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Why aren't students studying higher level maths?

How ATAR scaling may affect maths uptake

Centre for Education Statistics and Evaluation

Publication and contact details

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Centre for Education Statistics and Evaluation
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Acronyms

ABS	Australian Bureau of Statistics
ANCOVA	Analysis of Covariance
ATAR	Australian Tertiary Admissions Rank
ATSI	Aboriginal and Torres Strait Islander
BEC	Board Endorsed Course
BOSTES	Board of Studies Teaching and Educational Standards
CESE	Centre for Education Statistics and Evaluation
COAG	Council of Australian Governments
coed	coeducational
DiD	Differences-in-Differences
HSC	Higher School Certificate
HSIE	Human Society and Its Environment
IRSD	Index of Relative Socio-Economic Disadvantage
KLA	Key Learning Area
NAPLAN	National Assessment Program - Literacy and Numeracy
NESA	NSW Education Standards Authority
NSW	New South Wales
PDHPE	Personal Development Health and Physical Education
SA1	Statistical Area 1
SC	School Certificate
sd	standard deviation
SE	standard error
SEIFA	Socio-Economic Indexes for Areas
SES	socio-economic status
STEM	Science, Technology, Engineering and Mathematics
TAFE	Technical and Further Education
UAC	Universities Admission Centre
VET	Vocational Education and Training

Abstract

Despite the growing focus on Science, Technology, Engineering and Maths (STEM) in education, in recent years there has been a declining trend in enrolments in the Year 12 subject HSC Mathematics (includes calculus; commonly referred to as ‘2 Unit Mathematics’) in New South Wales. One possible explanation for this trend could be the existence of a scaling advantage for HSC General Mathematics (does not include calculus) in Year 12. The current study investigated whether there was a scaling advantage for HSC General Mathematics over HSC Mathematics (excluding the Mathematics Extension courses) during the period from 2009 to 2013 and examined the characteristics and factors associated with students’ subject choices. Findings showed a significant scaling advantage for HSC General Mathematics over the period from 2009 to 2013, ranging between an additional 5.3 to 6.5 scaled marks. Some types of students and schools had higher proportions studying HSC General Mathematics than others. When controlling for student and school characteristics, students and schools of relatively higher socioeconomic status, with lower average mathematics scores in Year 10 and/or who studied less average units in certain Key Learning Areas (e.g. English) were more likely to choose HSC General Mathematics. Results also showed that students who went on to study STEM in university regretted not taking HSC Mathematics. In addition, there was evidence that students who chose to study HSC General Mathematics were more influenced by concerns about perceived subject workload than a perceived scaling advantage.

1. Introduction

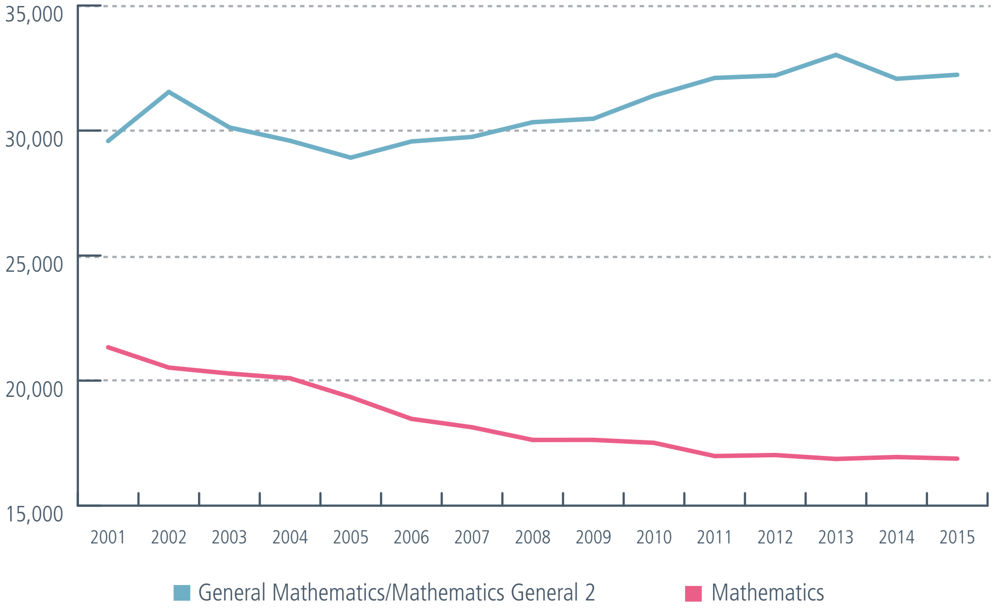
In recent years, participation in Science, Technology, Engineering and Mathematics (STEM) subjects has garnered increased public focus and worldwide coverage. In Australia, the contribution that STEM makes to the economy is substantial, with the advanced physical and mathematical sciences sector currently estimated to contribute over 22 per cent of Australia's economic activity, adding approximately $292 billion per year in gross value-added to the economy (Australian Academy of Science 2015). The importance of innovation and technology to the world economy has also shifted government and schools' priorities to place a greater emphasis on STEM through education policy. For example, the Australian federal government recently announced $112 million in spending to boost engagement in STEM among young Australians (Commonwealth of Australia 2016).

Despite the increased focus on STEM in education, student enrolments in fundamental STEM subjects such as mathematics that includes calculus have decreased over the last few decades in Australia (Board of Studies Teaching and Educational Standards NSW 2016a; Dekkers & de Laeter 2001; Lyons & Quinn 2015). In New South Wales (NSW), overall enrolments in mathematics in the Higher School Certificate (HSC) have increased by seven per cent from 2001 to 2015. However, enrolments in the HSC Mathematics course, an intermediate mathematics course that includes calculus, decreased by 4,453 enrolments over this period (see Figure 1 below). This reflects a drop from 39 per cent of all mathematics enrolments in the HSC in 2001 to 29 per cent in 2015. At the same time, enrolments in the HSC General Mathematics course (does not include calculus; renamed Mathematics General 2 in 2014) have increased by nine per cent since 2001. These enrolment trends suggest that there has been a shift from HSC Mathematics towards HSC General Mathematics, which may have implications for a future where STEM skills are increasingly important.

Figure 1:

Annual Enrolments in HSC General Mathematics and HSC Mathematics – 2001-2015

Source: Board of Studies Teaching and Educational Standards NSW (2016a).



These trends in mathematics enrolments have led to questions about the university admission processes, in particular the scaling of the Australian Tertiary Admissions Rank (ATAR) and the lack of pre-requisites for studying tertiary STEM subjects. In a survey of NSW mathematics teachers, 51 per cent reported believing that students were picking Year 12 mathematics subjects below their ability, with a number of respondents stating that students were doing so to maximise their ATARs[1] (Mathematical Association of New South Wales 2014). This view was also echoed in a survey of university students who were required to take mathematics bridging courses because they did not study mathematics at a sufficiently advanced level in high school. Among the surveyed students, 45 per cent[2] reported maximising ATAR as a major reason for not studying higher levels of mathematics in school (Gordon & Nicholas 2013).

Policymakers have also publicly criticised the impact of the university admission processes on decreasing STEM enrolments and are proposing policy solutions to arrest these trends. Some have proposed building on “aspiration rather than compulsion” (Association of Heads of Independent Schools of Australia 2015, p. 2), such as the Council of Australian Governments’ (COAG) Education Council recommending the use of university entrance bonus point schemes for studying mathematics and advanced STEM subjects in schools (COAG Education Council 2015). Others have suggested making STEM study in school mandatory for progression to tertiary STEM studies through the reintroduction of a pre-requisite of at least Year 12 intermediate mathematics (i.e. HSC Mathematics) for all bachelor programs in science, engineering and commerce (Australian Academy of Science 2016). Recently, the Board of Studies Teaching and Educational Standards (BOSTES) NSW, now known as the NSW Education Standards Authority (NESA), announced new draft reforms that introduce new common content and marking scales between HSC General Mathematics and HSC Mathematics to “provide a disincentive to students choosing lower-level courses to gain a perceived advantage in their ATAR” (Board of Studies Teaching and Educational Standards NSW 2016b, p. 18). These reforms are set to be implemented from 2019.

