Actuaries Institute

PUBLIC POLICY STATEMENT

Mastering Mathematics for Australia's Future

DECEMBER 2021

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Context

As practitioners of applied mathematics, actuaries are well placed to recognise the value of mathematics studies in school. Like many Australian professions, strong mathematics skills of our members are a crucial enabler for the analysis and advice provided to a broad range of industries.

Effective mathematics education is vital for young Australians to help them confidently apply mathematics to everyday tasks and to create high-level capabilities which support the growth of science, technology, engineering and mathematics (STEM) industries in Australia.

The Actuaries Institute ('the Institute') acknowledges the complexity of educational policymaking, and ongoing programs to improve mathematics participation and outcomes for Australian students.

This Public Policy Statement highlights several policy recommendations to improve Australian students' participation and performance in mathematics.

This Statement is supported by evidence-based research. We acknowledge our interest in these policy improvements and reference our recent consultation with mathematics education stakeholders to validate our views.

Issues

Declining Year 12 Mathematics Participation Rates

In the last decade, the proportion of Australian Year 12 students studying higher level (intermediate or advanced) mathematics has declined[1]. Figures released by the Australian Mathematical Sciences Institute (AMSI) show that, in 2019, only 20.5% of Year 12 students opted to study intermediate mathematics compared with 23.3% participation in 2008, and only 10.1% of students chose advanced mathematics, compared with 11.6% participation in 2008 [2].

In those states where Year 12 mathematics is not compulsory (New South Wales, Victoria, Australian Capital Territory, Western Australia), the proportion of students studying any mathematics subject has also declined (with the exception of Western Australia). In NSW, where mathematics is currently not compulsory beyond Year 10, the proportion of students studying HSC mathematics dropped to around 75% in 2020, compared with over 90% in 2003[3].

1 AMSI definition – higher level mathematics is representative of the Australian Curriculum Level Specialist Mathematics, intermediate represents Mathematical Methods and elementary combines both Essential and General Mathematics. Reference: Year 12 participation intermediate and higher mathematics remains stubbornly low https://amsi.org.au/?publications=year-12-mathematics-participation-in-australia-2008-2019

2 Year 12 participation in intermediate and higher mathematics remains stubbornly low https://amsi.org.au/?publications=year-12-mathematics-participation-in-australia-2008-2019

3 Fewer Australians are taking advanced maths in Year 12. We can learn from countries doing it better https://theconversation.com/fewer-australians-are-taking-advanced-maths-in-year-12-we-can-learn-from-countries-doing-it-better-149148

Driving factors of declining higher level mathematics participation

Reasons commonly cited for declining Year 12 higher level mathematics participation include:

- dissatisfaction with mathematics based on student ability, achievement and longer-term usefulness
- other subjects may be less demanding
- students attempt to maximise their Australian Tertiary Admission Rank (ATAR) result so they avoid higher level mathematics based on the perception that higher level mathematics is not appropriately scaled
- higher level mathematics is not a prerequisite for many university degrees, even when those degrees have a reliance on mathematics[4].

The mathematics gender imbalance

Declining higher level mathematics participation in Australian schools is more extreme for female high school students. Females are significantly less likely to study higher level mathematics subjects than their male counterparts. Although female students represented over half of all Year 12 students in 2019, males were more than one and a half times more likely to study higher level mathematics than females[5]. This contributes to the under-representation in mathematics-intensive STEM careers[6], which exacerbates gender wage inequality. This may contribute to a resource shortage if the number of Australians completing mathematics intensive studies continues to decline.

The disparity occurs despite male and female students typically achieving similar results in mathematics-based Year 12 subjects and is believed to be due to many female students having lower confidence in their mathematical abilities than their male peers[7].

Under-representation of Australian sub-groups in STEM careers

Other sub-groups of Australia's population with under-representation in STEM careers includes people from low socio-economic status (SES) backgrounds, Aboriginal and Torres Strait Islanders and people from rural, regional and remote areas[8]. There is less data on Year 12 mathematics participation for these cohorts, however non-Indigenous or metropolitan students in PISA and TIMSS international tests perform significantly higher than their Indigenous and regional counterparts[9]. At this time, we have not adopted an explicit policy position in relation to these groups. We consider that our policy positions would apply to and would benefit these groups. We acknowledge other factors may contribute to reduced educational outcomes for low SES backgrounds, regional and Aboriginal and Torres Strait Islander students and welcome policies that address national minimum standards and achievement gaps.

