Australian Mathematical Sciences Institute

Discipline Profile of the Mathematical Sciences 2015

Schools

Higher Education

Research

Contents

Author: Maaike Wienk   Editor: Stephanie Pradier   Design: Michael Shaw

Published August 2015

Note: this document does not currently cover the research enterprise of Australia's government agencies such as ABS, BoM, CSIRO and DSTO, or the private sector in areas such as finance and mining. Research training is predominantly the domain of universities with some co-supervision and postdoctoral training taking place at the agencies.

Introduction

It is impossible to overstate the importance of the mathematical sciences to Australia's society and economy — now, and into the future. Mathematics and statistics play crucial roles in virtually every aspect of life. In order to equip the Australian population with the mathematical skills and knowledge necessary for life and employment, the discipline must have a significant presence at all levels of the education system. Only then will we be able to feed the needs of business, government and the research sector.

This is the fourth edition of AMSI's *Discipline Profile of the Mathematical Sciences*. It provides a snapshot of the current state of the field, in the broadest sense. This annual publication brings together data from various sources to identify trends in school education, higher education, research and employment prospects for graduates in the mathematical sciences. The intention of these profiles is to provide evidence and inspiration for policy development by AMSI, government, business and various stakeholder groups — universities, societies and government agencies.

The overall picture indicates many deeply disturbing problems affect Australia's capacity and capability in the mathematical sciences. It also shows these problems start early in the mathematics pipeline.

There are not nearly enough fully qualified mathematics teachers in secondary schools — especially in Years 7–10. And while most students take at least some mathematics in Year 12, the proportion of students taking intermediate and advanced mathematics subjects in secondary school — particularly girls — has been in steady decline for two decades. This trend seriously undermines the prospects of creating a scientifically literate population.

At the same time, a report by the Centre for International Economics for the Office of the Chief Scientist and the Australian Academy of Science has highlighted the crucial nature of mathematical research to virtually all aspects of the economy.

Included in this year's profile is preliminary data from the 2014 AMSI Survey, as well as new data on research funding and research performance. As always, we've included the latest NAPLAN data. We have also been able to include more comprehensive data on the destinations and employment prospects of graduates in the mathematical sciences. And last but not least, there are new data comparing Australian mathematical research internationally.

This document should be read in conjunction with the updated version of *A Vision for a Maths Nation*, AMSI's policy document.
www.amsi.org.au/maths_nation

Schools

WEAKENING FOUNDATIONS 2003–2012

25%
decrease in high performers
page 9

33%
increase in poor performers
page 9

20%
decrease in proportion of advanced mathematics enrolments at Year 12
page 12

Higher Education

LOST OPPORTUNITES

Only **30%** of undergraduate and postgraduate students are female
pages 28–30

Australian entry into mathematics degrees is less than **50%** of the OECD average
page 32

41% of engineering degrees do NOT have intermediate mathematics as a pre-requisite
page 13

State of the discipline

IN STARK CONTRAST:

Mathematical & physical science research is worth
$145 billion
to the Australian economy per year.

54% of adults have only basic numeracy skills—below the OECD average.
pages 17 & 37

SOLID PEFORMANCE 2011–2015

The mathematical sciences had the highest success rate for ARC Discovery grants:
28% against **21%**
in all other science fields
page 39

Australian applied maths and statistics both
rank above
all 15 EU countries on publication citation rates
page 42

Research

At **1.7%** mathematical sciences have the smallest share of public research expenditure on STEM
page 39

Schools

25%
decrease in high performers
page 9

33%
increase in poor performers
page 9

20%
decrease in proportion of advanced mathematics enrolments at Year 12
page 12

School education and numeracy

2.1 STUDENT PERFORMANCE IN NUMERACY AND MATHEMATICS

Despite the introduction of programs to improve mathematical performance, NAPLAN national reports show that student performance in numeracy in Years 3, 5, 7 and 9 has not lifted at all over the past seven years. Figure 2.1 shows the achievement by year; the mean numeracy score is in the upper band and the percentage of students scoring at, or above, the national minimum standard is in the lower band. Between 2008 and 2013 most scores show no significant difference, except for Year 9, which showed a moderate decline in the percentage of students scoring at or above the national minimum standard in 2013. In 2014 this percentage increased again closer to its longer term level.

Figure 2.1 NAPLAN Achievement of Students in Numeracy

Figure TS.N1: Achievement of Students in Numeracy, Australia, 2008–2014.

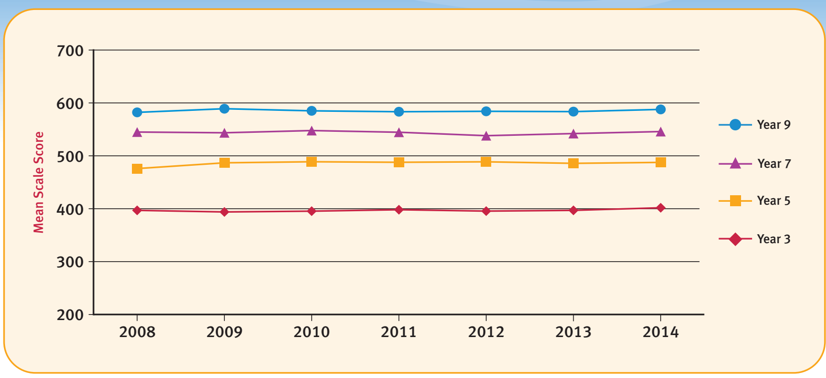


Table TS.N1: Achievement of Students in Numeracy, Australia, 2008–2014.

Students		2008	2009	2010	2011	2012	2013	2014	Nature of the difference	
									2008 vs. 2014	2013 vs. 2014
Year 9	Mean / (S.D.)	582.2 (70.2)	589.1 (67.0)	585.1 (70.4)	583.4 (72.1)	584.2 (72.4)	583.6 (82.2)	587.8 (70.9)	■	■
	% at or above NMS	93.6	95.0	93.1	93.0	93.7	90.6	94.1	■	△
Year 7	Mean / (S.D.)	545.0 (73.2)	543.6 (71.0)	547.8 (72.4)	544.6 (73.7)	538.1 (73.9)	542.1 (71.4)	545.9 (73.0)	■	■
	% at or above NMS	95.4	94.8	95.1	94.5	93.8	95.0	95.1	■	■
Year 5	Mean / (S.D.)	475.9 (68.8)	486.8 (67.8)	488.8 (69.9)	487.8 (68.2)	488.7 (70.9)	485.8 (71.5)	487.6 (69.0)	■	■
	% at or above NMS	92.7	94.2	93.7	94.4	93.3	93.4	93.5	■	■
Year 3	Mean / (S.D.)	396.9 (70.4)	393.9 (72.9)	395.4 (71.8)	398.1 (70.6)	395.5 (72.6)	396.9 (65.8)	401.8 (73.0)	■	■
	% at or above NMS	95.0	94.0	94.3	95.6	93.9	95.7	94.6	■	■

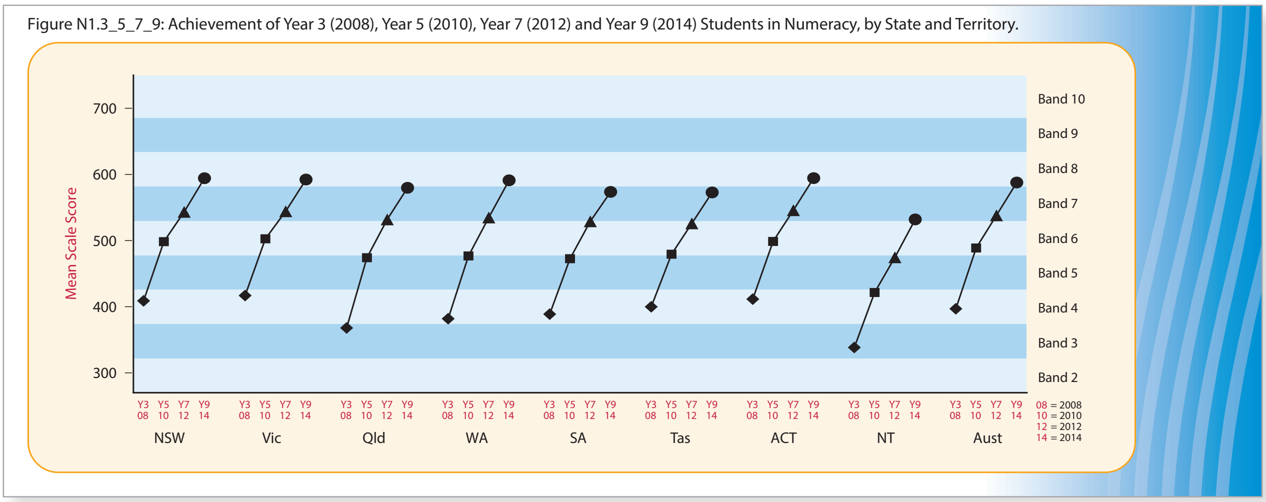
NMS: national minimum standard.
Δ indicates statistically significant increase when compared to the base year or previous year.
• indicates no statistically significant difference when compared to the base year or previous year.

Source: NAPLAN, 2014 National Report, page 287.

Figure 2.2 depicts the gains in numeracy skills over a six year period. This cohort sat the first NAPLAN tests in 2008, when they were in Year 3. Then again in 2010, 2012 and 2014, when they were in Years 5, 7 and 9 respectively. In this cohort the highest achievement gain took place between Year 3 and 5, and the lowest between Year 7 and 9. Significantly, the students in WA and QLD gained the most in numeracy skills in their schooling years — they did, however, start from a lower base. In contrast, students in NSW and Vic began with a higher proficiency but have not gained as much.

The international surveys TIMSS (Table 2.3) and PISA (Table 2.4) indicate that the average mathematical performance of Australian teenagers has declined. At the same time, however, other countries, mainly in the Asia-Pacific region, have managed to significantly improve students' mathematical proficiency.

Figure 2.2 NAPLAN Achievement of Students in Numeracy



Source: NAPLAN, 2014 National Report, page 362.

Table 2.3 International Student Achievement in Mathematics: selection of data from TIMSS 1995–2011

	Girls	Boys	Australia overall	Int. (scaling) Average	Number of countries outperforming Australia	Countries outperforming Australia
4th grade						
1995			495			
2003	497	500	499	495	13	Singapore, Hong Kong SAR, Japan, Chinese Taipei, Belgium (Fl), Netherlands, Latvia, Lithuania, Russian Federation, England, Hungary, United States, Cyprus
2007	513	519	516	500	12	Hong Kong SAR, Singapore, Chinese Taipei, Japan, Kazakhstan, Russian Federation, England, Latvia, Netherlands, Lithuania, United States, Germany
2011	513	519	516	500	17	Singapore, Republic of Korea, Hong Kong SAR, Chinese Taipei, Japan, Northern Ireland, Belgium (Fl), Finland, England, Russian Federation, United States, Netherlands, Denmark, Lithuania, Portugal, Germany, Ireland
8th grade						
	Girls	**Boys**	**Australia overall**	**Int. (scaling) Average**	**Number of countries outperforming Australia**	**Countries outperforming Australia**
1995			509			
2003	499	511	505	467	9	Singapore, Republic of Korea, Hong Kong SAR, Chinese Taipei, Japan, Belgium (Fl), Netherlands, Estonia, Hungary
2007	488	504	496	500	10	Chinese Taipei, Republic of Korea, Singapore, Hong Kong SAR, Japan, Hungary, England, Russian Federation, United States, Lithuania
2011	500	509	505	500	6	Republic of Korea, Singapore, Chinese Taipei, Hong Kong SAR, Japan, Russian Federation

Source: Selected data from TIMSS 1995, 2003, 2007 and 2011; Sue Thomson et al., Highlights from TIMSS and PRLS from Australia's perspective, ACER 2012.

Table 2.4 Student performance in the mathematical sciences among 15-year olds: selection of data from OECD PISA reports in the period 2000–2012

	Australia score	Comparison to int. average	No of countries significantly outperforming Australia	Countries significantly outperforming Australia
2000	533	Above average	1	Japan
2003	524	Above average	4	Hong Kong-China, Finland, Korea, Netherlands
2006	520	Above average	8	Chinese Taipei, Finland, Hong Kong-China, Korea, Netherlands, Switzerland, Canada, Macao-China
2009	514	Above average	12	Shanghai-China, Singapore, Hong Kong-China, Korea, Chinese Taipei, Finland, Liechtenstein, Switzerland, Japan, Canada, Netherlands, Macao-China
2012	504	Above average	16	Shanghai-China, Singapore, Hong Kong-China, Chinese Taipei, Korea, Macao-China, Japan, Liechtenstein, Switzerland, Netherlands, Estonia, Finland, Canada, Poland, Belgium, Germany

Source: Selected data from PISA 2000, 2003, 2006, 2009 and 2012; Sue Thomson et al., PISA 2012: How Australia measures up, ACER 2013.