Two factors that may be associated with the apparent link between taking the HSC General Mathematics course and maximising ATAR are student demographics and subject offerings in high school. Both of these factors have changed substantially since scaling was first introduced in NSW with the 1964 implementation of quotas on university places (Universities Admissions Centre 2015). Across Australia, retention rates to Year 12 drastically increased in the 1980s, from only 35 per cent in 1982 to 77 per cent in 1992 (Ainley, Kos & Nicholas 2008). This led to more diversity in Year 12 cohorts in terms of student characteristics (e.g. wider range of academic ability and increased proportion of female students) and in terms of subject preferences (Dekkers & de Laeter 2001). In response to this increased diversity, subject offerings in high schools began to expand in the 1980s, giving students more choice in their study options (Dekkers & de Laeter 2001). This increase in course diversity, combined with the elimination of pre-requisites for university STEM courses, may have made it less likely that students would choose to study higher level science and mathematics in Year 12. Indeed, if these subjects are no longer necessary to gain acceptance to a tertiary STEM degree, students may choose alternatives that better fit their preferences. This suggests that wider diversity in both student preferences and high school subject offerings are likely contributing factors to the reduction in enrolments in STEM subjects observed across Australia (Lyons & Quinn 2015).

Although much of the current scaling process was in place before these developments, these factors are still relevant to a situation where HSC General Mathematics students, on average, achieve higher scaled marks in mathematics than similar HSC Mathematics students, herein defined as a scaling advantage for HSC General Mathematics. Scaling is used to compare the marks of groups of students that study different subjects to account for the fact that a student’s mark and rank in a particular subject is dependent on both their ability and the abilities of others who study the same subject (Universities Admissions Centre 2015). Scaling achieves this through a system of equations that equates the scaled mean of all students who studied a subject (for example HSC Mathematics) to the scaled means those same students achieved in all their other subjects (Universities Admissions Centre 2015). This raises scaled marks for a subject if the students who studied HSC Mathematics performed better in their other subjects relative to the students who did not study HSC Mathematics. This means that scaling is dependent on the overall subject choices made by students with differing ability and is therefore vulnerable to changes in the preferences that drive these choices.

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[1] This was an open response question asking why teachers believed students were studying mathematics below their ability.

[2] This figure was calculated by combining the two groups of students included in the Gordon & Nicholas (2013) study, those that completed mathematics in the HSC (n=26) and those that started but dropped mathematics in the HSC (n=12). Seven and ten students from each respective group stated that they made their mathematics choice to maximise ATAR: 17/38 = 45 per cent.

Recent research indicates that there may be a scaling advantage for HSC General Mathematics over HSC Mathematics. Pitt (2015) examined results for all students in NSW who studied either HSC General Mathematics or HSC Mathematics in 2013 and compared their Year 12 mathematics scaled marks and their Year 10 School Certificate (SC) scores in mathematics from 2011. Results showed that for students with similar Year 10 SC scores, those who chose HSC General Mathematics achieved higher scaled marks than those who chose HSC Mathematics, demonstrating a significant scaling advantage for HSC General Mathematics[3]. Despite mathematics that includes calculus (e.g. HSC Mathematics) being essential to tertiary STEM studies, the competition for university places and the need to achieve a high ATAR may drive many students who want to pursue STEM studies to choose mathematics that does not include calculus (e.g. HSC General Mathematics) in order to maximise their ATAR (Gordon & Nicholas 2013). The existence of a scaling advantage combined with the additional challenge of studying HSC Mathematics (Gordon & Nicholas 2013; Mathematical Association of New South Wales 2014) may be persuasive factors in leading students to choose the HSC General Mathematics course.

Aims

The objective of this research was to examine whether the current scaling process[4] used in NSW provides a disincentive for students to study HSC Mathematics. Specifically, the current study aimed to address four key research questions:

1. Has there been a scaling advantage for HSC General Mathematics over HSC Mathematics for the years 2009 to 2013?
2. Of the student and school characteristics available, which student- and school-level characteristics are related to student choice of HSC General Mathematics rather than HSC Mathematics?
3. Do students studying STEM subjects at university regret choosing HSC General Mathematics?
4. Does the perceived scaling advantage or subject workload have greater influence on choosing HSC General Mathematics over HSC Mathematics?

The current study aimed to re-examine the results reported by Pitt (2015) by using a more rigorous method of comparing outcomes for matched students with similar characteristics (described in further detail in the Method section). The current study also extends these earlier findings by investigating scaling outcomes across five years and by examining the characteristics and factors associated with students' subject choices as well as their views on their course choice once at university. However, the current study does not examine scaling in relation to the Mathematics Extension subjects nor does it cover the full breadth of characteristics and factors that impact subject choice such as students' interests.

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[3] Pitt (2015) found an effect size of 0.35. Effect size is a standardised measure of the difference in performance of two groups on an outcome (e.g. the mean difference in scaled marks between HSC General Mathematics and HSC Mathematics) in terms of the standard deviation of the outcome.

[4] The current scaling process for mathematics will be changed in 2019 through the introduction of a common marking scale between HSC General Mathematics and HSC Mathematics. For more details, see Board of Studies Teaching and Educational Standards NSW (2016b).

2. Method

Data

Three key datasets were used in this research: a student mathematics dataset, a dataset on local area characteristics and a dataset on post-HSC outcomes, with other variables derived from these data.

Student Mathematics Data

This dataset contained mathematics results for all students, both government and non-government, who took the HSC General Mathematics course or the HSC Mathematics course from the years 2009 to 2013[5]. This included each student's moderated school assessment mark and final exam mark[6], as well as their raw marks for Year 10 SC tests in English and Mathematics[7]. The dataset also included the number of HSC units studied under each Key Learning Area (KLA) for each student as well as a range of other student- and school-level characteristics[8]. The dataset also included the number of units studied in Board Endorsed Courses (BEC), which do not have external examinations, and Vocational Education and Training (VET) courses.

Australian Census Data

Australian 2011 Census data[9] was used to obtain further information on the demographic characteristics of each student's and school's local area[10]. This included socio-economic status (SES), proportion of local population that are Aboriginal and Torres Strait Islanders, unemployment rates and other relevant demographic, economic and educational measures.

Post-Secondary Expectations and Destinations Survey

Data from the 2015 Post-Secondary Expectations and Destinations Survey[11] conducted by the Centre for Education Statistics and Evaluation (CESE) was used to obtain information on post-school destinations (i.e. work and university studies) for a stratified sample of Year 12 completers from the 2013 and 2014 HSC cohorts (n = 9,040). This survey also included information on students' mathematics course choice for the HSC, including whether they regretted their choice, what or who influenced their course choice, and whether it fit their academic ability. This dataset also included information on Year 9 NAPLAN results and SES for all respondents.

Derived Variables

A number of other variables were created or imputed. HSC scaled scores were not provided and were estimated through linear interpolation and extrapolation (see Appendix 1) using information provided in the published UAC scaling tables (Universities Admission Centre 2016). School-level variables were also created, including an area-based measure of school SES[12] and average SC Mathematics mark. In total, 186 characteristics were included to identify matched pairs of students to include in the scaling analysis, as described in the next section.

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[5] This dataset was provided by BOSTES.

[6] The standardised HSC mark was calculated as an equally weighted average of these two marks.

[7] SC raw marks provided important baseline information on students' prior academic performance/ability.

[8] These characteristics included gender, school sector and whether the school was a coeducational (coed), girls only or boys only school.

[9] Sourced from the Australian Bureau of Statistics (ABS) (http://www.abs.gov.au/websitedbs/censushome.nsf/home/Census).

[10] This was at the level of Statistical Area 1 (SA1) which is a geographic classifier created by the ABS and is the smallest geographic unit published in the Census data.

[11] Respondents were selected through stratified random sampling with strata based on school sector and local area. Furthermore, all Aboriginal and Torres Strait Islander Year 12 completers were included in the sample. For more information on the 2015 Post-Secondary Expectations and Destinations Survey, please refer to Myers et al. (2015) (http://cese.nsw.gov.au/publications-filter/annual-report-nsw secondary-students-post-school-destinations-and-expectations-2015).

[12] The Socio-Economic Indexes for Areas (SEIFA) Index of Relative Socio-Economic Disadvantage (IRSD) score developed by the ABS was used to measure SES. This included the IRSD score for the student and school SA1. In addition, a school mean IRSD score was calculated by averaging the IRSD score of all students who went to that school and took any mathematics for the HSC.

Statistical analyses

Estimating the scaling advantage

It is important to recognise that subject choice may be influenced by confounding factors that are also related to student achievement. This means that simply comparing mean scaled scores between HSC Mathematics and HSC General Mathematics may misrepresent the true causal impact of subject choice[13]. To control for the influence of potentially confounding factors, the current study used a double propensity score adjustment (a type of propensity score matching method) to estimate the scaling advantage associated with taking HSC General Mathematics over HSC Mathematics.

