equations (MICE): Implementation in Stata. *Journal of Statistical Software, 45*(4), 1–20.
Schafer, J. L., & Graham, J. W. (2002). Missing data: Our view of the state of the art. *Psychological Methods, 7*(2), 147–177.
Sikora, J., & Pitt, D. G. W. (2019). Does advanced mathematics help students enter university more than basic mathematics? Gender and returns to Year 12 mathematics in Australia. *Mathematics Education Research Journal, 31*(2), 197–218. https://doi.org/10.1007/s13394-018-0249-3
Sikora, J., & Pokropek, A. (2021). Immigrant optimism or immigrant pragmatism? Linguistic capital, orientation towards science and occupational expectations of adolescent immigrants. *Large-Scale Assessments in Education, 9*(7), 1–24. https://doi.org/10.1186/s40536-021-00101-9
Teese, R. (2013). *Academic success and social power: Examinations and inequality*. Melbourne University.
Williams, R. (2012). Using the *margins* command to estimate and interpret adjusted predictions and marginal effects. *Stata Journal, 12*(2), 308–331.
Wilson, R. (2015). Why it matters that student participation in maths and science is declining. *The Conversation*. Retrieved from https://theconversation.com/why-it-matters-that-student-participation-in-maths-and-science-is-declining-47559
Xie, Y., & Goyette, K. (2003). Social mobility and the educational choices of Asian Americans. *Social Science Research, 32*(3), 467–498. https://doi.org/10.1016/S0049-089X(03)00018-8
Zhu, Y., & Leung, F. K. S. (2011). Motivation and achievement: Is there an East Asian model? *International Journal of Science and Mathematics Education, 9*(5), 1189–1212. https://doi.org/10.1007/s10763-010-9255-y

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