2.2. DISTRIBUTION OF MATHEMATICAL ACHIEVEMENT

More worrying is the fact that there is significant inequality in performance among Australian students: between students in metropolitan areas and remote areas; between states and territories; and between top performers and low performers. Starting with the latter, the 2012 PISA survey showed that since 2003 the number of students performing very well in mathematics has been dropping, while the number of low performers has been rising. The percentage of Australian students reaching the two highest levels of proficiency is slightly under 15 per cent; the OECD average is 12.6 per cent. In 2003, this was approximately 20 per cent, equating to a 25 per cent drop over nine years. In comparison there has been a 33 per cent increase in our low performing (below proficiency level 2) students. In 2003, only 15 per cent of Australian students were considered as under-performing, in 2012, 20 per cent were (source: PISA 2012, Volume I, page 70).

To show the possible influence of different factors on achievement levels, the annual NAPLAN reports show achievement levels according to gender, geolocation, language background other than English (LBOTE), state and territory, and parental education and occupation. Table 2.5 is an extract from the 2014 NAPLAN report summarising Year 9 numeracy achievement by these variables.

Table 2.5 shows that, in terms of reaching minimum standards, there is very little difference between male and female students. Males are, however, represented significantly more in the highest achievement bands. This difference warrants close examination, especially to see if there is a relation with the lower percentage of girls choosing advanced mathematics in Year 12 (see section 2.3).

Having a language background other than English does not appear to be a particular disadvantage — on the contrary, in the highest bands of achievement the percentage of students with a non-English background is significantly higher. Parental education and occupation are important factors in achievement in numeracy, this effect is especially pronounced in the highest achievement bands. Geolocation is also an important factor. Students in metropolitan and provincial areas fare much better than their counterparts in remote and very remote areas. However, this appears to be intimately linked to indigenous status. If we compare the achievement of non-indigenous students in remote and very remote areas to that in metropolitan and provincial areas, the results are not dramatically different — in terms of meeting the minimum standards — whereas the achievement of indigenous students in remote and very remote areas is extremely far behind the rest of Australia.

Table 2.5 NAPLAN Year 9 Numeracy in 2014

	Below national minimum standard (%)		At national minimum standard (%)	Above national minimum standard (%)				At or above national minimum standard (%)
	Exempt	Band 5 and below	Band 6	Band 7	Band 8	Band 9	Band 10	
Achievement of Year 9 Students by Sex, 2014								
Male	2.2	3.8	15.3	27.0	25.1	15.8	10.9	94.0
Female	1.3	4.4	17.9	29.9	25.4	13.7	7.4	94.3
Achievement of Year 9 Students by LBOTE* Status, 2014								
LBOTE	2.3	4.5	15.3	24.0	22.0	15.7	16.1	93.2
Non-LBOTE	1.6	3.9	16.9	29.7	26.2	14.5	7.3	94.5
Achievement of Year 9 Students by Parental Education, 2014								
Bachelor degree or above	0.9	0.8	6.3	19.8	28.9	24.0	19.3	98.3
Advanced Diploma/Diploma	1.1	2.4	14.5	31.2	28.6	14.9	7.4	96.5
Certificate I to IV	1.5	4.3	21.1	34.4	24.7	10.2	3.8	94.1
Year 12 or equivalent	2.0	4.2	19.4	31.7	24.8	11.9	6.1	93.8
Year 11 or equivalent or below	3.6	10.4	29.7	31.9	16.4	5.9	2.2	86.0
Not stated (10%)	3.2	7.8	19.4	27.4	22.4	12.6	7.2	88.9
Achievement of Year 9 Students by Parental Occupation, 2014								
Senior Management/qualified professionals	0.8	0.9	7.0	20.8	29.2	23.5	17.8	98.3
Other business managers and associate professionals	0.9	1.7	12.0	28.8	29.4	17.2	10.0	97.4
Tradespeople, clerks, skilled office, sales and service staff	1.3	3.4	18.6	33.4	26.0	11.8	5.4	95.3
Machine operators, hospitality staff, assistants, labourers	2.3	6.3	24.9	33.1	20.1	8.6	4.7	91.4
Not in paid work in the previous 12 months	5.0	11.3	29.5	29.0	15.7	6.5	3.0	83.7
Not stated (13%)	3.3	8.6	22.2	28.3	20.6	10.7	6.3	88.2
Achievement of Year 9 Students by Indigenous Status, 2014								
Indigenous	2.7	21.1	34.1	26.3	11.4	3.6	0.8	76.2
Non-Indigenous	1.7	3.1	15.6	28.5	26.0	15.4	9.6	95.2
Achievement of Year 9 Students by Geolocation, 2014								
Metro	1.8	3.3	15.1	27.3	25.7	16.0	10.9	94.9
Provincial	1.7	5.0	20.3	31.9	24.8	11.7	4.6	93.2
Remote	2.0	13.1	26.3	29.8	18.8	7.7	2.3	84.9
Very Remote	1.3	41.4	26.1	18.5	8.9	3.2	0.6	57.3
Achievement of Year 9 Non-Indigenous students by Geolocation, 2014								
Metro	1.7	2.9	14.5	27.2	26.1	16.4	11.3	95.5
Provincial	1.7	3.9	18.8	32.3	26.0	12.4	5.0	94.4
Remote	1.5	4.9	21.9	34.3	24.0	10.3	3.2	93.6
Very Remote	0.9	4.8	22.8	38.9	22.6	8.6	1.5	94.3
Achievement of Year 9 Indigenous Students by Geolocation, 2014								
Metro	3.0	15.5	32.8	29.1	13.8	4.5	1.2	81.5
Provincial	2.5	17.1	36.5	28.2	11.5	3.7	0.5	80.4
Remote	3.2	33.5	37.2	18.6	6.0	1.5	0.1	63.4
Very Remote	1.5	57.8	27.7	9.1	2.8	0.8	0.2	40.7

*LBOTE: Language Background Other Than English.
Source: NAPLAN, 2014 National Report, extracts from tables 9.N2-N9, pages 239–248.

2.3. STUDENT NUMBERS AND PARTICIPATION RATES

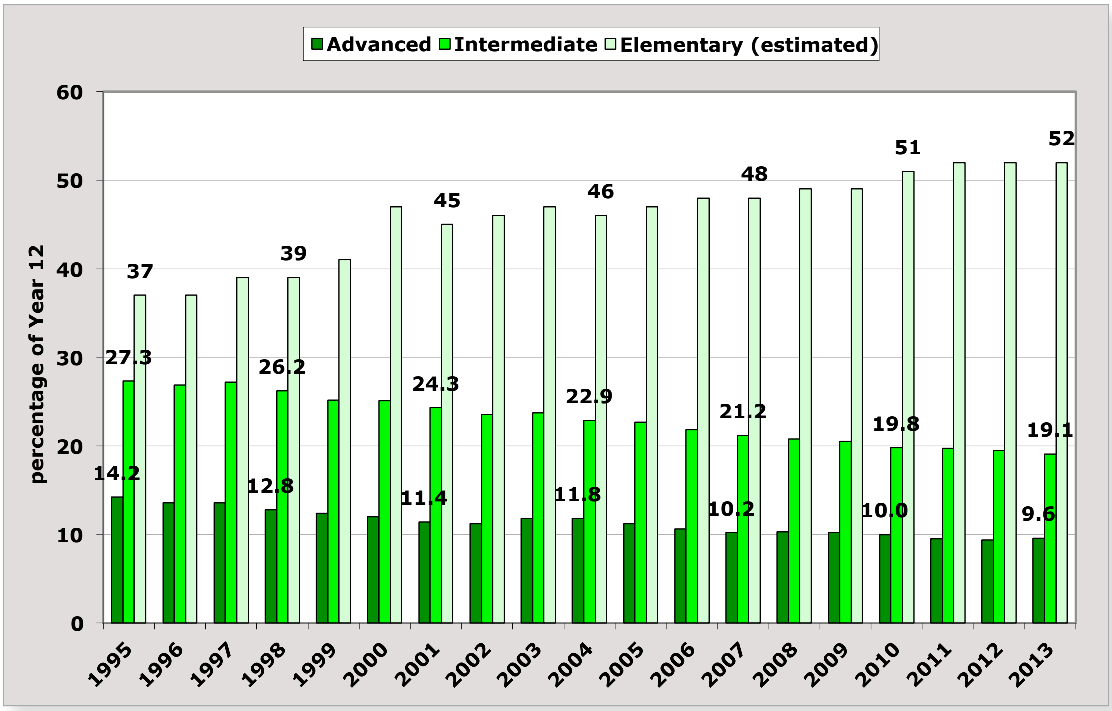
Year 12 mathematics participation rates have been tracked since 1995. Figure 2.6 clearly illustrates that the proportion of students choosing intermediate and advanced mathematics subjects has been in steady decline for some time.

The data displayed in Figure 2.6 include all Year 12 mathematics students enrolled through the secondary boards of studies and the Australian International Baccalaureate (IB) in all states and territories, for the years 1995 to 2013.

The number of Australian Year 12 students studying advanced mathematics rose from 20,617 in 2012, to 21,189 in 2013. The 2013 advanced mathematics percentage participation rate of 9.6 per cent was also slightly up from 9.4 per cent in 2012. The number of intermediate students (those enrolled in an intermediate mathematics subject but NOT enrolled in an advanced mathematics subject) decreased, from 42,605 in 2012, to 42,232 in 2013. When measured against the ever-increasing Australian Year 12 population, there has been a persistent and ongoing decline in the percentages of Year 12 students taking advanced and intermediate mathematics. For example, in 2013, the Year 12 population was just under 221,000, compared with approximately 200,000 in 2007.

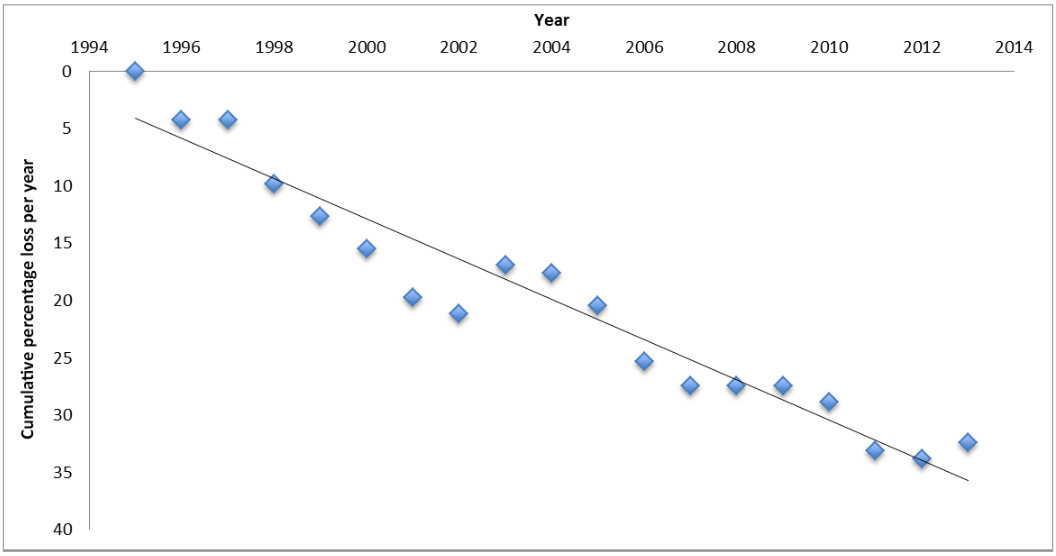
The number of elementary mathematics students (those enrolled in an elementary mathematics subject but NOT enrolled in either an intermediate or advanced mathematics subject) increased very slightly between 2012 and 2013. The proportion remained at roughly 52 per cent. The proportion of Australian students studying SOME mathematics in Year 12 has remained at 80 per cent over the past nineteen years. However, the level of mathematics studied has dropped considerably. The proportion of Year 12 students taking advanced mathematics dropped by 20 per cent between 2000 and 2013 and by 32 per cent between 1995 and 2013 (see Figure 2.7).