First, a logistic regression model was used to generate a propensity score for each student. These propensity scores reflected the probability that a given student would take HSC Mathematics, based on their individual characteristics. The propensity scores were then used to match students who took HSC Mathematics to those with the closest propensity score who took HSC General Mathematics. Within the matched sample, a covariate adjustment using the propensity score was then used to impute the missing potential outcome for each student who took HSC Mathematics (i.e. the score they would have received had they taken HSC General Mathematics). This method has been shown to reduce the effects of confounding covariates when using observational data to estimate causal effects (Austin 2014). More detailed information regarding the analytical approach used in the current study is presented in Appendix 2.

Identifying predictors of mathematics subject choice

A Hybrid or Between-Within method (Allison 2014; Sjölander et. al. 2013) was used to examine the student- and school-level characteristics associated with students' choices to study HSC General Mathematics over HSC Mathematics. This approach consists of a combination of fixed effects and random effects regression models that take into account both the impact of a school's characteristics on the choices of all its students ('between schools effect') and the impact of a student's characteristics on their own choice ('within schools effect'). This involved calculating a school mean for each student-level characteristic[14] as well as each student's deviation from their school's mean and then estimating the effect of both using random effects logistic regression. Unlike fixed-effects regressions which remove all between-school variability, this method allowed the impact of school-level characteristics such as school type to be estimated. For further details, please refer to Appendix 3.

Identifying whether tertiary students regret their mathematics choices

In the Expectations and Destinations Survey, respondents who had completed the HSC in previous years were asked about whether they regretted their mathematics subject choice. Regret was measured through the question "Looking back now on your choice of mathematics unit or level, would you have:"

- "Selected the same math unit(s)"
- "Selected a more challenging math unit"
- "Selected an easier math unit"
- "Would not have selected a math unit for my HSC at all".

Multinomial logistic regression was used to analyse the impact of university degree studied (studying STEM subjects relative to studying Society and Culture, i.e. Humanities), prior achievement (i.e. Year 9 NAPLAN scores) and other student characteristics on whether respondents regretted their mathematics choice. Regressions were conducted using sampling weights that accounted for the stratified survey design. For further details, please refer to Appendix 4.

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13 In 2013, simply comparing scaled mark means would yield a scaling advantage of almost 10 marks for the HSC Mathematics course over the HSC General Mathematics course (31.1 and 21.5 mean scaled marks respectively).

14 For example, the mean student SC mathematics mark and the mean student SES (IRSD) score was estimated for each school.

Determining whether perceived scaling advantages or workload influenced mathematics subject choice

In the Expectations and Destinations Survey, respondents were asked a number of questions regarding the factors that influenced their mathematics choice. Respondents were asked three questions about whether their mathematics choice was influenced by a perceived scaling advantage and/or lighter workload:

- On the perceived scaling advantage: "Could you please tell me which of these apply to you - I thought [mathematics choice] would help to get a higher ATAR" with binary response options of "Yes" and "No"
- On the perceived difficulty: "When you selected your maths level for Years 11 and 12, did you choose a maths that you thought would be ..." with categorical response options of "Easy for you", "About right for you" and "Hard for you"
- On the amount of homework required: "Could you please tell me which of these apply to you - There was less homework than the level above" with binary response options of "Yes" and "No".

Logistic or multinomial logistic regression models were used to investigate if there were correlations between mathematics subject choice and whether students' choices were influenced by homework required, perceived scaling advantage or ease of subject[15]. These models also controlled for each student's Year 9 NAPLAN numeracy score. Regressions were conducted using sampling weights that accounted for the stratified survey design. For further details, please refer to Appendix 5.

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[15] Separate regressions were conducted for each of the three questions as the outcome. For further details, please refer to Appendix 5.

3. Findings

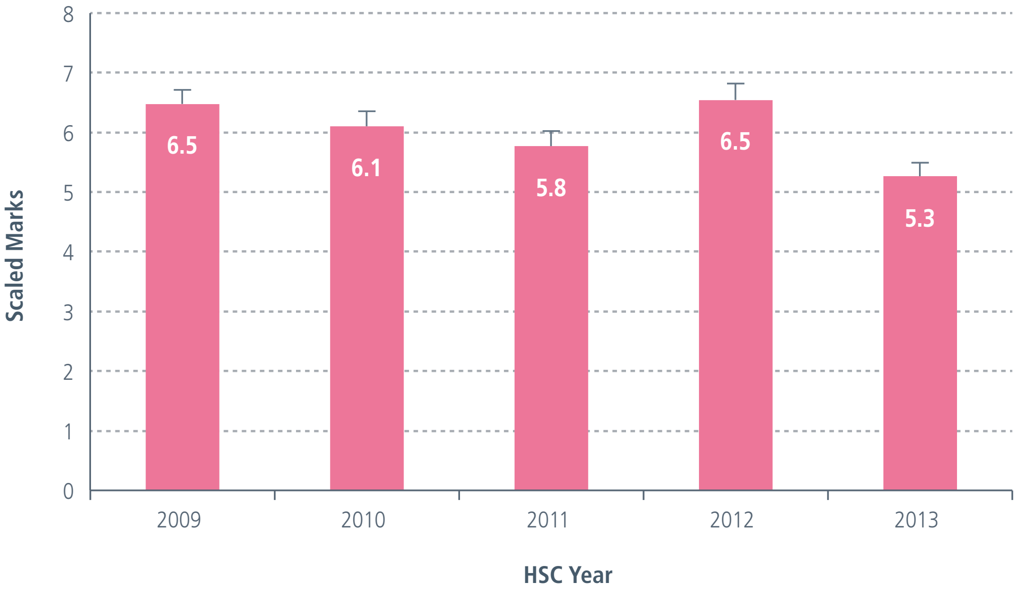
Estimating the scaling advantage

Results showed a substantial and statistically significant scaling advantage for HSC General Mathematics over HSC Mathematics from 2009 through 2013[16]. As shown in Figure 2, students who studied HSC Mathematics would have scored between 5.3 and 6.5 scaled marks more if they had studied HSC General Mathematics. In terms of effect size[17], the scaling advantage ranged from 0.62 standard deviations (sd) in 2009 to 0.48 sd in 2013, both of which are larger than the effect observed in the Pitt (2015) analysis (0.35)[18].

Figure 2:

Scaling Advantage of HSC General Mathematics over HSC Mathematics 2009-2013

Source: CESE analysis of BOSTES student mathematics data (2016)



Identifying predictors of mathematics subject choice

There were a number of characteristics associated with choosing to study HSC General Mathematics. Figure 3 presents the impact of some notable and statistically significant ($p<0.05$), student- and school-level predictors on choosing HSC Mathematics over HSC General Mathematics, presented as odds ratios with a logarithmic scale on the vertical axis. An odds ratio above one means that the odds of choosing HSC Mathematics are higher with an increase in that predictor; odds ratios below one means that the odds of choosing HSC Mathematics are lower with an increase in that predictor. Figure 3 shows that the odds of choosing HSC Mathematics are 1.2 times greater for every additional unit studied by a student in the English KLA, above the school average. If a school's average number of units studied in the English KLA increases by one unit, the odds are 21.74 times greater. Since studying two units of English is compulsory in the HSC, more than two units in the English KLA means that students and schools were studying English Extension units. Thus, students and schools that studied the English Extension units were more likely to study HSC Mathematics. For SC Mathematics standardised score, the odds are 7.63 times greater with a one standard deviation increase in a student's score relative to their school average and 3.5 times greater with a one standard deviation increase in a school's average score. On the other hand, the odds are lower with increases in SES and the number of units studied in BEC, both at the student and school level.

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[16] For checks on the validity and robustness of the results using alternative methods, please refer to Appendix 2.

[17] Effect size is a standardised measure of the difference in performance of two groups on an outcome (e.g. the mean difference in scaled marks between HSC General Mathematics and HSC Mathematics) in terms of the standard deviation of the outcome.

