AMSI monitoring of participation in Year 12 mathematics

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Summary

- Over the last two decades, the proportion of Year 12 students taking some mathematics has remained at roughly 80%.
- However, both the number and proportion of Year 12 students now taking Advanced mathematics is much lower than in 1995: there has been a significant shift to the non-calculus mathematics subjects.
- Females continue to be outnumbered by males (almost 2:1) in Year 12 Advanced mathematics.
- This data-collection project began with AustMS, but ongoing monitoring of Year 12 participation rates is now done by AMSI.

A very short history

In 2004, Tony Guttmann (the then President of AustMS) referred anecdotal claims of falling enrolments in the 'more difficult' Year 12 mathematics subjects to the AustMS Education Committee. We (Barrington and Brown) were members of that committee, which encountered numerous problems with enrolment data, including different counting and reporting procedures between the various state and territory authorities.

Jan Thomas (at that time the AustMS Exective Officer) suggested that the task be handballed to AMSI, and late in 2004, Garth Gaudry (then Director of AMSI ICE-EM) commissioned Helen Forgasz (Monash University) to undertake a detailed study of Australian Year 12 mathematics enrolment trends. At the same time, Garth Gaudry asked us (Barrington and Brown) to inspect the syllabi of all of the 2004 Year 12 mathematics subjects and to work through the examination papers, for every Australian state and territory, in order to 'verify' the splitting of subjects into three categories: 'Advanced', 'Intermediate' and 'Elementary'. In fact, John Malone (Curtin University) [2] had previously used these descriptors in compiling time-series data on Australian secondary school mathematics enrolments from about 1970, in collaboration with colleagues John Dekkers and John de Laeter. These descriptors acknowledge the tiered structure of Year 12 mathematics in all states and territories of Australia.

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In December of 2004, we two met with Helen Forgasz and Michael Evans (AMSI), and soon resolved that the categorisation of subjects and the assembly of enrolments data be done in tandem. The Barrington and Brown Report [1] which compared the then Year 12 mathematics subjects across Australia was published by AMSI in October 2005, followed in February 2006 by Helen Forgasz's comprehensive report of over 100 pages [3] on Year 12 mathematics enrolments for the period 2000 to 2004. Both these reports are still available on the AMSI website. Later in 2006, we obtained data back to 1995, and since then we have collected data, mostly by direct access to the websites of the state and territory secondary boards of studies. Since 2004, via its website, AMSI has released a yearly update of percentage participation rates in the form of a simple table: the latest version for 1995 to 2013 is reproduced below.

Categories of mathematics students (current)

First, the terms 'Advanced mathematics student', 'Intermediate mathematics student' and 'Elementary mathematics student' require some explanation.

The number of Year 12 Advanced mathematics students in Australia is the sum of the enrolments in the subjects:

NSW Mathematics Extension 1[1]
VIC Specialist Mathematics
QLD Mathematics C
WA Specialist Mathematics MAS3CD
SA Specialist Mathematics
TAS Mathematics — Specialised
ACT Specialist Mathematics
NT Specialist Mathematics
IBO Mathematics HL

There were just over 21 000 Advanced mathematics students in 2013, compared with over 25 000 in 1995.

The Australian Year 12 Intermediate mathematics subjects are:

NSW Mathematics (2-unit)
VIC Mathematical Methods
QLD Mathematics B
WA Mathematics MAT3CD
SA Mathematical Studies
TAS Mathematics — Methods

[1]There are two types of NSW Advanced mathematics student. One type takes Mathematics Extension 1 together with the NSW Intermediate mathematics subject Mathematics (2-unit), while the second type takes Mathematics Extension 1 together with (the more challenging) Mathematics Extension 2.

ACT Mathematical Methods
NT Mathematical Studies
IBO Mathematical Methods SL

An Intermediate mathematics student is one who is enrolled in one of the Intermediate mathematics subjects above but is not enrolled in an Advanced mathematics subject.

In 2013 there were just over 42 000 Intermediate students in Australia, compared with approximately 48 500 in 1995. In 2013 the total number of enrolments in Intermediate mathematics subjects was about 60 000. Most (but not all) Advanced mathematics students take an Intermediate subject concurrently.

The Australian Elementary mathematics subjects are numerous: some are accepted for inclusion in tertiary entrance scores, some not. In 2013, there were approximately 115 000 Elementary mathematics students in Australia (that is, those taking an Elementary mathematics subject but not taking an Intermediate subject nor an Advanced one). The number of Elementary mathematics subject enrolments was in excess of 120 000 in 2013: many students now take both an Elementary subject and an Intermediate subject in their Year 12 certificate.

In the coming Australian Curriculum for Mathematics, as outlined in the AustMS *Gazette* in 2010 by Michael Evans [2], the first two levels of Year 12 mathematics course are labelled 'Course A' and 'Course B'. Both of these fit John Malone's Elementary mathematics schema to which we have adhered.

Yet in retrospect, 10 years ago we might have been better advised to distinguish between 'Course B' Elementary mathematics (such as NSW General Mathematics, VIC Further Mathematics, QLD Mathematics A etc.) and 'Course A' Elementary mathematics subjects which were designed as 'life skills' courses. In 2004, there were 74 Elementary mathematics subjects offered across Australia, and some were difficult to categorise as 'Course B' or otherwise. Hopefully, the coming Australian Curriculum Course A/Course B system will be a little more transparent. Clearly the Australian Curriculum 'Course C' mathematics can be equated to Intermediate mathematics and 'Course D' to Advanced mathematics.

Participation rates

Table 1 gives mathematics participation rates as a percentage of students eligible to complete Year 12 for the years 1995 to 2013.