Figure 2.6 Australian Year 12 mathematics students



Source: Frank Barrington, Year 12 Mathematics Participation Rates in Australia 1995–2013, data collection provided to AMSI.

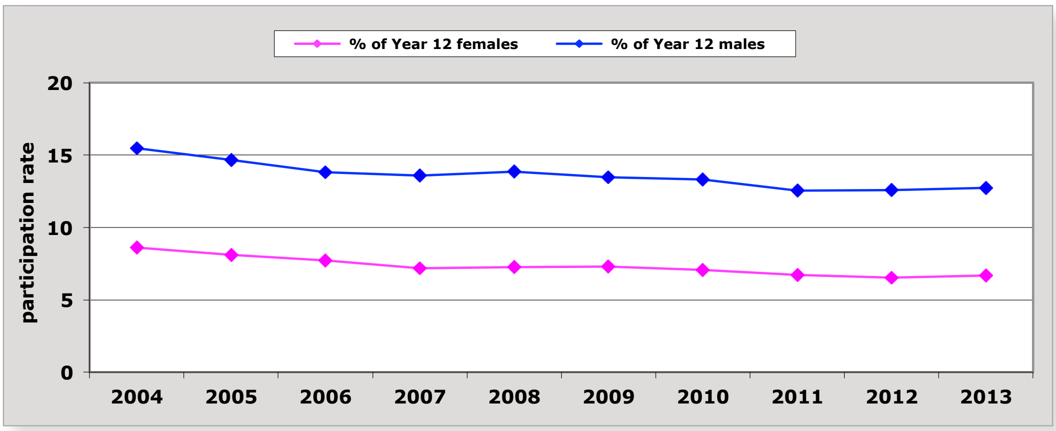
Figure 2.7 Percentage decline proportion of advanced mathematics students



Source: Frank Barrington, Year 12 Mathematics Participation Rates in Australia, data collection provided to AMSI.

While the percentage of boys and girls taking elementary mathematics is virtually the same, only 17.6 per cent of girls took an intermediate mathematics subject compared with 20.7 per cent of boys. In advanced mathematics, girls tend to be most heavily under-represented. In 2013, only 6.7 per cent of girls took advanced mathematics, compared with 12.7 per cent of boys (see Figure 2.8).

Figure 2.8 Year 12 advanced mathematics students in Australia



Source: Frank Barrington, Year 12 Mathematics Participation Rates in Australia 1995–2013, data collection provided to AMSI.

While the slide in performance in school mathematics overall and the decline in the proportion of students choosing to do "harder" mathematics is a complex issue, it is possible to point out a few factors that are likely to contribute to the problem. First of all, cultural attitudes towards the study of mathematics might be important. Achievement in mathematics is certainly related to students' self-confidence and attitude towards learning it. Table 2.9 sets out students' attitudes towards mathematics and science in Year 8. According to the TIMSS 2011 results, Australian students' self-confidence, and the value they place on learning mathematics, lie close to the international average. However, 45 per cent of Australian Year 8 students do not like mathematics, compared to 31 per cent internationally.

A second factor likely to contribute to the slide in the proportion of students choosing intermediate and advanced mathematics in Year 12 is the fact that many universities have dropped intermediate or advanced mathematics as a prerequisite to enter science and engineering degrees, in favour of "assumed knowledge" mathematics requirements. This affects the perceived need among school students to step up to the challenge of choosing the "harder" maths subjects. Table 2.10 summarises maths prerequisites and assumed knowledge to enter bachelor of science, engineering and commerce degrees across the states. Across Australia, only 14 per cent of universities require at least intermediate level maths for entry into a bachelor of science; and only 13 per cent for entry into a bachelor of commerce. Engineering degrees have stricter prerequisites in this regard, however 41 per cent of engineering degrees do not require at least intermediate level mathematics as a condition of entry.

A third factor might be that students believe it will optimise their university entrance scores if they choose a maths subject below their capability. In fact, a recent study has shown that for NSW students the study of (elementary) HSC general mathematics leads to higher scaled ATAR scores than the study of more advanced, calculus based HSC mathematics (Pitt, Australian Journal of Education 2015). No evidence suggests this problem extends beyond NSW. However, all these, and other, possible factors certainly warrant further investigation.

Table 2.9 Student attitudes towards mathematics: selection of data from TIMSS 2011

% of students who like science and mathematics						
	Like		Somewhat like		Do not like	
	Science	Mathematics	Science	Mathematics	Science	Mathematics
Australia	25	16	42	40	33	45
International average	35	26	44	42	21	31
% of students who are confident in science and mathematics						
	Confident		Somewhat confident		Not confident	
	Science	Mathematics	Science	Mathematics	Science	Mathematics
Australia	16	17	49	46	35	37
International average	20	14	49	45	31	41
% of students who value science and mathematics						
	Value		Somewhat value		Do not value	
	Science	Mathematics	Science	Mathematics	Science	Mathematics
Australia	25	46	31	40	44	14
International average	41	46	33	39	26	15

Source: TIMSS 2011, selected data from Exhibits 8.1 to 8.5; Sue Thomson et al., Monitoring Australian year 8 student achievement internationally: TIMSS 2011.

Table 2.10 Minimum requirements for entry into Bachelor Degrees

	Science				Engineering				Commerce			
State	No of Unis offering course	Intermed. Maths PreReq	Assumed Knowledge of Intermed. Maths	% with Intermed. Maths as pre req	No of Unis offering course	Intermed. Maths PreReq	Assumed Knowledge of Intermed. Maths	% with Intermed. Maths as pre req	No of Unis offering course	Intermed. Maths PreReq	Assumed Knowledge of Intermed. Maths	% with Intermed. Maths as pre req
TAS	1	0	1	0%	1	1	0	100%	0	0	0	0%
VIC	7	2	0	29%	7	6	1	86%	7	2	0	29%
NSW *	10	0	9	0%	9	0	9	0%	7	0	5	0%
QLD	7	3	3	43%	7	6	1	86%	5	1	0	20%
SA	3	0	1	0%	3	3	0	100%	3	0	0	0%
ACT	2	0	1	0%	2	1	1	50%	2	1	0	50%
WA	4	0	1	0%	4	3	0	75%	4	0	0	0%
NT	1	0	0	0%	1	0	1	0%	1	0	0	0%
National	2	0	0	0%	0	0	0	0%	2	0	0	0%
Total courses	37	5	16	14%	34	20	13	59%	31	4	5	13%
* NSW Mathematics Extension 1 for majority of majors in BSc												

Please note: some degrees may list advanced mathematics as a prerequisite or assumed knowledge for entry into certain majors, e.g. mathematics or physics majors.
Source: data collected by the FYiMaths network, 2015.

2.4 TEACHER PROFILES AND QUALIFICATIONS

Research consistently shows there are not enough teachers qualified to teach mathematics in Australian secondary schools. The commonly accepted definition of being qualified in a discipline is to have completed methodology training in the area. The most recent data — gathered in 2013 — on qualifications of mathematics teachers in secondary education indicate the following (see Table 2.11):

- 73.9 per cent of Years 7–10 teachers teaching mathematics have completed methodology training in the area, suggesting that 26.9 per cent of these teachers are not fully qualified. This is an improvement on the 2010 data, which indicated only 60.4 per cent of Years 7–10 teachers teaching mathematics had completed methodology training in the area. These numbers lag behind general science teachers. Data suggests in Years 7–10, 79.6 per cent of science teachers have completed methodology training in the area.

- In Years 11–12, 86.1 per cent of mathematics teachers have completed methodology training, up from 76.3 per cent in 2010.

- 72.5 per cent of Years 11 and 12 mathematics teachers had at least three years tertiary education in mathematics, up from 64.1 per cent in 2010 and 68 per cent in 2007.

- 60.1 per cent of Years 7–10 mathematics teachers had at least three years tertiary education, up from 54.8 per cent in 2010 and 53.0 per cent in 2007.

The data presented by ACER (Table 2.11) were collected in 2013 and suggest an important improvement in training levels of mathematics teachers compared to only a few years ago. It is not clear what has caused the remarkable change in the figures between 2010 and 2013, and close scrutiny of this issue remains necessary.

For instance, data provided by the Queensland Audit Office in a report from 2013 indicated the shortage of qualified mathematics teachers was much more serious than the shortage of science teachers (see Table 2.12). According to this report, in Years 8–10, 36.5 per cent of mathematics teachers had no specialist qualification, against 20.3 per cent of teachers teaching science.

Table 2.11 Teachers teaching in selected areas: qualifications, experience and professional learning activities

Area currently teaching	Years of tertiary education in the area (%) 1 Sem Yr 1	2 Sems Yr 1	2	3+	Total with at least 1 year	Methodology training in the area? Yes (%)	≥5 years teaching experience in the area? Yes (%)	Professional learning in past 12 months in the area? Yes (%)
Primary								
LOTE	3.3	4.1	4.8	60.0	68.9	60.5	56.8	64.3
Special Needs	19.5	15.1	8.1	28.4	51.6	-	31.5	50.0
Secondary								
LOTE 7/8-10	1.3	3.1	5.1	78.9	87.0	73.9	61.0	70.3
LOTE 11-12	0.3	2.1	1.8	89.0	92.9	82.5	72.6	76.1
Chemistry 11-12	2.6	7.7	20.5	68.6	96.7	79.7	72.7	63.5
IT 7/8-10	13.5	12.7	6.0	42.3	61.0	45.6	50.3	61.9
IT 11-12	6.2	13.0	10.3	58.4	81.7	62.5	66.3	83.4
Maths 7/8-10	5.6	11.5	11.0	60.1	82.6	73.9	69.9	74.8
Maths 11-12	4.2	7.9	10.7	72.5	91.0	86.1	79.6	84.5
Physics 11-12	3.6	19.9	21.8	52.1	93.9	72.1	76.3	66.0
General Science 7/8-10	6.9	11.5	6.4	61.3	79.2	79.6	68.9	56.7

Note: The 'Total with at least 1 year' column does not include those who indicated that they had only studied one semester in year 1 of tertiary education. All areas, including the Primary 'Special Needs' area, include teachers in Special Schools.

From: Phillip McKenzie et al., *Staff in Australia's Schools 2013: Main Report on the Survey*, ACER, April 2014, Table 5.32, page 67.

Table 2.12 Out-of-field teachers teaching mathematics and science subjects in 2010

Subject and level		Teachers with no specialist subject area qualification and teaching %
Maths	All maths subjects	33.3
	Years 8–10	36.5
	Mathematics A	32.5
	Mathematics B	12.5
	Mathematics C	8.8
Science	All science subjects	14.5
	Years 8–10	20.3
	Chemistry	9.80
	Physics	17.0
	Biology	7.8

From: Queensland Audit Office, Supply of specialist subject teachers in secondary schools, Report to Parliament 2: 2013–2014, page 19.

Seen from an international perspective the Australian situation only recently looked significantly worse than the international average. Compared to the international average of 12 per cent, a staggering 34 per cent of Australian Year 8 students were being taught mathematics by a teacher without a solid mathematical background, according to the 2011 TIMSS survey (see Table 2.13).

Furthermore, lack of teacher training in mathematics had a negative effect on student performance. The average achievement of students in classes with a teacher without a major in either mathematics or mathematics education in 2011 was 500 — five points lower than the national average achievement of 505 points (see Table 2.1, page 7), whereas the achievement of students with a teacher with a mathematical background was the same or higher than the national average.

Table 2.13 Teachers Majored in Education and Mathematics (8th Grade): extract from TIMSS 2011 Exhibit 7.4

	Major in Mathematics and Mathematics Education		Major in Mathematics Education but no Major in Mathematics		Major in Mathematics but no Major in Mathematics Education		All Other Majors	
	% of students	Average Achievement	% of students	Average Achievement	% of students	Average Achievement	% of students	Average Achievement
Australia	37	505	9	522	21	519	34	500
International Average	32	471	12	470	41	468	12	462

Source: TIMSS 2011 Exhibit 7.4: Teachers Majored in Education and Mathematics.

Data dating back to 2010 also indicated levels of teacher training differ significantly between metropolitan, provincial and remote areas (see Table 2.14). The proportion of teachers with three years or more tertiary education in mathematics who teach Years 7 to 10 is 45 per cent in metropolitan, 37 per cent in provincial and 40 per cent in remote areas. For Years 11 and 12, 64 per cent of metropolitan teachers have three years or more tertiary mathematics, compared to 57 per cent and 43 per cent in provincial and remote areas respectively. Table 2.14 shows that only biology has a good supply of qualified teachers — unfortunately very few biology teachers are also qualified to teach mathematics.