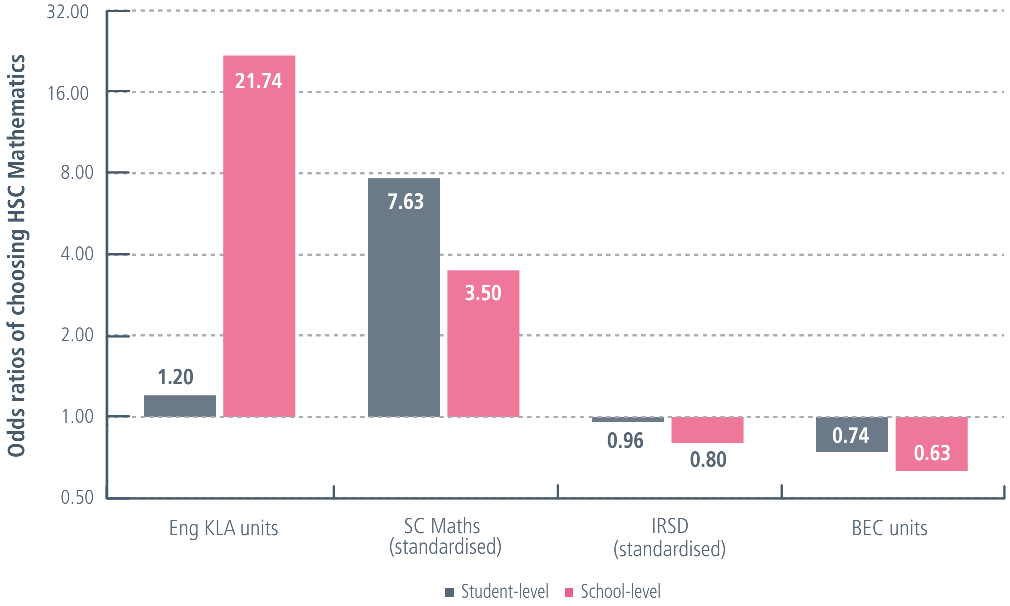
[18] Results in the current study differed from Pitt (2015) due to differences in sampling. Unlike in Pitt (2015), extension mathematics students were not included in the current study. When included, results were approximately equal to Pitt (2015). For further details, please refer to Appendix 2.

These effects, which are net of other effects like score in SC Mathematics, are smaller than those of English KLA units and SC Mathematics score, but are still statistically significant. Other predictors that increased the odds of choosing HSC Mathematics were more units studied in the Science, Human Society and its Environment (HSIE), Languages and Art KLAs. Other predictors that decreased the odds of choosing HSC Mathematics were more units studied in the Personal Development Health and Physical Education (PDHPE) KLA and Vocational Education and Training (VET) courses. For further details on these results, please refer to Appendix 3.

Figure 3:

Impact of student- and school-level characteristics on choosing HSC Mathematics

Source: CESE analysis of BOSTES student mathematics data (2016)



Note: all were significant at the five per cent level of significance.

Once student- and school-level characteristics were adjusted for, results showed that certain types of schools were more likely than others to have students who chose HSC General Mathematics and potentially benefitted from the scaling advantage. Students from Technical and Further Education (TAFE) colleges had the highest odds of taking HSC General Mathematics, while students from government boys' schools had the lowest odds. These two were the only school types with statistically significant differences ($p<0.05$) from other school types.

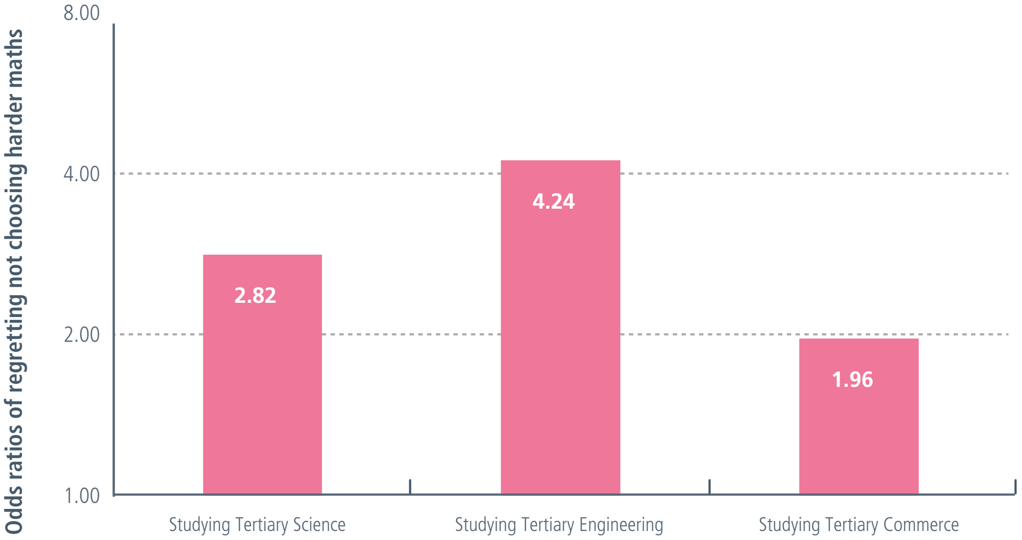
Identifying whether tertiary students regret their mathematics choices

Despite the scaling advantage associated with choosing HSC General Mathematics, a significant proportion of students who went on to study tertiary STEM subjects at university and had studied HSC General Mathematics reported wanting, in hindsight, to have selected more challenging mathematics. Amongst school completers in 2013 and 2014 who took HSC General Mathematics and went on to tertiary education, Figure 4 shows the relationship between studying tertiary STEM subjects at university and wishing to have done harder mathematics in their HSC. Results are presented as odds ratios with a logarithmic scale on the vertical axis. In comparison with students who studied tertiary Humanities, the odds of wishing to have done harder mathematics were 2.82 times greater for those who studied tertiary Science. The odds were 4.24 times greater for those who studied tertiary Engineering and 1.96 times greater for those who studied tertiary Management and Commerce compared to students who studied tertiary Humanities. For further results and model specifications, please refer to Appendix 4.

Figure 4:

Whether tertiary STEM students would have selected more challenging mathematics than HSC General Mathematics

Sources: CESE analysis of Destinations Survey data (2016)



Note: all were significant at the five per cent level of significance.

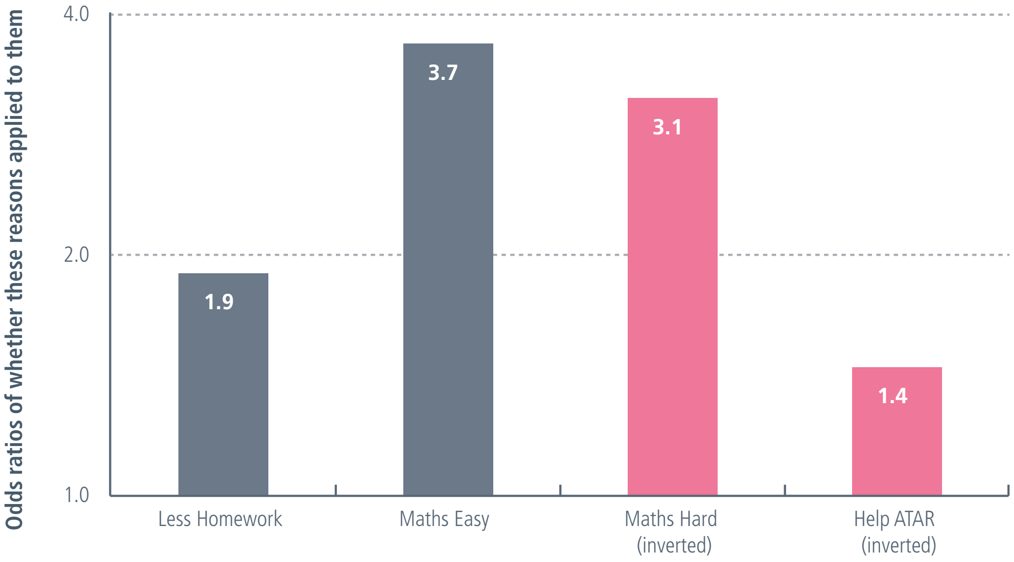
Determining whether perceived scaling advantages or workload influenced mathematics subject choice

Despite the evidence of a scaling advantage for HSC General Mathematics, it appears that many students believed that HSC Mathematics had the scaling advantage. Results presented in Figure 5 show the odds ratios (with a logarithmic scale on the vertical axis) associated with the factors that school completers in the Expectations and Destinations Survey reported influenced their mathematics choice. For this analysis, results examining whether the choice was made to lower homework or because they perceived the course as easy are shown for HSC General Mathematics students relative to HSC Mathematics students. In contrast, results for the influence of helping ATAR and whether they perceived the course as hard are inverted, showing the outcomes for HSC Mathematics students compared to HSC General Mathematics students. Relative to HSC General Mathematics students, the odds of making their course choice in order to maximise ATAR were 1.4 times greater for HSC Mathematics students. In contrast, the odds of being influenced by less homework were 1.9 times greater for HSC General Mathematics students than HSC Mathematics students. For perceived difficulty of their course choice, the odds were greater for HSC General Mathematics students to think their subject was easy but the odds were greater for HSC Mathematics students to think their subject was hard. From these results, it appears that HSC General Mathematics students were more influenced by perceptions of a lower workload rather than a scaling advantage.