We may be slightly adventurous allowing time series data to run for such a long period. Certainly there have been changes in some mathematics subjects in some of the jurisdictions, and some counting procedures have changed during the last 20 years. However, Advanced and Intermediate students have been easy to identify during this period, and the proportion of Australians enrolled and 'eligible to complete Year 12' (about 178 000 in 1995; about 221 000 in 2013) has remained at approximately 1% of the total Australian population for the last two decades. We have been unwilling to include pre-1995 data owing to our inability convincingly

Table 1.

	Advanced mathematics students	Intermediate mathematics students	Elementary mathematics students (estimated)
1995	14.2	27.3	37
1996	13.6	26.9	37
1997	13.6	27.2	39
1998	12.8	26.2	39
1999	12.4	25.2	41
2000	12.0	25.1	47
2001	11.4	24.3	45
2002	11.2	23.5	46
2003	11.8	23.7	47
2004	11.8	22.9	46
2005	11.2	22.7	47
2006	10.6	21.8	48
2007	10.2	21.2	48
2008	10.3	20.8	49
2009	10.2	20.5	49
2010	10.0	19.8	51
2011	9.5	19.7	52
2012	9.4	19.5	52
2013	9.6	19.1	52

to categorise the Victorian Year 12 subjects 'Change and Approximation' etc. of the early 1990s, and owing to the 1980s seeing a doubling of Year 12 participation generally.

The trends

Note that the proportion taking mathematics at least to Intermediate level (add the Advanced and Intermediate percentages) fell from 41.5% in 1995 to 28.7% in 2013. This decline was general, with all nine jurisdictions contributing to it. Why has there been such a pronounced shift away from Advanced and Intermediate mathematics in favour of Elementary mathematics, and hence a diminution in the proportions well prepared for tertiary Science and Engineering courses?

We two possess no particular wisdom here, but recent dismantling of course prerequisites by some universities and scaling (or lack thereof) of so-called 'difficult' subjects for inclusion in university entrance scores would have to be on a list of suspected causes. And some reasons may be societal, which are difficult to measure. As long ago as the year 2000, Jan Thomas [5] issued the warning that 'there is a chronic shortage of mathematics teachers looming'. Secondary mathematics teaching now may not be such an attractive career for mathematics graduates and a shortage of suitably qualified secondary mathematics teachers may be a contributing factor.

Yet it is encouraging that from 2012 to 2013 the Advanced mathematics proportion recovered slightly. And, (adding the three percentages for each year) the proportion of students taking some mathematics in Year 12 has been slightly higher in

recent years (just over 80%) than in the late 1990s (just under 80%), so perhaps general mathematical literacy in the community is being maintained.

Differing participation rates among the jurisdictions

All of the states and territories and IBO offer respectable Year 12 mathematics subjects in each category. To state the obvious, no direct inferences can be made from participation rates about the quality and standard of mathematics achieved by students exiting Year 12.

We are reluctant to quote individual jurisdictions' participation rates. Differences among the nine jurisdictions are largely explained by demographics; the proportion of the population finishing school to Year 12 varies across the country; and the jurisdictions all have protocols governing the use of the data on their websites. So for these reasons and others, we will not quote numbers for any particular one, but suggest that any reader interested in a particular state or territory's mathematics enrolments refer to the relevant secondary board of studies website.

Yet we cannot resist mentioning that in 2013, NSW, the most populous state, had a few more Advanced mathematics students than VIC and QLD combined, yet had fewer Intermediate mathematics students than either VIC or QLD, both of which have substantially lower total Year 12 populations than NSW. We mean neither to praise NSW for its Advanced mathematics student participation rate being well above the national average, nor to censor it for having an Intermediate mathematics student participation rate well below average. However, we believe that the main reason for this phenomenon is that NSW has the luxury of a two-tier Advanced mathematics system.

The International Baccalaureate (IBO) student cohort in Australia is a select group, accounting for less than 1% of the Australian Year 12 population, and for these students, mathematics is a compulsory part of their program. Unsurprisingly, the IBO Diploma has higher Advanced and Intermediate mathematics participation rates than any of the states and territories, and the lowest Elementary mathematics participation rate.

The gender divide

Of the 221 000 students eligible to complete Year 12 in Australia in 2013, 52% were female. Of the girls, approximately 76% took some mathematics, compared with 85% of the boys. And more boys than girls took more than one mathematics subject.

Girls are still under-represented in Advanced mathematics: in 2013, 6.7% of girls took Advanced mathematics compared with 12.7% of boys. The 2013 overall Advanced mathematics participation rate was 9.6%, just slightly less than the arithmetic mean of the girls' and boys' rates because females outnumber males in Year 12.

Girls continue to be under-represented in the Intermediate mathematics cohort, but not severely so. In 2013, 17.6% of Year 12 girls were Intermediate mathematics students versus 20.7% of boys, for a combined rate of 19.1%. (These are percentages of students enrolled in an Intermediate mathematics subject but not enrolled in an Advanced mathematics subject.)

Girls have outnumbered boys in the Elementary mathematics cohort (those taking one or more Elementary mathematics subjects but not taking an Intermediate one nor an Advanced one) every year since we began keeping records, but not by much, and not in every jurisdiction. For 2013, we estimate that 52% of the Year 12 population were Elementary mathematics students.

Further information

Year 12 mathematics participation rates and schools data from other sources are reported in the AMSI annual Discipline Profile, which can be found on the AMSI website www.amsi.org.au.

Since its establishment, AMSI has been active in promoting the importance of the mathematical sciences to the nation, and data on participation rates in Year 12 mathematics has been a part of its 'ammunition' in the lobbying of governments. To this end, it has been useful to be able to quote with reasonable precision the proportions of Australian Year 12 students attempting each level of mathematics, the proportion choosing to take none at all, and the gender differences in participation.

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