Table 2.14 Highest year level of tertiary education in field by geolocation: 2010

	Highest Year Level of Tertiary Education in Field														
	None			Year 1			Year 2			Year 3 and higher			**Total**		
	Metro	Prov.	Remote	Metro	Prov.	Remote	Metro	Prov.	Remote	Metro	Prov.	Remote	Metro	Prov.	Remote
Year 7-10 Maths	359 24%	223 31%	31 26%	242 16%	119 6%	20 17%	214 14%	116 16%	20 17%	669 45%	266 37%	48 40%	1484	724	119
Year 11-12 Maths	112 12%	62 16%	7 14%	92 10%	47 12%	9 18%	139 15%	62 16%	13 25%	600 64%	226 57%	22 43%	943	397	51
Year 11-12 Physics	21 8%	11 9%	2 18%	38 15%	24 20%	4 36%	50 20%	19 16%	1 9%	139 56%	66 55%	4 36%	248	120	11
Year 11-12 Chemistry	12 4%	7 5%	0	27 9%	13 9%	2 33%	40 13%	22 15%	3 50%	220 74%	103 71%	1 17%	299	145	6
Year 11-12 Biology	18 5%	17 9%	2 11%	11 3%	9 5%	0	18 5%	7 4%	2 11%	342 88%	147 82%	14 78%	389	180	18

From: Office of the Chief Scientist, Mathematics, Engineering and Science in the National Interest, May 2012, Appendix F.

Despite the encouraging new ACER data from 2013, available teaching positions in mathematics are still more likely to remain unfilled than any other teaching positions. In 2007, 10 per cent of secondary schools reported at least one unfilled vacancy for a mathematics teacher at the start of the school year. This decreased to 8.3 per cent in 2010. In 2013, 8.7 per cent of schools reported at least one vacancy in mathematics (even though the absolute number of vacancies decreased by 130). Reported vacancies in most other areas have decreased considerably; in contrast, proportionally and in absolute terms mathematics teaching positions have been, and remain the most difficult to fill (see Table 2.15).

Table 2.15 Unfilled teaching positions in selected areas, at Day 1 of the school year, 2007, 2010 and 2013

	Per cent of schools			Total positions		
	2007 %	2010 %	2013 %	2007	2010	2013
Primary						
Generalist primary teaching	*10*	*7.6*	*10.2*	1,500	1,080	1,640
LOTE	*4*	*2.9*	*4.2*	500	240	320
Special needs	*5*	*0.8*	*3.0*	500	70	300
Library	*4*	*3.6*	*0.9*	300	280	60
Secondary						
English	*8*	*7.5*	*1.7*	300	350	60
LOTE	*5*	*5.4*	*2.9*	150	150	90
Mathematics	*10*	*8.3*	*8.7*	300	400	270
Science	*8*	*7.2*	*5.9*	200	190	190
SOSE	*5*	*3.2*	*3.2*	150	190	90

Source: Phillip McKenzie et al., Staff in Australia's Schools 2013: Main Report on the Survey, ACER, April 2014, Table 12.8, page 127.

Difficulty in filling vacancies leads to teachers teaching "out-of-field"; retired teachers being hired on short-term contracts; or, in acute shortages, teachers not fully qualified in subject areas being recruited to teach these subjects. Table 2.16 shows the significant differences between government, catholic and independent schools in teacher shortages and their strategies used to deal with these. Teaching out-of-field and recruiting not fully qualified teachers are the most prevalent solutions in catholic schools; principals in government schools mostly opt for teaching out-of-field and recruiting retired teachers on short-term contracts. Over half of independent schools do not report having recent teacher shortages. Of those who do, the most popular solutions are recruiting retired teachers and combining classes within subject areas. Teaching out-of-field is much less prevalent in independent schools. For all schools, compared to 2010, more principals report not having teacher shortages (38.4 per cent versus 33.4 per cent in 2010) and teaching out-of-field is less prevalent (33.2 per cent versus 42.2 per cent in 2010) which suggests some improvement in staffing shortages.

Table 2.16 Secondary Principals' strategies to deal with staffing shortages

Which of the following strategies do you use to deal with teacher shortages at your school?	Secondary			
	Govt	**Cath**	**Ind**	**All**
Reduce the curriculum offered	18.7	7.1	8.9	15.0
Reduce the length of classroom time for a subject	2.2	2.4	0.0	1.7
Combine classes within subject areas	11.6	9.5	7.6	10.4
Combine classes across subject areas	3.6	0.0	2.5	2.9
Combine classes across year levels	14.2	2.4	8.9	11.6
Require teachers to teach outside their field of experience	39.1	35.7	15.2	33.2
Recruit teachers not fully qualified in subject areas with acute shortages	24.4	14.3	7.6	19.4
Recruit retired teachers on short-term contracts	30.2	11.9	6.3	22.5
Share programs with other schools	8.9	9.5	7.6	8.7
Not relevant - no recent teacher shortages	***31.6***	***52.4***	***50.6***	***38.4***

Note: Principals could indicate >1 strategy.

Source: Phillip McKenzie et al., Staff in Australia's Schools 2013: Main Report on the Survey, ACER, April 2014, Table 12.12, page 129.

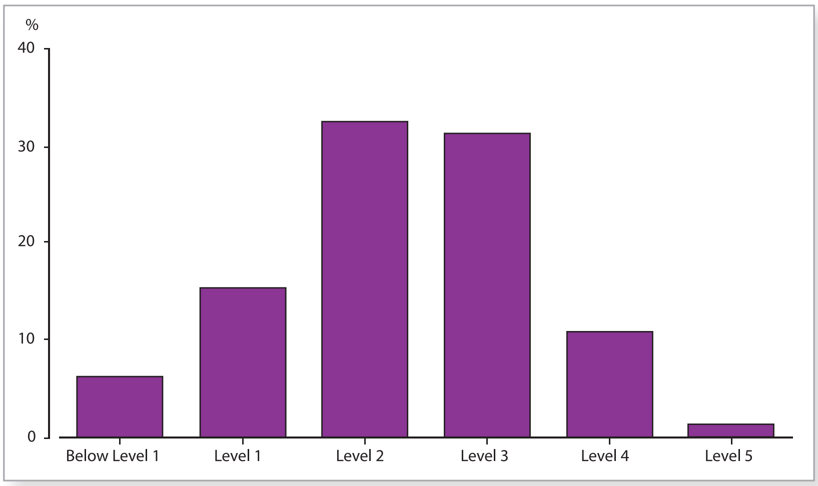
2.5 ADULT NUMERACY

The Programme for the International Assessment of Adult Competencies (PIAAC) has a scale with six levels — level five the highest and below level one the lowest. According to IPAAC, the numeracy skills of 53.5 per cent of the Australian population is at level two or below (see Figure 2.17).

Tasks in level two are: calculation with whole numbers and common decimals, percentages and fractions, and the interpretation of relatively simple data and statistics in texts, tables and graphs. The IPAAC results mean most Australian adults have only basic skills in numeracy.

Shown in Figure 2.17 are the results across Australia's entire population: 31 per cent (5.2 million) fall into level three; 11 per cent (1.8 million) at level four; and 1.4 per cent (230,000) at level five. On a positive note, Figure 2.19 shows Australian adult numeracy levels are only slightly lower than the international average.

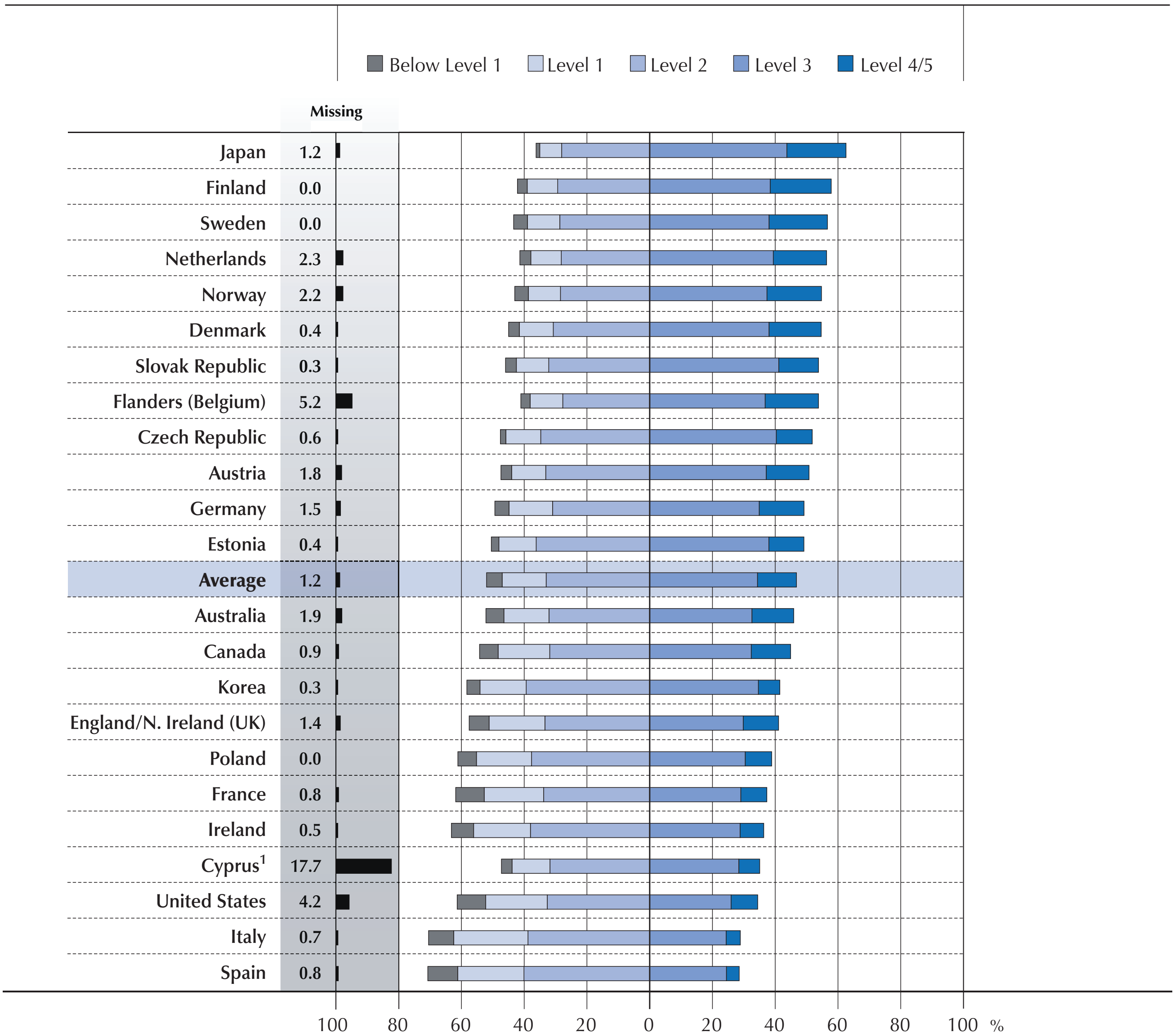
Figure 2.18 Proportion of Australian adult population at each numeracy level 2011–12



Source: ABS, Programme for the International Assessment of Adult Competencies, Australia, 2011–2012.

Figure 2.19 Numeracy proficiency among adults

Percentage of 16-65 year-olds scoring at each proficiency level in numeracy



1. See notes at the end of this chapter.

Notes: Adults in the missing category were not able to provide enough background information to impute proficiency scores because of language difficulties, or learning or mental disabilities (referred to as literacy-related non-response).

Countries are ranked in descending order of the combined percentage of adults scoring at Level 3 and Level 4/5.

Source: Survey of Adult Skills (PIAAC) (2012), Table A2.5.