Figure 5:

Stated influences on choosing HSC General Mathematics over HSC Mathematics

Source: CESE analysis of Destinations Survey data (2016)



Note: all were significant at the five per cent level of significance.

4. Discussion

Findings from the current study show a significant scaling advantage for the HSC General Mathematics course over the HSC Mathematics course from 2009 to 2013. Whether students were consciously maximising ATAR (Gordon & Nicholas 2013; Mathematical Association of New South Wales 2014) or reducing perceived workload in their choosing of HSC General Mathematics, this scaling advantage may have provided a substantial disincentive to take HSC Mathematics. For example, in 2013 the average scaling advantage for taking HSC General Mathematics was 5.3 scaled marks, which is approximately equal to 1.3 ATAR[19] points. There may also be further increases beyond this estimate as HSC General Mathematics may leave more study time for other subjects (Gordon & Nicholas 2013). There is evidence from the Expectations and Destinations Survey that many students who chose to study HSC General Mathematics did so to maximise their ATAR (53 per cent). Therefore, this scaling advantage is likely to be partially driving the declining enrolments in HSC Mathematics.

This scaling advantage also appears to have benefitted some students more than others. Relative to their school average, students who either took more PDHPE or non-ATAR-eligible (VET and BEC) units, those with lower SC Mathematics scores and those from higher SES backgrounds were more likely to choose HSC General Mathematics. Thus they benefitted more from the scaling advantage compared to students, relative to their school average, who studied more ATAR-eligible (e.g. English and Languages) units, those with higher SC Mathematics scores and those from lower SES backgrounds who were more likely to choose HSC Mathematics. These differences also occurred between schools, with students from schools of higher average SES, lower average SC Mathematics scores or lower average ATAR-eligible units more likely to study HSC General Mathematics. Given that the purpose of scaling is to rank students on overall academic merit (Universities Admissions Centre 2015), it appears that scaling is working in reverse between HSC Mathematics and HSC General Mathematics, raising questions around fairness.

However, evidence from the Expectations and Destinations Survey showed that many students who went on to study tertiary STEM subjects regretted their choice to take HSC General Mathematics and in hindsight would have selected harder mathematics. A significantly higher proportion of tertiary STEM students who studied HSC General Mathematics reported wishing they had studied more challenging mathematics than tertiary students studying Humanities. One possible interpretation of this finding is that students who studied HSC General Mathematics may not have felt sufficiently prepared for the level of mathematics required in their tertiary STEM studies. These findings suggest that addressing the scaling advantage may help to ensure that students choose mathematics subjects that more adequately prepare them for their future studies and careers.

Despite the presence of a scaling advantage for HSC General Mathematics, analysis of the Expectations and Destinations Survey found that many students seemed to be more driven by the perceived workload advantages rather than a belief in a scaling advantage. For example, relative to HSC Mathematics students, students who took HSC General Mathematics were more likely to report making this choice because they perceived it to be an easier subject with a lighter homework load rather than to help their ATAR. While many students may still be trying to maximise their ATAR by taking HSC General Mathematics, these results suggest that the perceived lower workload and greater ability to focus on other subjects may be influential factors for at least some students. The implication of this is that even if the scaling issue is addressed through the forthcoming NESA HSC reforms, further efforts may be needed to counterbalance the influence of these factors and to encourage students to study the course that suits their ability.

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[19] Calculated by using Table A9 in Universities Admission Centre (2016) and: 1) dividing all ATAR aggregates by their corresponding ATAR; 2) taking the average of all these; 3) dividing the estimated scaling advantage in 2013 of 5.3 scaled marks by this average. Note that the estimates of impact ranged from 1.17 to 1.39 ATAR.

There are two major limitations of the current study: the inability to explicitly test whether scaling is directly impacting participation in HSC Mathematics and whether the observed scaling advantage will persist in the future. Rigorous quasi-experimental methods are difficult to apply when looking at the direct impact of scaling on mathematics enrolments as many students do not know that a scaling advantage exists and scaling is sensitive to changes in the characteristics of a student cohort. Thus, the current study can only examine whether a scaling disadvantage provides a disincentive to study HSC Mathematics. Furthermore, the dynamic nature of scaling also means that any scaling advantage observed in the current study cannot be generalised beyond the years included in the analysis (2009-2013). Scaling is recalculated each year and is completely dependent on that year's student cohort, with any significant changes in student demographics and subject preferences leading to changes in scaling. However, given that student demographics and subject preferences are likely to be relatively stable, at least in the short-term, the results of the current study may also be applicable to the neighbouring years outside of the study period, though this is speculative and should be examined directly in future research.

Another important point to consider is whether this scaling advantage is purely the result of the scaling process or whether it reflects learning gains for HSC General Mathematics students. HSC General Mathematics may better match the ability of many students such that they learn more and thus achieve higher scaled marks than they may have if they had studied HSC Mathematics. The current study cannot directly discern whether this is the case or whether the scaling process simply awards more scaled marks to HSC General Mathematics.

The results of the current study suggest that changes to policy, such as those recently announced by NESA (Board of Studies Teaching and Educational Standards NSW 2016b), are required to boost enrolments in HSC Mathematics. These forthcoming reforms, commencing in 2019, will likely help to address the scaling advantage by allowing direct comparisons between the two subjects and their students. However, it is also important to ensure that the advantages of studying higher level courses are clearly communicated to students who are likely balancing a number of factors in making their course choices. Indeed, implementing a system with a clearly communicated scaling advantage for taking HSC Mathematics could potentially increase the uptake of mathematics that includes calculus in a relatively efficient manner. For students intending to undertake further STEM studies, this may facilitate subject choices that more closely align with the priorities of students and governments.

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Appendix 1: Estimating scaled marks

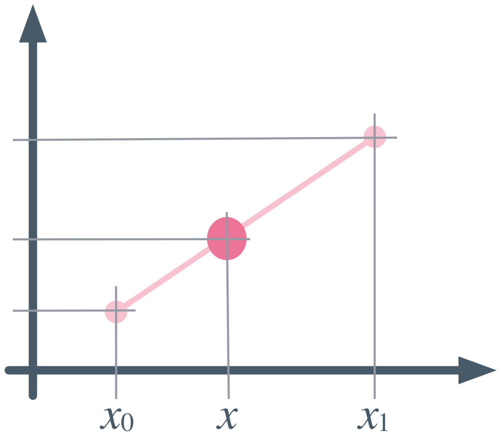
As scaled marks are not calculated by BOSTES and are calculated by the Technical Committee on Scaling (which reports to the NSW Vice Chancellors Committee), they were not included in the BOSTES dataset provided to CESE. Scaled marks were estimated through linear interpolation and extrapolation, a method of imputing missing data. This is done by having a variable that has no missing data (i.e. the HSC mark) and has some corresponding values in the variable with missing data (i.e. the scaled mark). Each year for every HSC subject, UAC reports the mean, standard deviation, maximum mark, and the marks at the 25th, 50th, 75th, 90th and 99th percentiles for the HSC mark and scaled mark. Using this information, a set of points can be described using the HSC mark and corresponding scaled mark as coordinates for each point. Separate linear equations are then estimated between each point and the missing value for variable y (i.e. scaled marks) is estimated by substituting in the value of its corresponding non-missing value for x (i.e. HSC mark) using the below equation in Figure 6:

Figure 6:

Graphical representation of linear interpolation

Source: http://people.cs.uchicago.edu/~glk/class/scivis-2013/proj1.html

$$y_0 + \frac{(x - x_0)(y_1 - y_0)}{x_1 - x_0} = y$$



Where (x_0, y_0) and (x_1, y_1) are the coordinates of the two closest points on either side of the point (x, y) where y is missing and x is non-missing. Pitt (2015) has further discussions on this method and potential weaknesses, however concludes that it "works very well for courses with large enrolments like HSC General Mathematics and HSC Mathematics" (Pitt 2015, p. 11).

Appendix 2: Technical details regarding double propensity score adjustment

Method

As described in the Method section, the first step in applying the double propensity score adjustment was to match each student who took HSC Mathematics to a similar student who took HSC General Mathematics. This involved fitting a propensity score model (through logistic regression) which related a series of covariates to the probability of undertaking HSC Mathematics over HSC General Mathematics. The fitted values from this model (i.e. the propensity scores) were used in the matching process. Table 1 below lists the main covariates used in the propensity score model. A total of 186 covariates were included.