4 Mapping University Prerequisites in Australia https://www.chiefscientist.gov.au/sites/default/files/2020-09/mapping_university_prerequisites_in_australia.pdf

5 Year 12 participation in intermediate and higher mathematics remains stubbornly low https://amsi.org.au/?publications=year-12-mathematics-participation-in-australia-2008-2019

6 Second national data report on girls and women in STEM https://www.industry.gov.au/news/second-national-data-report-on-girls-and-women-in-stem

7 Gender Report 2019 Mathematics and Gender: Are Attitudes and Anxieties Changing towards Mathematics? https://amsi.org.au/wp-content/uploads/2019/07/gender-report-2019.pdf

8 Optimising STEM Industry-School Partnerships: Inspiring Australia's Next Generation https://www.chiefscientist.gov.au/sites/default/files/2019-11/optimising_stem_industry-school_partnerships_-_final_report.pdf

9 PISA – Programme for International Student Assessment, TIMMS – Trends in International Mathematics and Science Study

Potential consequences of declining higher level mathematics participation

The decline in Year 12 higher level mathematics participation in Australia has coincided with a period of unprecedented demand for STEM qualified workers. Automation and digitisation have replaced manual jobs with technology-based processes. Preparing for many of these roles requires a solid foundation in mathematics, and the current declining rates of participation may limit career choices for those students who have chosen to opt out of studying higher level mathematics.

Declining Year 12 mathematics participation (including declining higher level mathematics participation) will inevitably result in supply issues for several mathematics-based professions, an issue crucial for the actuarial profession.

General numeracy skills are valuable life skills required for all Australians to fully participate in society, including financial literacy, critical and creative thinking and personal management of health and consumer choices.

The mathematics teaching profession has already been adversely affected by declining higher level mathematics participation with a distinct shortage of teachers. A 2018 survey conducted by the Australian Education Union noted that "45% of secondary school principals reported that there were mathematics and science classes taught at their school by a teacher not fully qualified in the subject area"[10]. The shortage of qualified mathematics teachers limits the ability of schools to effectively offer higher level mathematics classes to students, even if demand for such courses were to exist.

Policy Positions

The Institute has adopted the following policy positions with the aim of:

- increasing the proportion of Year 12 students electing to study higher level mathematics subjects
- improving the participation rates and capabilities of senior students studying any mathematics subject.

1. Compulsory mathematics or numeracy courses for all Australian students, including senior students, to school completion

Every Australian student should leave school being able to demonstrate a minimum standard of numeracy and our education system should be accountable for achieving that with a suitable range of courses. The Institute acknowledges that policy outcomes consistent with this recommendation have recently been implemented in some Australian states, including numeracy courses for students requiring further support to assist them in meeting the numeracy standard by the end of Year 12[11].

Simple mathematical concepts and numerical fluency are relevant in daily life. Logical, ordered thinking learned in mathematics studies can help in general problem-solving situations for all Australians. However, the mathematical performance of Australian students is deteriorating against both national and international benchmarks[12].

10 The State of Mathematical Sciences 2020, p.32. https://amsi.org.au/wp-content/uploads/2020/05/amsi-discipline-profile-2020.pdf

11 WA School Curriculum and Standards Authority: https://senior-secondary.scsa.wa.edu.au/syllabus-and-support-materials/mathematics/mathematics-foundation

12 https://naplanreview.com.au/pdfs/2020_NAPLAN_review_final_report.pdf

With increased mathematics participation in Australian schools, we expect an improvement in numerical fluency, which will better equip students to take on the future challenges of an innovation and technology driven economy over our current commodity-based economy.

Making mathematics or numeracy compulsory may also uncover students with the ability and interest to study mathematics, giving a wider cohort the confidence and ability to choose a wider range of degrees at University.

We support the first goal of the Alice Springs Declaration[13] "The Australian education system promotes excellence and equity". Australian students must have access to high-quality schooling regardless of their gender, culture, ethnicity, socio-economic background or geographic location, factors that have contributed to declining participation in higher level mathematics in Australian schools.

The Institute supports policy that can be implemented widely, uniformly and sustainably for all Australian students.

2. *STEM industries to support Australia's mathematics curriculum*

Australia's mathematics curriculum should provide students with real-life examples of using mathematics. While procedural fluency may be highly rewarded in traditional assessment, students are likely to be more engaged and better equipped to make use of their skills if they understand how concepts are applied[14].

Students' aspiration and awareness of the value of STEM skills and the breadth of STEM careers is declining because students are unaware of how mathematics is relevant to them[15]. STEM professionals should collaborate with Education Departments to include practical examples and relevant applications of mathematics concepts to deliver high-quality learning outcomes[16]. This enhances the mathematical connection ability of students[17] and promotes engagement[18].