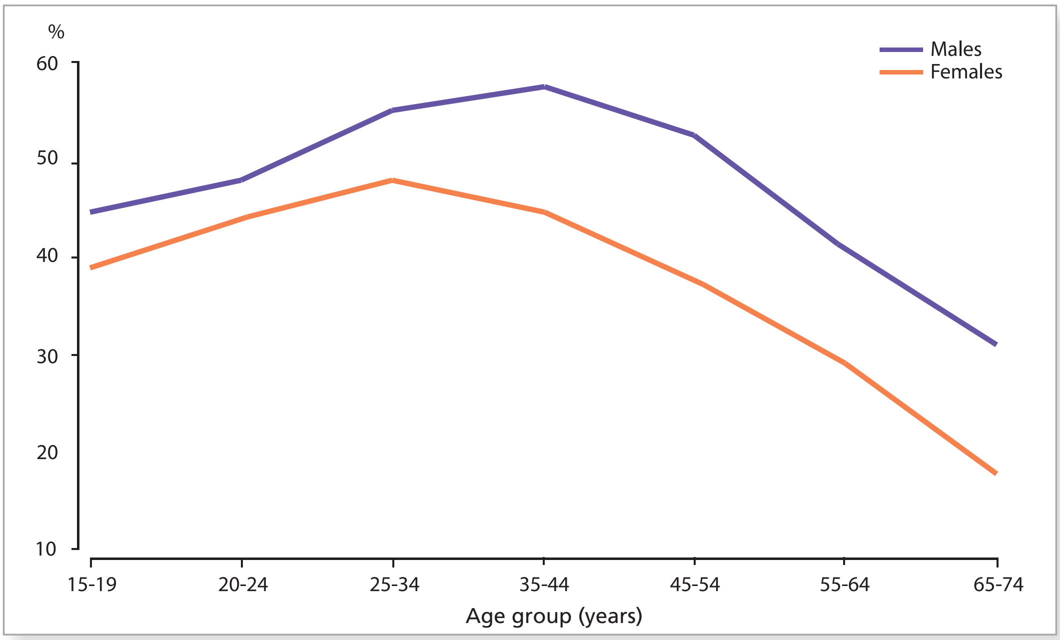
StatLink http://dx.doi.org/10.1787/888932900479

Source: OECD Skills Outlook 2013, First results from the Survey of Adult Skills (Program for the International Assessment of Adult Competencies), figure 2.5, page 75.

The data shown in Figure 2.20 suggests that numeracy competency is closely related to age and gender. Numeracy skills for both genders tend to drop after reaching a peak between the ages of 35 and 44. And are at their lowest for people of retirement age (65 years and over).

The data also illustrates the consequences of the under-representation of girls and young women in mathematical education both in school and university. As Figure 2.20 shows there is a significant, and constant, gap in the mathematical skills between Australian men and women.

Figure 2.20 Proportion of Australian adult population at numeracy level 3 or above, by sex and age group 2011–12



Source: ABS, Programme for the International Assessment of Adult Competencies, Australia, 2011–2012.

Higher Education

Only 30% of undergraduate and postgraduate students are female

pages 28–30

Australian entry into mathematics degrees is less than 50% of the OECD average

page 32

41% of engineering degrees do NOT have intermediate mathematics as a pre-requisite

page 13

Higher education

3.1 STAFFING AT MATHEMATICAL SCIENCES DEPARTMENTS

Table 3.1 Number of staff employed in mathematical sciences departments in FTE (excluding casuals) in 2014

	Teaching only	Research only	Teaching and Research	All Staff	Average number of staff
Total Go8 universities	20	183	232	435	62
Total ATN universities	5	51	63	118	32
Total IRU universities	2	13	66	81	13
Total RUN and unaligned universities	11	23	80	114	14
Total all universities	61	234	431	726	30

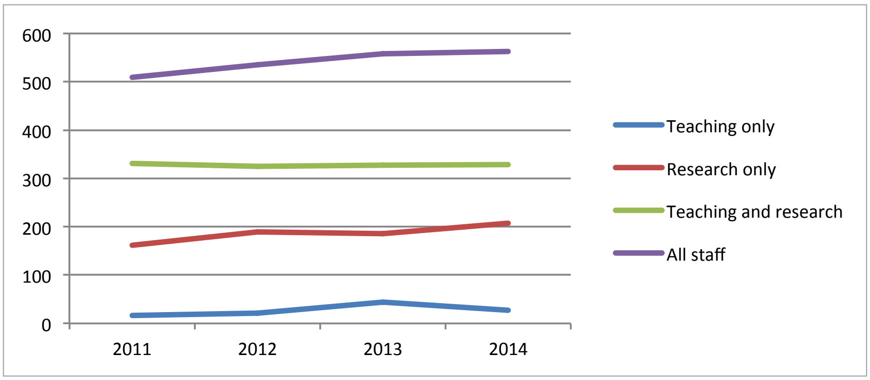
See glossary for an explanation of the acronyms Go8, ATN, IRU and RUN.
Source: AMSI Member and Non-member Survey 2014, preliminary results.

In 2014, mathematical sciences departments in participating in the annual AMSI university survey (AMSI members as well as non-members) reported employing 726 staff (in FTE) (see Table 3.1). The average number of staff in mathematics and statistics departments in 2014 was 30 (22 in 2013) — but the average number of staff differs greatly between Group of Eight (Go8) universities and other universities.

The 2014 average number of staff does not adequately reflect reality because, in contrast to last year, only a small number of non-AMSI member universities participated in the 2014 survey. This means fewer departments with very small numbers of staff were included in the 2014 results, hence, the average number of staff increased considerably.

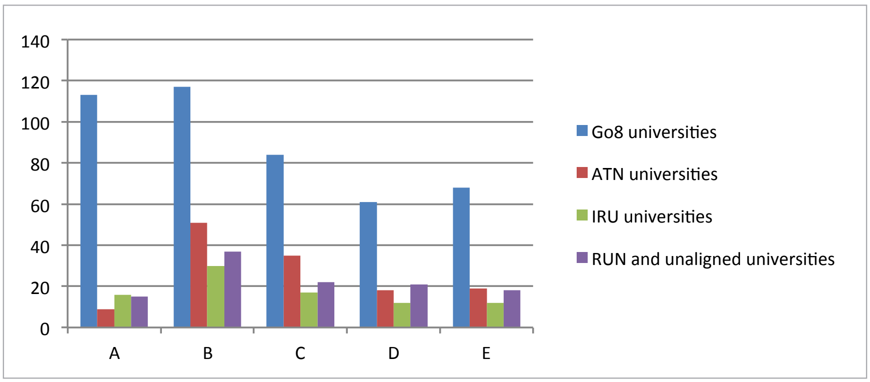
This does not take away the fact that the overall picture shows staff numbers could be slowly on the rise again. If we look at the staff numbers in the 16 universities who have participated in **all** AMSI surveys so far (see Figure 3.2), there has been an overall increase of 10 per cent in staff levels between 2011 and 2014. In that period, 12 of the 16 universities increased staff numbers, while 4 decreased staff numbers. The rise stems mostly from an increase in research-only staff.

Figure 3.2 Number of staff at mathematical sciences departments which participated in AMSI Surveys 2011–2014 (in FTE)



Source: AMSI Member Survey 2012, 2013 and preliminary results 2014.

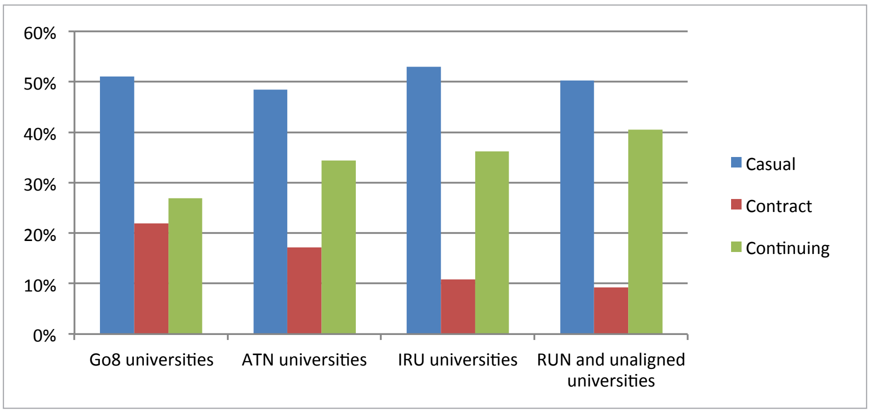
Figure 3.3 Staff in mathematical sciences departments by employment level (excluding casual staff) in 2014



Source: AMSI Survey 2014, preliminary results.

Figure 3.3 shows that the staffing profile remains heavy at the top, with a relatively large number of staff employed at level E (professorial level). Non-Go8 universities tend to employ fewer staff at entry level A, whereas Go8 universities employ many more junior researchers at this level — a function of the much higher ARC research revenue they generate. However, in contrast to earlier years Go8 universities employed slightly more staff at level B than at level A in 2014.

Figure 3.4 Proportion of staff in mathematical sciences departments by type of employment in 2014

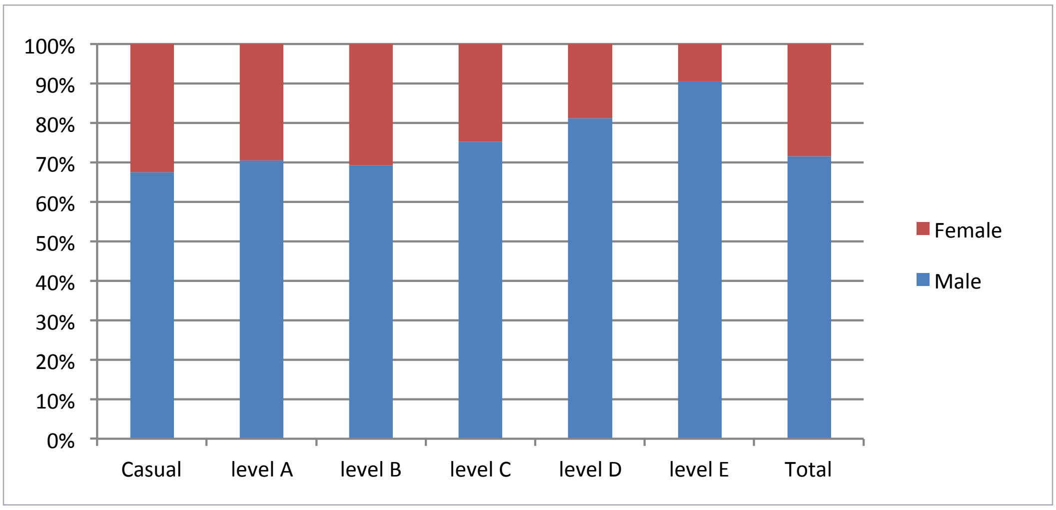


Source: AMSI Survey 2014, preliminary results.

All maths departments employ casual staff in large numbers (see Figure 3.4). There is however a substantial difference in the mix of fixed-term and continuing staff between Go8 and other universities; this is, of course, a consequence of the higher number of research-only staff on fixed-term contracts at Go8 universities.

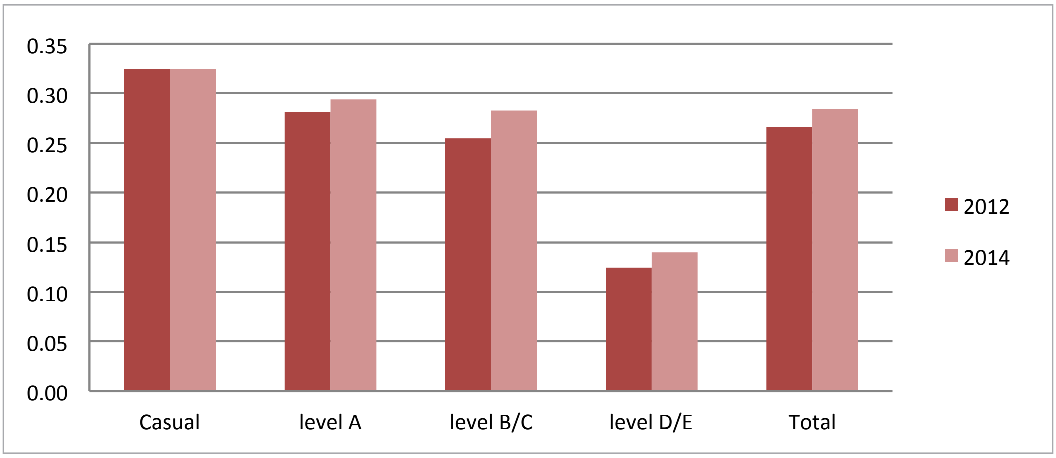
It is clear from Figure 3.5 that the academic workforce is predominantly male and that the proportion of females reduces with the level of seniority. In 2014, about 32 per cent of reported casuals were female which decreased to 29 per cent at level A, 31 per cent at level B and 25 per cent at level C. This drops significantly to 19 per cent at level D and 9 per cent at level E. Overall, only 28 per cent of the academic workforce in mathematics and statistics is female. The share of female staff among levels A to E has increased slightly since 2012 (see Figure 3.6).

Figure 3.5 Staff in mathematical sciences departments by gender and employment level



Source: AMSI Survey 2014, preliminary results.