Table 1:

Covariates used in the propensity score model

Major student-level variables	Major school-level variables
SC Maths mark	Schools' mean SC Maths mark
SC English mark	Schools' mean SC English mark
Whether student received an ATAR	School sector
Gender	Whether school was coed or single sex
# of units in each KLA, BEC and VET subject areas	% of School HSC students taking Extension Maths
Whether in same school for SC and HSC	% of School HSC students taking non-ATAR Maths
Student SA1 SES (SEIFA)	School SA1 SES (SEIFA)
Student SA1 proportion of Aboriginal and Torres Strait Islander	School SA1 proportion of Aboriginal and Torres Strait Islander
Student SA1 proportion who completed Yr 12	School SA1 proportion who completed Yr 12
Other 2011 Census data for both student and school SA1: economic & education	

Source: CESE analysis of BOSTES student mathematics data (2016)

For the current study, nearest neighbour matching with replacement was used to define the matched sample. For the full sample of HSC Mathematics students, this process resulted in an average number of matches of 2.15 and a maximum number of matches of 128 for students in 2013. This is common when the densities of the propensity scores for each group are reasonably different, as was the case in the current study[20].

Students with an excessive number of matches all had probabilities in the upper tail of the distribution above 0.9 (HSC Mathematics n = 936; 11.8 per cent). Thus, students who had a probability of choosing HSC Mathematics of 0.9 or above were removed from the sample (Crump et al. 2009). This means that the final treatment effect pertains to the students who had some probability of taking HSC General Mathematics (please see Table 2 in the Results subsection below for sample sizes).

Double propensity score adjustment and other propensity score matching methods can be affected by two major sources of bias: incomplete matching bias and inexact matching bias. Incomplete matching bias can occur when not all HSC Mathematics students are matched while inexact matching bias occurs when HSC Mathematics students are matched to HSC General Mathematics students who are not very similar across the measured covariates. By using nearest neighbour matching to find the most similar student no matter how distant the propensity score, bias due to incomplete matching is impossible (i.e. every student who took HSC Mathematics was matched to a student who took HSC General Mathematics). This process, however, can introduce bias due to inexact matching. To remove residual bias due to inexact matching, a regression adjustment was applied to the matched sample. This method has been shown to estimate treatment effects that are essentially unbiased (Austin 2014).

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[20] The area under the Receiver Operating Characteristic curve in the current study was above 0.9 for all years, meaning that the propensity score model discriminated between HSC Mathematics students and HSC General Mathematics students with a high degree of accuracy.

The use of this method resulted in significant sampling differences to the analysis reported by Pitt (2015). Pitt (2015) included all students who took either of the two mathematics subjects; however, the current study focused only on HSC Mathematics students and the students from HSC General Mathematics that could act as 'virtual twins': that is, students who were very similar to HSC Mathematics students on the basis of their observed characteristics, yet took HSC General Mathematics. As a result, a number of HSC General Mathematics students could not be matched and were removed from the sample and excluded from the analysis.

Checks on assumptions

To verify whether propensity score matching methods were applicable to measuring the scaling advantage, two main assumptions were tested: whether student cohorts for the two mathematics subjects could be balanced on all covariates and whether there was sufficient overlap over covariates such that there were enough similar students from both subjects. The first assumption demands that 'unconfoundedness' be met, whereby there is no additional unobserved covariate that explains both a student's choice of mathematics subject and their scaled marks once all observed characteristics are taken into account (Imbens and Wooldridge 2009). Formally, this is stated as:

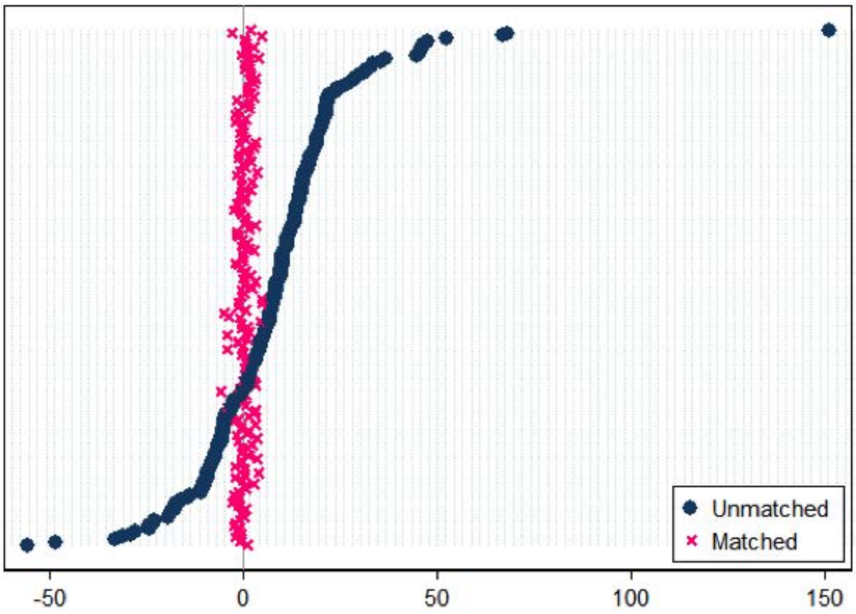
$$W_i \perp (Y_i(0), Y_i(1)) \mid X_i$$

where W_i is the mathematics subject choice of individual i ($W_i = 1$ if they chose HSC Mathematics and $W_i = 0$ if they chose HSC General Mathematics); $(Y_i(0), Y_i(1))$ are the scaled marks individual i could score if they chose HSC Mathematics or HSC General Mathematics; and X_i are individual i's values for all observable covariates. In other words, a student's choice of mathematics must be independent of the set of potential scaled marks they could score in either subject once all of their observed characteristics are taken into account. To fulfil this assumption, it is usually shown that there is 'balance' across all characteristics; that is, that there are little to no differences on average between students of the two subjects across all covariates after matching. Figure 7 shows that differences were mostly removed across all covariates, showing balance between the two mathematics subjects.

Figure 7:

Standardised Average Differences Across All Characteristics – Pre and Post Matching – 2013

Source: CESE analysis of BOSTES student mathematics data (2016)



Standardised % bias across covariates

The second key assumption is that there needs to be overlap across all characteristics: that is, no value in any covariate can be populated only by students from just one of the mathematics subjects (Imbens and Wooldridge 2009). Formally, this is stated as:

$$0<pr(W_i=1 \mid X_i=x)<1, \text{ for all } x$$

where $pr(\ldots)$ is probability of, x is a given vector of values across all covariates, and W_i and X_i are as defined for the previous equation. This states that, in order to be included in the analysis, all students in either mathematics subject must have some chance of choosing HSC General Mathematics and some chance of choosing HSC Mathematics.

The overlap assumption had a substantial impact on sampling, particularly in relation to HSC Mathematics students who studied Mathematics Extension. As students can only study Mathematics Extension if they study HSC Mathematics (or study both Mathematics Extension subjects), almost no students across the years 2009 to 2013 studied both HSC General Mathematics and Mathematics Extension. This meant that a binary indicator variable for students who studied Mathematics Extension did not meet the overlap assumption as it perfectly predicted choosing HSC Mathematics. When the indicator was removed from the propensity score model and Mathematics Extension students were matched, there were so few matches for these students that 632 of them were matched to just one HSC General Mathematics student in 2013. This indicates that overlap was not very strong for Mathematics Extension students, meaning that these students were too different from others to be included in the analysis. Notably, the exclusion of Mathematics Extension students from the current analysis is likely one explanation for the observed differences between the current results and those reported in the Pitt (2015) study (effect size: 0.48 and 0.35 sd respectively in 2013). When Mathematics Extensions students were included (by excluding the Mathematics Extension indicator), results were approximately equal to the Pitt (2015) study.

Results

Table 2 below shows the results of the analysis for 2009 to 2013. This table shows the average unmatched and matched differences in scaled marks between HSC General Mathematics and HSC Mathematics students expressed in effect size. Prior to matching, HSC Mathematics students scored between 0.5 to 0.62 sd higher than HSC General Mathematics students (as shown by the negative values). However, once matching and regression adjustment were conducted, HSC Mathematics students would have scored 0.48 to 0.62 sd higher if they had studied HSC General Mathematics. Table 2 also shows the standard errors (SE), with all matched differences found to be significant at the one per cent level of significance. The sample sizes are also included, with sample size ranging from 14,000 to 15,000 per year (of roughly 34,000 students per year who had values for all 186 covariates).