The Institute supports recommendations from Australia's Chief Scientist[19]:

- Industry and business can support teachers with the development of relevant learning materials in schools
- Governments and industry should work together to focus the narrative for primary and secondary students on how STEM skills and knowledge can solve real-world problems.

3. *Advanced training for mathematics educators*

The Institute recognises the importance of highly trained teachers to support quality mathematics education in schools. We support mathematics education training initiatives for existing teachers, and the use of incentives that attract more specialist mathematics teachers to the profession.

Appropriate training will help teachers to develop higher quality, engaging methods to promote deeper mathematics learning[20].

13 https://www.dese.gov.au/alice-springs-mparntwe-education-declaration/resources/alice-springs-mparntwe-education-declaration

14 https://www.cde.state.co.us/comath/mathteachingpractice6

15 Attard, 2014 *I Don't like it, I Don't Love it, but I Do it and I Don't Mind*: Introducing a Framework for Engagement with Mathematics. Curriculum Perspect. 34, 1–14.

16 Attard, Berger, Mackenzie – https://www.frontiersin.org/articles/10.3389/feduc.2021.693221/full

17 https://www.chiefscientist.gov.au/news-and-media/release-stem-education-resources-toolkit-support-industry-partnerships#:~:text=Release%20of%20STEM%20Education%20Resources%20Toolkit%20to%20support%20industry%20partnerships,-Friday%2C%2004%20September&text=Australia's%20Chief%20Scientist%2C%20Dr%20Alan,engineering%20and%20mathematics%20(STEM)

18 Anderson, J., Katrak, Z. (2017). Higher order thinking, engagement and connectedness in lessons based on STEM contexts. 41st Conference of the International Group for the Psychology of Mathematics Education (PME41), Singapore: PME.

19 https://www.chiefscientist.gov.au/news-and-media/release-stem-education-resources-toolkit-support-industry-partnerships

20 Evidence for Learning, 2018. https://evidenceforlearning.org.au/

Continuing professional development (CPD) should be provided for primary school teachers and secondary mathematics teachers. This will enable primary school teachers to equip early learners with a robust understanding of mathematics foundations, vital for building the understanding required for higher level mathematics learning. It will also ensure secondary school teachers have a good understanding of the broader mathematics curriculum, and mathematics specific pedagogy.

Initiatives designed to incentivise high achieving individuals to become mathematics teachers and encourage already qualified mathematics teachers to remain in the teaching profession should be supported. This could include scholarships[21], mentorship programs for early career teachers and monetary inducements[22]. We support the Australian Teacher Workforce Data initiative to understand the Australian teacher career paths and maintain teacher standard[23] .

A shortage of qualified mathematics teachers mean that a large proportion of Australian students are taught mathematics by 'out-of-field' teachers for at least part of their schooling[24]. CPD for teachers without mathematics specific education training should improve student performance, and in turn, increase participation. This should be most notable in more disadvantaged schools where the prevalence of out of area teachers is highest[25].

The shortage of qualified teachers also limits schools' ability to offer higher level mathematics courses to Years 11 and 12 students. More than one-third of schools in Queensland, Victoria and NSW are unable to offer higher level mathematics courses[26].

4. *Promote increased participation in higher level mathematics, including mathematics as a prerequisite for admission to STEM-based university degrees*

Participation rates for Year 12 students in higher level mathematics subjects has declined steadily from 2008 to 2019[27]. One factor driving this decline is that higher level mathematics subjects are no longer a formal prerequisite for many STEM-based university degrees[28]. As a result, the mathematics skills of students entering STEM-based degrees may be declining, resulting in some students struggling with university subjects, in some cases dropping out of their degree. However, Australian students need higher level mathematics subjects for a solid mathematical foundation for STEM-based degrees. Undertaking higher level mathematics in senior secondary school can also assist with the volume of challenging content in many first-year STEM university courses.

Introducing appropriate mathematics prerequisites for STEM-based university degrees would send a clear signal to students of the importance of having a foundational knowledge of higher level mathematics[29] and improve the baseline knowledge of students studying STEM-based degrees.

The latter would also increase the likelihood of students successfully completing any STEM-based degrees[30].