Figure 3.6 Proportion of female staff in mathematical sciences departments by gender and employment level in 2012 and 2014

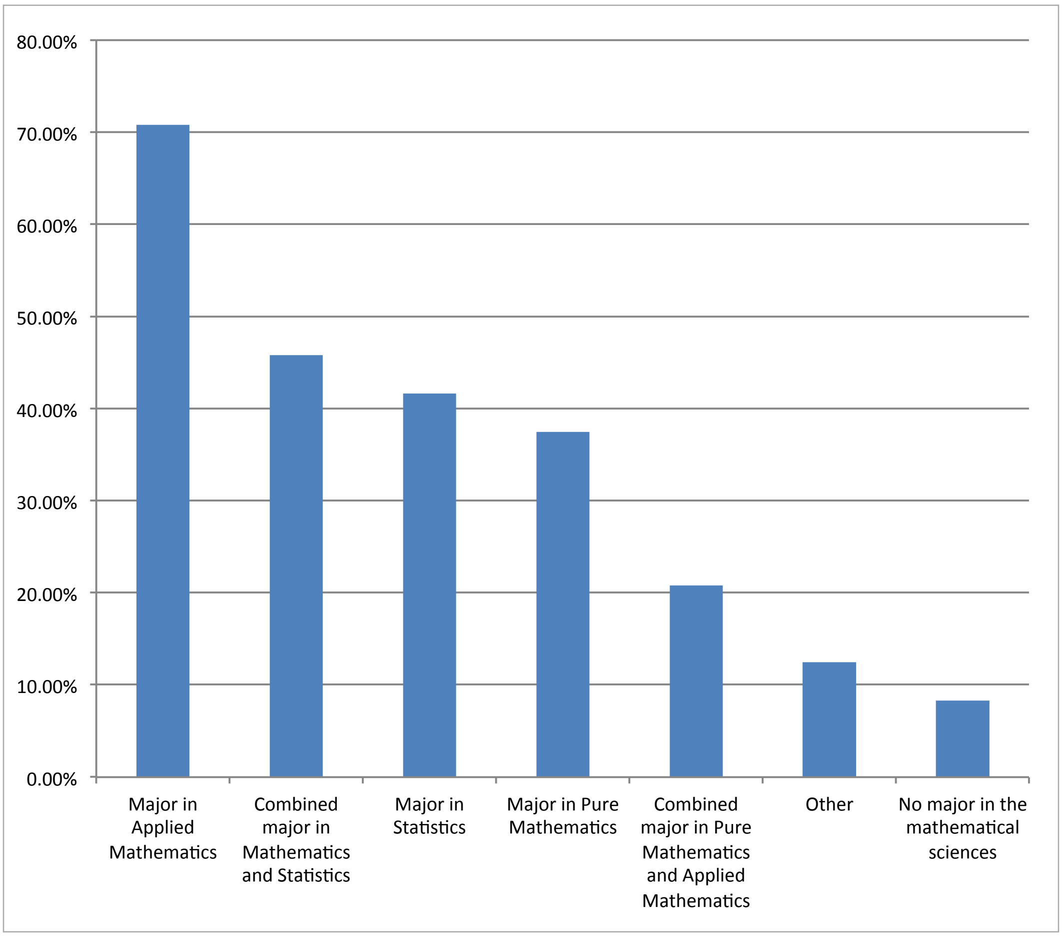


Source: AMSI Survey 2014, preliminary results.

3.2 MATHEMATICS AND STATISTICS TEACHING AT UNIVERSITIES

In 2014, the most prevalent major offered to mathematics and statistics students remained in applied mathematics, which was offered by 70 per cent of all surveyed universities. The second most prevalent is a combined major stream in mathematics and statistics (46 per cent), followed by a major in statistics (42 per cent). Of the 24 departments providing data for this question in 2014, 2 small departments in non-AMSI member universities reported not offering a major at all in the mathematical sciences. Most universities offer one to three majors. Under "other" majors, universities reported decision science, quantitative risk, oceanography, statistics and operations research.

Figure 3.7 Majors offered in the mathematical and statistical sciences in 2014



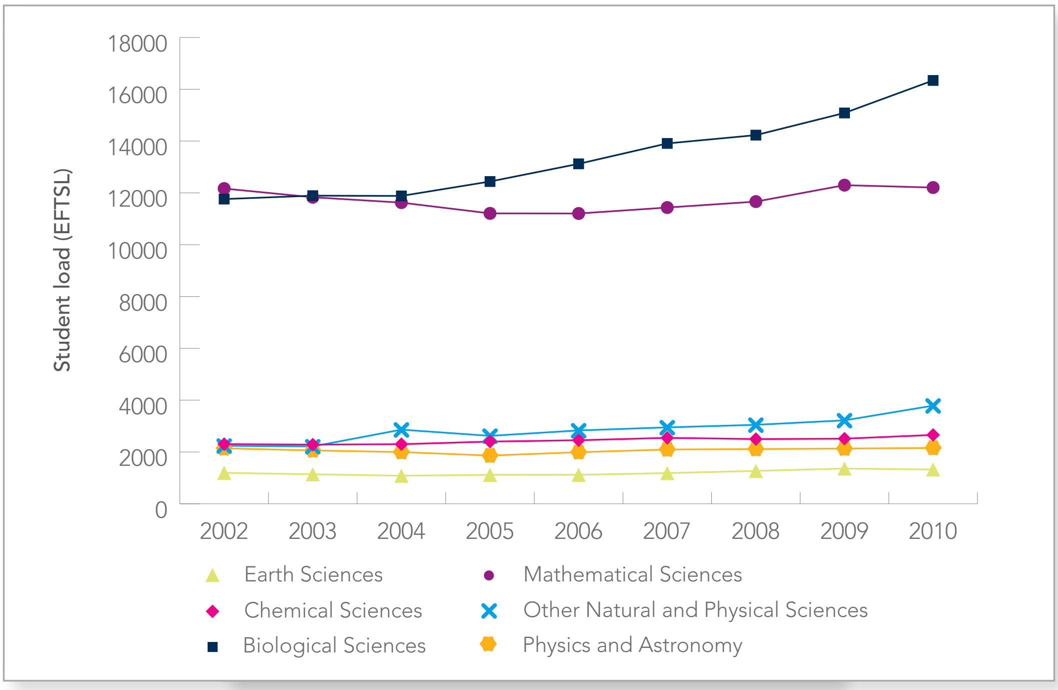
Source: AMSI Survey 2014, preliminary results.

Mathematics is an essential element of many disciplines and mathematics departments supply service teaching to many other departments and faculties. The data in Figure 3.8, measured in EFTSL, shows the mathematical sciences are the second most important service discipline after biological sciences (this is a reflection of the enormous increase in popularity of health sciences which receives most of the biological service teaching). Mathematical science departments supply teaching to disciplines as varied as information technology (IT), engineering, agriculture and environment, society and culture, health and management.

All member university departments who responded to this question supplied service teaching to other disciplines in 2014 (see Figure 3.9). Most departments supplied teaching to at least 3 or 4 other areas, some even offer teaching to 12.

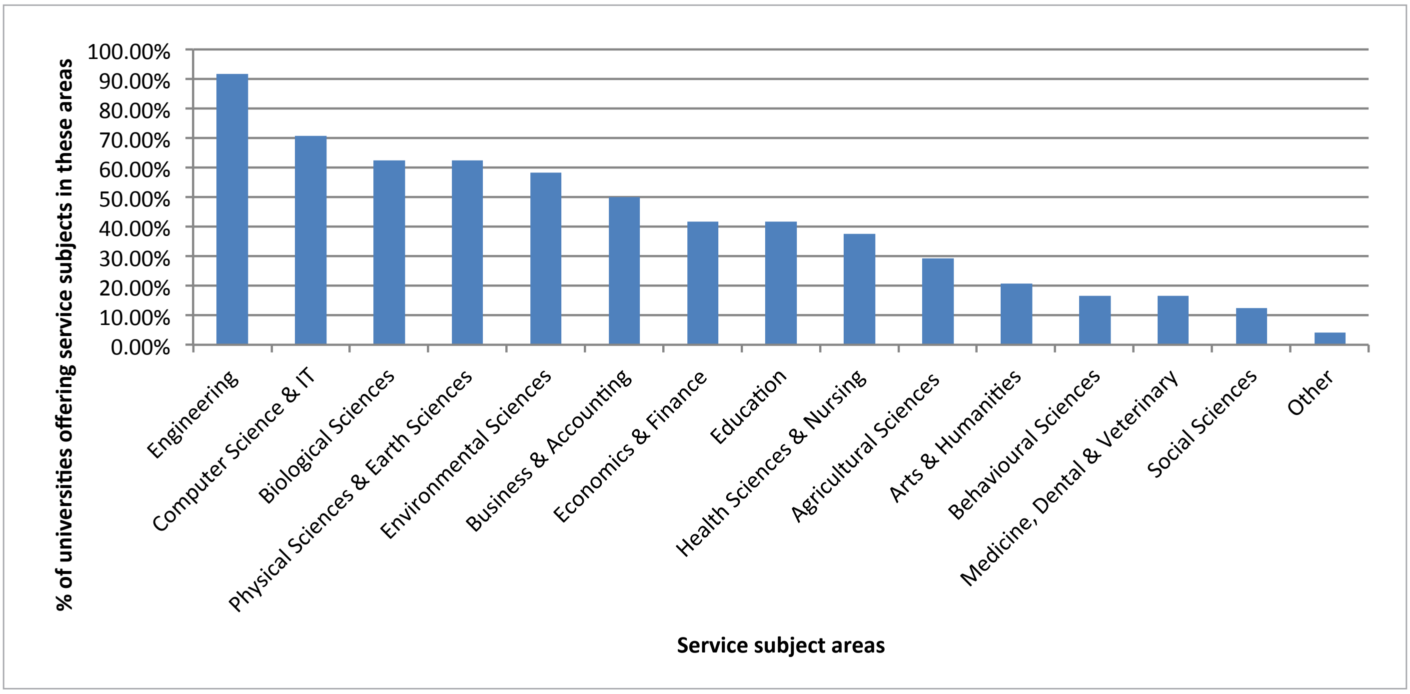
The average number of subject areas serviced by mathematics departments is six. Engineering, computer science, IT and biological, physical and earth sciences are the most serviced disciplines.

Figure 3.8 Undergraduate science service teaching: narrow disciplines



Source: Office of the Chief Scientist, Health of Australian Science, May 2012, Figure 4.4.16, page 84.

Figure 3.9 Areas of service teaching in 2014



Source: AMSI Survey 2014, preliminary results.

The data in Table 3.10 shows that casual staff perform the majority of tutorial teaching. These numbers decreased from the 2012 and 2013 rates (64 per cent and 69 per cent respectively) to just 58 per cent in 2014. The proportion of lecture teaching by casuals increased slightly, from 9 and 11 per cent in 2012 and 2013 respectively, to 11 per cent in 2014. However the number of respondents in 2014 was significantly lower.

Table 3.10 Teaching by academic and casual staff in 2014

	tutorial hours all staff	tutorial hours casual staff	% of total taught by casuals
Average Go8 universities	244	134	55%
Average ATN and RUN universities	70	49	69%
Average IRU universities	92	63	68%
Average unaligned universities	63	41	66%
Average all universities	127	74	58%
	lecture hours all staff	**lecture hours casual staff**	**% of total taught by casuals**
Average Go8 universities	112	7	6%
Average ATN and RUN universities	115	30	26%
Average IRU universities	42	4	10%
Average unaligned universities	44	6	12%
Average all universities	69	8	11%

Please note that the numbers for RUN and ATN universities have been combined due to the small number of responses to this survey question.
Source: AMSI Survey 2014, preliminary results.

3.3 STUDENT NUMBERS

UNDERGRADUATE ENROLMENTS AND COMPLETIONS

Table 3.11 Undergraduate enrolments (in EFTSL*) in 2014

	3rd year	2nd year	1st year
Total Go8 universities	695	1781	5280
Total ATN universities	91	180	212
Total RUN universities	13	20	288
Total IRU universities	67	462	1287
Total unaligned universities	78	373	702
Total all universities	944	2816	7769

*See glossary for an explanation of the meaning of EFTSL.
Source: AMSI Survey 2014, preliminary results.

In 2014, first year mathematics subjects accounted for about 7769 EFTSL. For second year this dropped to around 2816 EFTSL and plummeted to approximately 944 in third year subjects — figures provided by 21 universities. Average first year enrolments increased at all universities between 2011 and 2014. Second year enrolments increased between 2011 and 2013 but dropped off in 2014. Third year enrolments are lower than in previous years, however this is likely caused by the low participation of ATN universities in the 2014 survey.