Table 2:

Results from Double Propensity Score Adjustment – Scaling Advantage (Effect Size)

Source: CESE analysis of BOSTES student mathematics data (2016)

Year	2009	2010	2011	2012	2013
Unmatched Difference	-0.51	-0.50	-0.57	-0.50	-0.62
Matched Difference	0.62	0.57	0.53	0.59	0.48
SE	0.01179	0.01218	0.01230	0.01260	0.01077
Unmatched N	33,656	34,354	34,604	34,607	34,629
Matched N	14,621	15,099	14,533	14,456	14,043

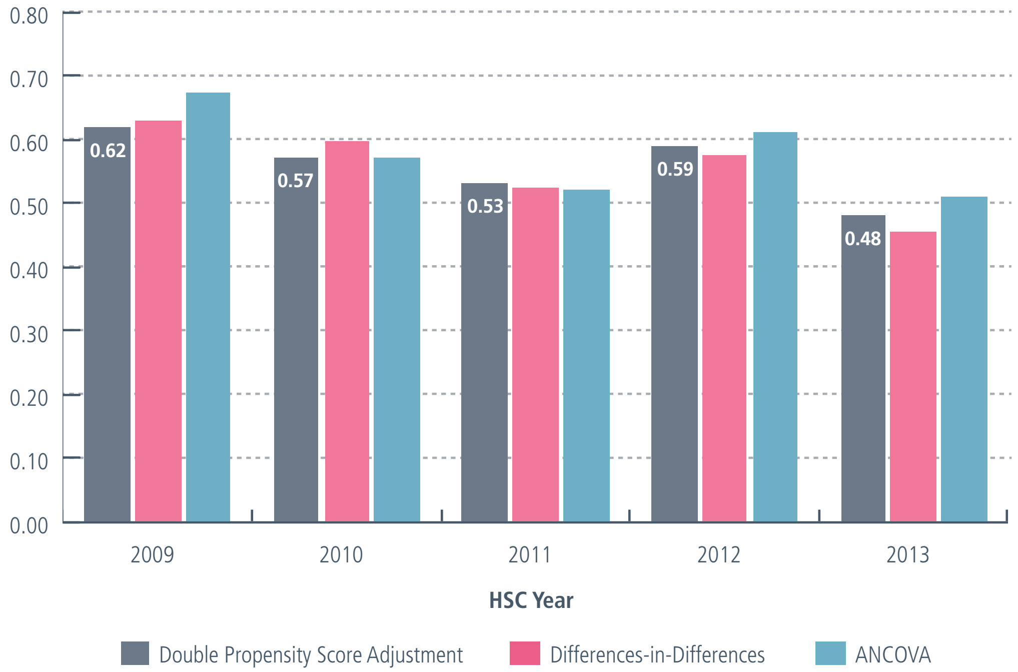
Robustness Checks – Other Methods

Two other methods were used to check the robustness of the double propensity score adjustment results: Differences-in-Differences (DiD) and Analysis of Covariance (ANCOVA). Both methods essentially measure the scaling advantage by only taking into account a student's prior achievement (i.e. SC Mathematics score in Year 10) and examining whether students with the same prior achievement level have different scaled marks if they take different mathematics subjects. DiD achieves this by calculating how much a student's relative score (raw SC score or HSC scaled marks, both standardised) changes if a student chose HSC General Mathematics compared to if they chose HSC Mathematics. The ANCOVA approach involves running a regression model controlling only for raw SC score. Sampling for both of these methods differed as all HSC General Mathematics and HSC Mathematics students (except Mathematics Extension students) were included. As can be seen in Figure 8, these methods found remarkably similar scaling advantages (as measured by effect size). This suggests that results showing a scaling advantage are robust.

Figure 8:

Scaling Advantage measured by Alternative Methods (Effect Size)

Source: CESE analysis of BOSTES student mathematics data (2016)



Appendix 3: Technical details regarding the Between-Within model

Method

To estimate the association between student- and school-level characteristics and choosing HSC General Mathematics over HSC Mathematics, the Hybrid method (Allison 2009), otherwise known as the Between-Within model (Allison 2014; Sjölander et. al. 2013), was used. The Between-Within model is essentially an extension of fixed effects estimation that "embeds a fixed effects estimator within the framework of a random effects (mixed) model, thereby enabling one to reap several benefits of both approaches" (Allison 2014, p. 1). As described previously in the Method section, this involved taking the school-level average of student-level covariates as representative of school fixed effects and then using random effects estimation. Using random effects estimation ensures that the standard errors reflect the dependence between different students who attended the same school (Allison 2009).

For this analysis, fixed effects and Between-Within models were run. Each model controlled for the gender of the student (coded as a dummy variable with one if male and zero if female), the units studied in each HSC KLA, the units studied in VET or BEC, prior achievement (SC Mathematics score in Year 10) and student SES (IRSD score). SC Mathematics score and IRSD score were standardised to have a mean of zero and standard deviation of one. School means and a student's deviation from the mean were calculated for each of these factors and included in the model as separate covariates. School type was also included in the Between-Within model and was a combination of sector and whether the school was a coed, boys-only or girls-only, resulting in seven school types. The full list of covariates can be seen in Table 3 in the next subsection.

The Between-Within model was preferred to fixed effects estimation as it allowed the inclusion of covariates that do not vary within a school, such as school type. As the coefficients from the random effects model are weighted averages of the student- and school-level coefficients (Allison 2009), the Between-Within model provides a test to check whether school means for student-level characteristics should be included (Allison 2009). This can be achieved through a Wald test which compares whether the student-level coefficients (e.g. number of HSC KLA English units studied by the student relative to the school mean) are equal to the school-level coefficients (e.g. the mean number of HSC KLA English units studied at the school) for all pairs of student- and school-level coefficients. The Wald test had a p-value of less than 0.0001, thus the school-level coefficients are not identical to student-level coefficients and should be included in the model.

Results

Table 3 presents the regression results for the fixed effects and Between-Within models. The fixed effects model used the actual values of student-level characteristics while the Between-Within model expressed these as deviations from the school mean[21]. Coefficients are presented as odds ratios, with odds ratios above one representing an increased probability of choosing HSC General Mathematics over HSC Mathematics, and odds ratios below one (but above zero) representing a decreased probability of choosing HSC General Mathematics. Results presented in Table 3 are the inverse of those in Figure 3 as the model was estimated for the probability of choosing HSC General Mathematics over HSC Mathematics. For example, in Table 3, the coefficient for student-level number of English KLA units studied is 0.83 and its inverse is 1.2, the result presented in Figure 3. As can be seen in the table, the estimates for the student-level characteristics are not identical across models. However, the largest difference is 0.005, indicating little difference in the underlying probabilities.

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[21] The Between-Within model was also run using the actual values, not the deviations, and results for student-level coefficients were identical.

When implemented in a binary outcome context (either choose HSC General Mathematics or HSC Mathematics), there are some concerns over the consistency of the Between-Within model when analysed using logistic regression. When school fixed effects are linear functions of the school means, then the Between-Within model is consistent for logistic regressions (Brumback et al. 2010), but if not, then the Between-Within model is inconsistent. Hence, the linearity assumption needs to be checked, which can be achieved by adding polynomial terms for the school mean covariates (Allison 2014). If these terms are insignificant and the student-level coefficients are largely unchanged, then bias is less of an issue (Allison 2014). This was done for the Between-Within model and all terms were insignificant except the squared and cubed terms for SC Mathematics score. However, the student-level coefficients were not practically different from the fixed effects model's coefficients, with the largest difference in odds ratios of 0.004. In this instance, bias is less likely to be an issue for the Between-Within model.