21 AMSI Occasional Paper 2 – Australian Secondary Mathematics Teacher Shortfalls: a Deepening Crisis, p.8. https://amsi.org.au/wp-content/uploads/2019/05/amsi-occasional-paper-2.pdf

22 Recruiting and Retaining Teachers: What Works? https://researchingeducation.com/b_see_2_1/

23 Australian Teacher Workforce Data https://www.aitsl.edu.au/research/australian-teacher-workforce-data

24 The State of Mathematical Sciences 2020, p.31. https://amsi.org.au/wp-content/uploads/2020/05/amsi-discipline-profile-2020.pdf

25 PISA 2018

26 AMSI Occasional Paper 2 – Australian Secondary Mathematics Teacher Shortfalls: a Deepening Crisis, p.8. https://amsi.org.au/wp-content/uploads/2019/05/amsi-occasional-paper-2.pdf.

27 https://amsi.org.au/?publications=year-12-mathematics-participation-in-australia-2008-2019

28 https://www.chiefscientist.gov.au/sites/default/files/2020-09/mapping_university_prerequisites_in_australia.pdf (Mapping University Pre-requisites in Australia, p. 3.)

29 https://www.chiefscientist.gov.au/2018/12/speech-the-prerequisite-for-success

30 Data Analysis: The impact of senior secondary study choices on success at university https://www.dese.gov.au/higher-education/resources/data-analysis-impact-senior-secondary-study-choices-success-university

5. University admissions to reward students who undertake higher level mathematics for STEM-based university courses

There is a perception among students that studying higher level mathematics will negatively impact their ATAR due to the absence of appropriate scaling. Even if scaling is perceived as beneficial, it may not compensate for the expected time, stress and effort required to succeed in higher level mathematics subjects[31]. This may lead to some students being less likely to study higher level mathematics[32].

The Institute supports university admissions that appropriately reward students for undertaking higher level mathematics. This could include enhanced scaling, bonus subject weighting or subject-specific pathways[33]. At a minimum, improved communication is required to address the perception that the ATAR outcome is negatively affected by studying higher level mathematics.

6. Promote female participation in higher level mathematics subjects

There is a significant gap between the percentage of female and male participation in higher level mathematic: 7% vs 12%, respectively[34]. However, performance indicators, including Year 9 mean NAPLAN results, demonstrate a marginal difference in the capabilities between female and male students[35].

Research has noted possible causes for reduced female participation, including students' self-confidence, mathematics anxiety, and entrenched stereotyped beliefs in students, teachers and parents[36], as well as a lack of female role models[37].

The Institute supports current initiatives focused on increasing participation for both female and male students. It encourages initiatives designed to specifically address gender-specific mathematics participation, including STEM professional mentoring programs, to ensure reductions in gender-specific mathematics participation of both female and male students overall, as well as address the gap between female and male higher level mathematics participation.

31 Hine, G. (2019). Reasons why I didn't enrol in a higher level mathematics course: Listening to the voice of Australian senior secondary students. Research in Mathematics Education, Online First. DOI: 10.1080/14794802.2019.1599998

32 *Australian Informed Choices for Higher Education* Position Paper, p.1, https://www.chiefscientist.gov.au/sites/default/files/2020-09/australian_informed_choices_position_paper.pdf

33 *Australian Informed Choices for Higher Education* Position Paper, p.1, https://www.chiefscientist.gov.au/sites/default/files/2020-09/australian_informed_choices_position_paper.pdf

34 AMSI 2020 Report: https://amsi.org.au/?publications=year-12-mathematics-participation-in-australia-2008-2019

35 2021 Naplan Results: https://reports.acara.edu.au/NAP/NaplanResults

36 Victorian Education Dept https://www.education.vic.gov.au/school/teachers/teachingresources/discipline/maths/Pages/research_genderissuesinmaths_explanation.aspx

37 Advancing Women in STEM strategy https://www.industry.gov.au/data-and-publications/advancing-women-in-stem-strategy/snapshot-of-disparity-in-stem

The Actuaries Institute acknowledges the traditional custodians of the lands and waters where we live and work, travel and trade. We pay our respect to the members of those communities, Elders past and present, and recognise and celebrate their continuing custodianship and culture.

Published December 2021

About the Actuaries Institute

As the sole professional body for Members in Australia and overseas, the Actuaries Institute represents the interests of the profession to government, business and the community. Actuaries assess risks through long-term analyses, modelling and scenario planning across a wide range of business problems. This unrivalled expertise enables the profession to comment on a range of business-related issues including enterprise risk management and prudential regulation, retirement income policy, finance and investment, general insurance, life insurance and health financing.

Our public policy principles can be viewed at: https://actuaries.asn.au/public-policy-and-media/public-policy/policyprinciples.

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