Table 3.12 AMSI Survey 2014: Average number of undergraduate enrolments 2011–2014 (in EFTSL)

<table>
<tr><th></th><th>2011</th><th>2012</th><th>2013</th><th>2014</th></tr>
<tr><td colspan="5">1st year</td></tr>
<tr><td>Average Go8 universities</td><td>573</td><td>562</td><td>594</td><td>754</td></tr>
<tr><td>Average ATN universities</td><td rowspan="4">166</td><td rowspan="4">165</td><td>257</td><td rowspan="4">178</td></tr>
<tr><td>Average RUN universities</td><td>85</td></tr>
<tr><td>Average IRU universities</td><td>265</td></tr>
<tr><td>Average unaligned universities</td><td>223</td></tr>
<tr><td>Average all universities</td><td>308</td><td>303</td><td>361</td><td>388</td></tr>
<tr><td colspan="5">2nd year</td></tr>
<tr><td>Average Go8 universities</td><td>246</td><td>265</td><td>261</td><td>254</td></tr>
<tr><td>Average ATN universities</td><td rowspan="4">62</td><td rowspan="4">84</td><td>67</td><td rowspan="4">74</td></tr>
<tr><td>Average RUN universities</td><td>45</td></tr>
<tr><td>Average IRU universities</td><td>68</td></tr>
<tr><td>Average unaligned universities</td><td>152</td></tr>
<tr><td>Average all universities</td><td>126</td><td>147</td><td>146</td><td>141</td></tr>
<tr><td colspan="5">3rd year</td></tr>
<tr><td>Average Go8 universities</td><td>83</td><td>89</td><td>90</td><td>99</td></tr>
<tr><td>Average ATN universities</td><td rowspan="4">29</td><td rowspan="4">31</td><td>42</td><td rowspan="4">18</td></tr>
<tr><td>Average RUN universities</td><td>14</td></tr>
<tr><td>Average IRU universities</td><td>19</td></tr>
<tr><td>Average unaligned universities</td><td>24</td></tr>
<tr><td>Average all universities</td><td>48</td><td>51</td><td>50</td><td>47</td></tr>
</table>

Due to the small number of respondents to the questions on undergraduate student numbers a breakdown by national alignment for the years 2011, 2012 and 2014 was not possible. See glossary for the meaning of the acronyms EFTSL, G08, ATN, RUN, IRU.
Source: AMSI Survey 2012, 2013 and 2014, preliminary results.

Table 3.13 Staff-student ratios in EFTSL per EFT teaching staff (excluding casuals) 2011–2014

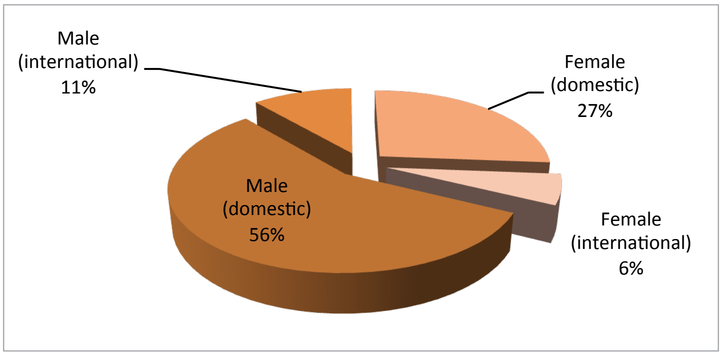
<table>
<tr><th></th><th>2011</th><th>2012</th><th>2013</th><th>2014</th></tr>
<tr><td>Average Go8 universities</td><td>25.35</td><td>26.65</td><td>27.47</td><td>33.67</td></tr>
<tr><td>Average ATN universities</td><td>20.82</td><td>23.14</td><td>21.57</td><td rowspan="2">26.09*</td></tr>
<tr><td>Average RUN/IRU/unaligned universities</td><td>29.14</td><td>27.83</td><td>24.91</td></tr>
<tr><td>Average all universities</td><td>26.71</td><td>26.65</td><td>25.46</td><td>27.42</td></tr>
</table>

* Due to the lower number of respondents to this question, the data from ATN/RUN/IRU and unaligned universities have been combined.
Source: AMSI Survey 2012, 2013 and 2014, preliminary results.

In 2014 participating universities reported a slightly higher undergraduate student load per teaching staff (see Table 3.13).

A significant number of universities reported difficulties in obtaining reliable undergraduate enrolment numbers (other than in EFTSL). In the universities who were able to report undergraduate student numbers, an estimated 37,000 students enrolled in one or more undergraduate mathematics subjects. Keeping in mind that not all participating universities were able to provide a breakdown of male/female or domestic/international numbers (or both), the male/female distribution among mathematics students was roughly 67:33. The proportion of international students in 2014 was 17 per cent.

Figure 3.14 Undergraduate student profile by gender and domestic/international status in 2014

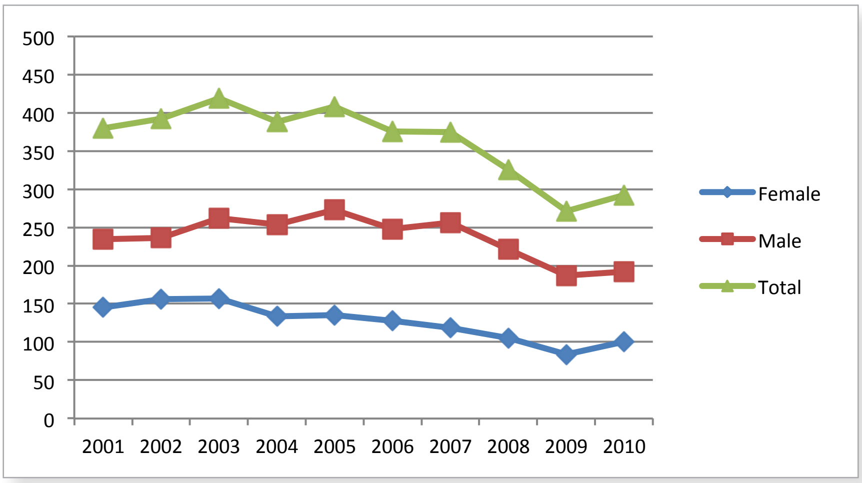


Source: AMSI Survey 2014, preliminary results.

Due to the important part played by service teaching in mathematical sciences, it is clear that a large number of Australian students complete at least some mathematics and statistics subjects during their studies. However, the number of students who complete a bachelor degree in mathematical sciences is substantially lower. According to data from the Department of Education and Training the number of domestic graduates in mathematical sciences has declined (see Figure 3.15).

The bachelor graduate numbers of Figure 3.15 are not quite accurate, as some of the universities with the largest number of bachelor graduates are not represented. However, if the decline in the number of bachelor graduates is accurate, it identifies a worrying trend.

Figure 3.15 Domestic Bachelor (pass) award completions 2001–2010 by gender in the field of education of mathematical sciences*



*Data from 29 universities, no data from the University of Melbourne and The University of Queensland included.
Source: Higher Education Data 2001–2010, Department of Education and Training.

HONOURS AND HIGHER DEGREE ENROLMENTS AND COMPLETIONS

Table 3.16 Honours and Higher Degree enrolments in 2014

	PhD	Masters by Research	Honours
total Go8 universities	314	42	91
total ATN/RUN universities	57	5	9
total IRU universities	54	3	18
total unaligned universities	48	3	11
total all universities	473	52	129

Source: AMSI Member Survey 2014, preliminary results.

The reported number of enrolments in postgraduate degrees remained static between 2013 and 2014. Honours and PhD enrolments were lower than last year, however, masters by research remained the same as in the previous years. Again, this could be attributed to the lower number of respondents to the 2014 survey — so low we are unable to report on the enrolments in masters by coursework.

Table 3.17 Average honours and higher degree enrolment numbers 2011–2014

	2011	2012	2013	2014
Honours				
average Go8 universities	15	14	13	13
average ATN universities	5	5	5	3
average RUN universities	<1	<1	5	1
average IRU universities	5	6	3	3
average unaligned universities	2	4	3	2
average all universities	7	7	7	6
Masters by Coursework				
average Go8 universities	17	17	16	n/a
average ATN universities	25	32	53	n/a
average RUN universities	1	<1	2	n/a
average IRU universities	2	3	1	n/a
average unaligned universities	8	7	4	n/a
average all universities	12	12	17	n/a
Masters by Research				
average Go8 universities	5	4	4	6
average ATN universities	2	2	2	2
average RUN universities	<1	<1	<1	<1
average IRU universities	2	2	1	<1
average unaligned universities	1	1	1	<1
average all universities	2	2	2	2
PhD				
average Go8 universities	36	38	37	45
average ATN universities	26	29	24	26
average RUN universities	9	7	6	2
average IRU universities	7	11	10	9
average unaligned universities	18	16	9	8
average all universities	21	23	22	21

Please note that between 2011–2012, 27 departments from 25 universities participated; in 2013, 33 departments from 32 universities participated. The increase in participation has come from unaligned universities and universities aligned with RUN and IRU so the 2013 figures for these categories are far more reliable than for the previous years.

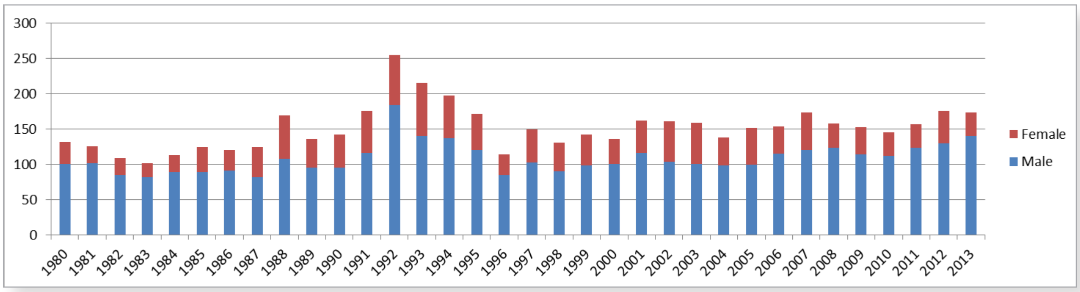
In 2014 this number dropped to 24 departments from 23 universities. The number of respondents reporting masters by coursework enrolment numbers was too low for publication.

Source: AMSI Member Survey 2012, 2013 and 2014 preliminary results.

Peter Johnston at Griffith University has, on behalf of the Australian Mathematical Society (AustMS), assembled longitudinal data on honours degree completions in Australia. Despite spikes upwards and downwards, completions in mathematics and statistics have been fairly stable since 1980. After a slight rise in honours completions in the period 2010–2012, the number of completions fell slightly in 2013. (Please note: for the time being, the two-year coursework masters degree offered at the University of Melbourne has been merged with the honours data). The proportion of females completing honours degrees had increased slightly since 1980 but has not been impressive in the last few years. In the 1980s the average proportion of females completing an honours degree was 26 per cent, in the 1990s this increased to 31 per cent and it has leveled out to 29 per cent in the first decade of this century. However, in the period 2010–2013 the proportion of female honours completions decreased to a disappointing 22 per cent.

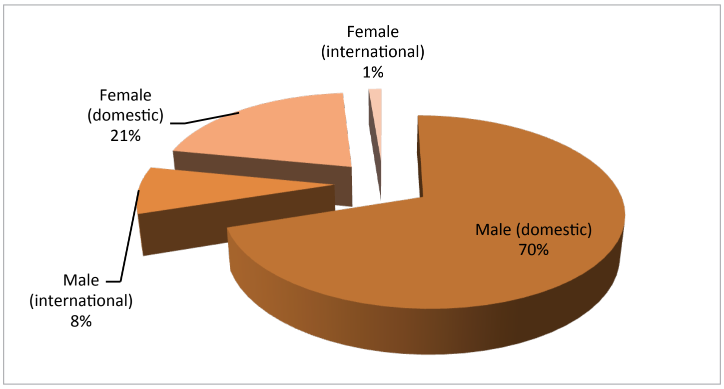
This is all the more worrying as the 2014 enrolments show a male/female ratio of 78:22 (see Figure 3.19).