Table 3:

Choosing HSC General Mathematics over HSC Mathematics (Odds Ratios)

Source: CESE analysis of BOSTES student mathematics data (2016)

	Fixed Effects	Between-Within
Student-level characteristics		
Male	1.063***	1.063***
	[0.019]	[0.019]
Eng KLA units	0.828***	0.830***
	[0.015]	[0.015]
Sci KLA units	0.590***	0.593***
	[0.005]	[0.005]
Hum KLA units	0.852***	0.853***
	[0.007]	[0.007]
Lang KLA units	0.638***	0.640***
	[0.009]	[0.009]
Tech KLA units	0.810***	0.812***
	[0.008]	[0.008]
Art KLA units	0.934***	0.935***
	[0.010]	[0.010]
PDHPE KLA units	1.073***	1.074***
	[0.012]	[0.012]
VET units	1.090***	1.090***
	[0.012]	[0.012]
BEC units	1.348***	1.343***
	[0.024]	[0.024]
SC Maths (standardised)	0.129***	0.131***
	[0.002]	[0.002]
IRSD (standardised)	1.044***	1.043***
	[0.011]	[0.011]
School type: Base category = Gov Boys		
Gov Coed		2.085***
		[0.545]
Gov Girls		1.927
		[0.899]
Non-Gov Boys		1.865***
		[0.408]
Non-Gov Coed		2.386***
		[0.630]
Non-Gov Girls		2.668**
		[1.215]

Table 3:

Choosing HSC General Mathematics over HSC Mathematics (Odds Ratios)

Source: CESE analysis of BOSTES student mathematics data (2016)

	Fixed Effects	Between-Within
Student-level characteristics		
TAFE		6.793***
		[2.405]
Male: school proportion		1.19
		[0.480]
Eng KLA units: school mean		0.046***
		[0.016]
Sci KLA units: school mean		0.583***
		[0.065]
Hum KLA units: school mean		0.760***
		[0.066]
Lang KLA units: school mean		0.241***
		[0.051]
Tech KLA units: school mean		0.891
		[0.102]
Art KLA units: school mean		0.93
		[0.117]
PDHPE KLA units: school mean		1.243
		[0.167]
VET units: school mean		1.095
		[0.095]
BEC units: school mean		1.587***
		[0.186]
SC Maths (standardised): school mean		0.286***
		[0.030]
IRSD (standardised): school mean		1.250***
		[0.078]
Constant	20.258***	8568.269***
	[7.679]	[8355.606]
Lnsig2u		-0.671***
		[0.034]
Sigma U		0.715
Rho		0.134
Log-Likelihood	-58936.101	-60228.943
N	184322	186264

* p<0.10, ** p<0.05, *** p<0.01

Appendix 4: Technical details on logistic regression of mathematics regret after HSC

As described in the Method section, whether student's regretted their mathematics course choice in the HSC was measured by examining whether students who participated in the 2015 Expectations and Destinations survey reported that they would have selected a different level of mathematics during the HSC. A multinomial logistic regression model was used to measure which covariates correlated with whether students would have selected a more challenging mathematics unit, an easier unit or no mathematics at all (compared to redoing the same level of mathematics). Covariates included in the model were their current field of study at university, Year 9 NAPLAN numeracy results, gender, SES and age. The analysis only included students who studied HSC General Mathematics and all sectors were combined. Sampling weights were applied in the regression analysis to account for the stratified sampling design. Results of this analysis, summarised in Table 4, are presented as odds ratios.

Two main checks on the sensitivity of these results were conducted: whether inclusion of different covariates biased coefficients and whether the results would differ for HSC Mathematics students. To examine whether coefficients pertaining to the relationship between field of further study and regret were robust, alternative specifications were conducted including field of further study but without other covariates. Results showed that coefficients were qualitatively similar (i.e. same direction but with slight changes in size) and the statistical significance of results did not change, providing confidence in the results. Analysis was also conducted including only students who studied HSC Mathematics. Results of this analysis were complementary to those reported in Table 4, showing that students who took HSC Mathematics and studied tertiary STEM may have been more satisfied with their level of mathematics. In particular, results showed that students who studied HSC Mathematics and tertiary STEM subjects at university were not more likely to have reported wanting to study more challenging mathematics relative to their counterparts who studied Humanities (as odds ratios were either below one or not statistically significant). These students also had low rates of reporting wanting to have chosen easier mathematics or no mathematics.

Table 4:

Desire to have done a different level of Mathematics rather than study same level (Odds Ratios)

Source: CESE analysis of Destinations Survey data (2016)

	Harder	Easier	No Maths
Base outcome: Same level of maths			
Field of further study: base category = Society and culture			
Natural and physical sciences	2.824***	0.000***	0.154**
	[1.132]	[0.000]	[0.117]
Information technology	1.716	1.776	0.389
	[1.077]	[2.874]	[0.271]
Engineering and related technologies	4.235***	0.000***	0.569
	[1.781]	[0.000]	[0.334]
Architecture and building	0.476	0.722	0.325*
	[0.286]	[0.976]	[0.188]
Agriculture environment and related	0.489	0.26	0.205
	[0.413]	[0.394]	[0.290]
Health	1.572	2.841	0.328***
	[0.567]	[2.750]	[0.113]
Education	0.823	1.201	0.347***
	[0.376]	[1.503]	[0.140]
Management and commerce	1.964**	5.694*	0.375***
	[0.645]	[5.929]	[0.135]
Creative arts	0.501	2.978	0.613
	[0.255]	[3.673]	[0.203]
Food hospitality and Personal services	0.877	4.986	0.233***
	[0.728]	[6.527]	[0.122]
Mixed field programmes	1.092	0.000***	0.531
	[0.916]	[0.000]	[0.591]
Other	1.202	0.000***	0.151**
	[0.652]	[0.000]	[0.125]
Don't know	0.000***	0.000***	0.000***
	[0.000]	[0.000]	[0.000]
Refused	5.427*	0.209	2.416e+09***
	[4.777]	[0.285]	[3.030e+09]
Student Characteristics			
Male (dummy)	1.564*	1.664	0.74
	[0.361]	[0.834]	[0.181]
Age (standardised)	1.002	0.994	0.966
	[0.105]	[0.261]	[0.101]
Parental SES (standardised)	1.146	0.735*	0.805**
	[0.138]	[0.118]	[0.082]
NAPLAN Y9 Numeracy (standardised)	1.181	0.497***	0.539***
	[0.227]	[0.097]	[0.074]
Constant	0.114***	0.007***	0.427***
	[0.032]	[0.007]	[0.083]
Pseudo R-Squared	0.09		
N	1745		

* p<0.10, ** p<0.05, *** p<0.01

Appendix 5: Technical details on logistic regression of influence of perceived scaling advantage vs workload concerns

To determine which factors (i.e. maximise ATAR, wanting less homework or perceived ease of the course) influenced students' mathematics course choice in the HSC, three separate regressions were conducted. As described in the Methods section, school completers who studied mathematics in the HSC and were surveyed in the 2015 Expectations and Destinations Survey were asked three questions on whether increasing ATAR and/or perceived workload influenced their mathematics course choice. Using each of the three questions as the dependent variable, logistic regressions (or multinomial logistic regression in the case of ease of the course) were used to measure which mathematics courses were influenced by perceived workload or increasing ATAR. Indicators for all mathematics courses were included, ranging from HSC Applied Mathematics to HSC Mathematics Extension 2, with HSC Mathematics as the base category. Regressions also controlled for Year 9 NAPLAN numeracy scores. For these analyses, all education sectors were combined to maximise sample size. Sampling weights were applied in the regression analysis to account for the stratified sampling design.

Results from the three regressions, summarised in Table 5, showed that for most students surveyed in 2015, the higher the mathematics level studied (with HSC Applied Mathematics the lowest and HSC Mathematics Extension 2 the highest), the more likely they were to indicate that helping their ATAR influenced their mathematics choice. For the two perceived workload questions, generally the opposite was true, in that the lower the mathematics level studied, the more likely students were to report wanting less homework or believing their mathematics level was easy as having influenced their course choice.

Table 5:

Whether perceived workload and/or increasing ATAR influenced mathematics subject choice (Odds Ratios)

Source: CESE analysis of Destinations Survey data (2016)

	Maths Easy	Maths Hard	Help ATAR	Less Homework
Base Category: Mathematics				
Applied	6.696***	0.301***	0.283***	2.657***
	[1.698]	[0.132]	[0.063]	[0.640]
General	3.679***	0.318***	0.691***	1.897***
	[0.674]	[0.053]	[0.081]	[0.278]
Extension 1	0.399**	1.035	1.859***	0.488***
	[0.149]	[0.187]	[0.327]	[0.110]
Extension 2	0.998	2.648***	3.434***	0.038***
	[0.391]	[0.591]	[0.922]	[0.028]
Y9 Numeracy (standardised)	1.233**	0.886	1.208***	1.426***
	[0.109]	[0.068]	[0.075]	[0.137]
Constant	0.121***	0.376***	1.549***	0.215***
	[0.021]	[0.044]	[0.156]	[0.028]
Pseudo R-squared	0.081		0.066	0.054
N	3964		3980	3963

* $p<0.10$, ** $p<0.05$, *** $p<0.01$

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