Figure 3.18 Honours completions in the period 1980–2013 by gender



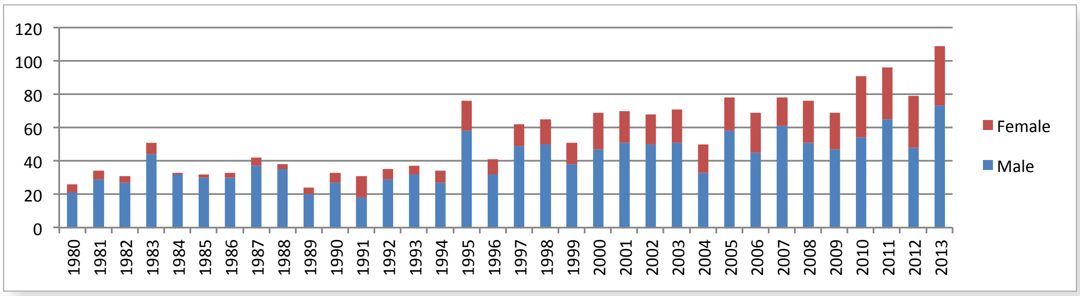
Source: Peter Johnston, Higher Degrees and Honours Bachelor Degrees in mathematics and statistics, data collection provided to AMSI.

Figure 3.19 Honours student profile by gender and domestic/international status in 2014



Source: AMSI Survey 2014, preliminary results.

Figure 3.20 PhD completions in the period 1980–2013 by gender



Source: Peter Johnston, Higher Degrees and Honours Bachelor Degrees in mathematics and statistics, data collection provided to AMSI.

Over the past 30 years, the number of PhD completions has seen an increase. This is partly due to the increased number of females completing a PhD (see Figure 3.20). In the 1980s, the average proportion of females completing a PhD in mathematics and statistics was only 12 per cent; in the 1990s this rose to 23 per cent and in the first decade of this century 29 per cent of PhD graduates were female. Between 2010–2012 the average female proportion rose to 36 per cent. However, as is shown in Figure 3.22, this was due in large part to the contribution of international female students.

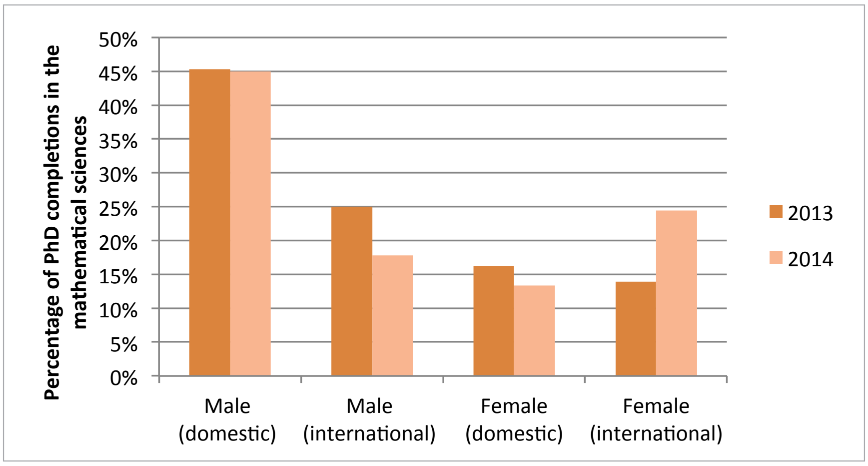
According to data reported to AMSI in its annual survey, PhD completions fell in 2012, and increased again in 2013. The number of completions was projected to fall again in 2014.

Table 3.21 PhD commencements and completions 2011–2014 (all universities)

	2011	2012*	2013*	2014**
Commencements	153	163	174	129
Completions	105	88	110	90

* partly based on projected figures. In the annual survey departments are asked projected numbers for the current year. In the next year departments are asked for the final commencement and completion figures of the previous year. If these are provided they replace the projected figures.
** based on projected figures for 2014.
Source: AMSI Member Survey 2012, 2013 and 2014, preliminary results.

Figure 3.22 PhD completions in 2013 and 2014* by gender and domestic/international status



*Based on projected figures for 2014.
Source: AMSI Member Survey 2014, preliminary results.

The numbers in Figure 3.22 clearly show a high proportion of international students completing PhDs in Australia (39 per cent in 2013 and 42 per cent in 2014). The proportion of females is significantly higher among international students than domestic students — in fact in 2014, the number of female international students completing a PhD in the mathematical sciences was projected to be higher than international males.

INTERNATIONAL COMPARISON OF ENROLMENT AND GRADUATION FIGURES

Australia has a very low number of students entering degrees in the mathematical sciences. Even though these figures need to be read with extreme care, due to the differences in higher education systems in various countries, the Australian figures are consistent with earlier OECD data collections.

The 2012 OECD data again confirmed the low figures (see Table 3.23). In fact, the proportion of entrants into a tertiary mathematical degree in Australia was so low it was deemed negligible: it was less than 0.5 per cent. We do have to take into account that Australia does not have tertiary type B programs in mathematical sciences, that is tertiary degrees of a practical or vocational nature, such as taught at TAFE colleges, as opposed to more theory-based tertiary type A degrees usually taught at universities in Australia.

Looking at gender differences, the data shows the number of males in these fields of study significantly outweighs the number of females. Compared with international figures, the proportion of females awarded a mathematical degree, in Australia, rose between 2000 and 2012; however, it is still lagging behind the OECD average. Note that Table 3.24 shows the percentage of qualifications awarded to women.

Table 3.23 Distribution of tertiary new entrants, by field of education (2012)

Education at a Glance 2014 - © OECD 2014

EXTRACT from Table C3.3a. Distribution of tertiary new entrants, by field of education (2012)

OECD countries	Note	Engineering, manufacturing and construction	Sciences	Life sciences	Physical sciences	Mathematics and statistics	Computing
Australia	1	9	12	5	3	n	4
Denmark		12	8	1	1	1	5
Finland		25	9	1	3	1	4
Germany		17	13	2	4	2	4
Ireland	2	11	17	5	2	1	7
New Zealand		7	17	5	3	3	7
Sweden		18	11	2	2	2	5
United Kingdom		8	15	5	4	2	4
OECD average		15	10	2	2	1	4
EU21 average		15	11	2	2	1	5

Note:
1: Exclude tertiary-type B programmes.
2: Exclude advanced research programmes.
n: Magnitude is either negligible or zero.
The numbers are percentages of all new tertiary entrants.

Source: selected data extracted from Education at a Glance 2014: OECD Indicators, Table C3.3a Distribution of tertiary new entrants, by field of education (2012).

Table 3.24 Percentage of tertiary qualifications awarded to women in tertiary-type A and advanced research programmes, by field of education (2000, 2012)

EXTRACT from Table A3.3 (Web only). Percentage of tertiary qualifications awarded to women in tertiary-type A and advanced research programmes, by field of education (2000, 2012)

		2012							2000						
		All fields	Engineering, manufacturing and construction	Sciences	Life sciences	Physical sciences	Mathematics and statistics	Computing	All fields	Engineering, manufacturing and construction	Sciences	Life sciences	Physical sciences	Mathematics and statistics	Computing
OECD countries	Note														
Australia	1	58	24	38	55	48	39	20	56	21	41	55	34	37	26
Denmark		59	33	40	65	42	47	27	49	26	42	60	36	41	22
Finland		61	22	43	73	46	47	24	58	19	46	69	42	46	30
Germany		55	22	44	67	42	59	17	45	20	32	55	27	42	11
Ireland		57	21	42	42	42	42	42	57	24	48	61	44	40	41
New Zealand		62	31	43	62	42	43	20	61	33	45	x(23)	46	56	33
Sweden		62	30	43	60	43	38	29	59	25	47	61	45	30	41
United Kingdom		56	23	38	50	43	42	19	54	20	44	62	39	38	24
United States		58	22	43	58	39	42	21	57	21	44	57	37	45	29
OECD average		58	28	41	63	43	46	20	54	23	40	60	40	42	23
EU21 average		60	29	42	65	44	50	20	55	23	40	61	40	44	21

Note:
1. Year of reference 2011.

Source: selected data extracted from Education at a Glance 2014: OECD Indicators, Table A3.3 (Web only). Percentage of tertiary qualifications awarded to women in tertiary-type A and advanced research programmes, by field of education (2000, 2012).

3.4 EMPLOYMENT OF MATHEMATICS GRADUATES

Table 3.25 Graduates in Mathematics

What are the characteristics of graduates in mathematics?	Bachelor			Masters by Coursework			Graduate Certificate/ Diploma			Masters by Research/PhD		
	M	F	Total	M	F	Total	M	F	Total	M	F	Total
Survey responses: mathematics	345	145	490	40	38	78	67	52	119	43	18	61
Sex: mathematics (%)*	70.4	29.6	100	51.3	48.7	100	56.3	43.7	100	70.5	29.5	100
Sex: all fields of education (%)*	37.9	62.1	100	42.3	57.7	100	33.2	66.8	100	44.8	55.1	100
Median age: mathematics (years)	23	23	23	30	37	33	34	32	33	30	29	30

What are graduates in mathematics doing after graduation?	Bachelor			Masters by Coursework			Graduate Certificate/ Diploma			Masters by Research/PhD		
	M	F	Total	M	F	Total	M	F	Total	M	F	Total
Available for full-time employment: mathematics (%)	41.7	41.4	41.6	75	71.1	73.1	77.6	76.9	77.3	76.7	72.2	75.4
Available for full-time employment: chemistry (%)			37.7			75			50			87.1
Available for full-time employment: computer science (%)			76.7			87.4			89.6			76.9
Available for full-time employment: accounting (%)			77.5			80.2			80.6			90
Available for full-time employment: all fields of education (%)			77.7			79.3			69.8			74.6
In further full-time study: mathematics (%)	43.5	44.1	43.7	20	13.2	16.7	11.9	7.7	10.1	14	0	9.8
In further full-time study: chemistry (%)			50.5			18.8			33.3			3.4
In further full-time study: computer science (%)			10.5			2.6			4.8			5.8
In further full-time study: accounting (%)			9.6			3.2			4.9			0
In further full-time study: all fields of education (%)						4.2			8.2			4.3
Of those available for full-time employment:												
In full-time employment: mathematics (%)	66.7	68.3	67.2	80	77.8	78.9	90.4	92.5	91.3	78.8	84.6	80.4
In full-time employment: chemistry (%)			66			66.7			*100**			76.2
In full-time employment: computer science (%)			70.3			79.5			88.2			72
In full-time employment: accounting (%)			77.4			72.6			88			88.9
In full-time employment: all fields of education (%)	71.3	71.3	71.3	84.1	80.4	82.1	86.7	83.2	84.5	80	77.5	78.7
Median salary												
Median salary: mathematics	58,000	55,000	56,500	75,000	78,000	75,000	95,000	80,600	87,000	80,000	79,000	80,000
Median salary: all fields of education	57,000	53,000	55,000	90,000	75,000	80,000	80,000	69,000	72,000	80,000	78,000	80,000

Most frequently reported occupations:	Bachelor	Masters by Coursework	Graduate Certificate/ Diploma	Masters by Research/PhD
	1. Business, Human Resource and Marketing Professionals	*1. Business, Human Resource and Marketing Professionals*	*1. Business, Human Resource and Marketing Professionals*	*1. Business, Human Resource and Marketing Professionals*
	2. Design, Engineering, Science and Transport Professionals	*2. Education Professionals*	*2. Design, Engineering, Science and Transport Professionals*	*2. Education Professionals*
	3. Education Professionals	*3. Specialist Managers*	*3. Education Professionals*	*3. Design, Engineering, Science and Transport Professionals*

*fewer than 10 respondents.
Source: Graduate Careers Australia, extract from Grad Job and Dollars/Mathematics.

Compared to other areas of study, a very high percentage of bachelor graduates in the mathematical sciences do not make themselves available for full-time employment, but proceed to further full-time study, and subsequently make themselves available for full time employment after finishing a postgraduate degree. According to Table 3.25, approximately 44 per cent of bachelor graduates in the mathematical sciences continued with further study. Of the 42 per cent who sought full-time employment 67 per cent were employed within four months of graduating– a relatively low percentage compared to other disciplines. Employment prospects of those who completed further study, however, increased to approximately 80 per cent for masters and PhD graduates, and 90 per cent for graduate certificate or diploma graduates. The median starting salary also increased considerably, from A$56,500 for bachelor graduates to A$75,000 for masters by coursework graduates, A$80,000 for PhD and research masters graduates and A$87,000 for graduate certificate or diploma holders.

The mathematical sciences had the highest success rate for ARC Discovery grants:
28% against 21%
in all other science fields
page 39

Australian applied maths and statistics both
rank above
all 15 EU countries on publication citation rates
page 42

Research

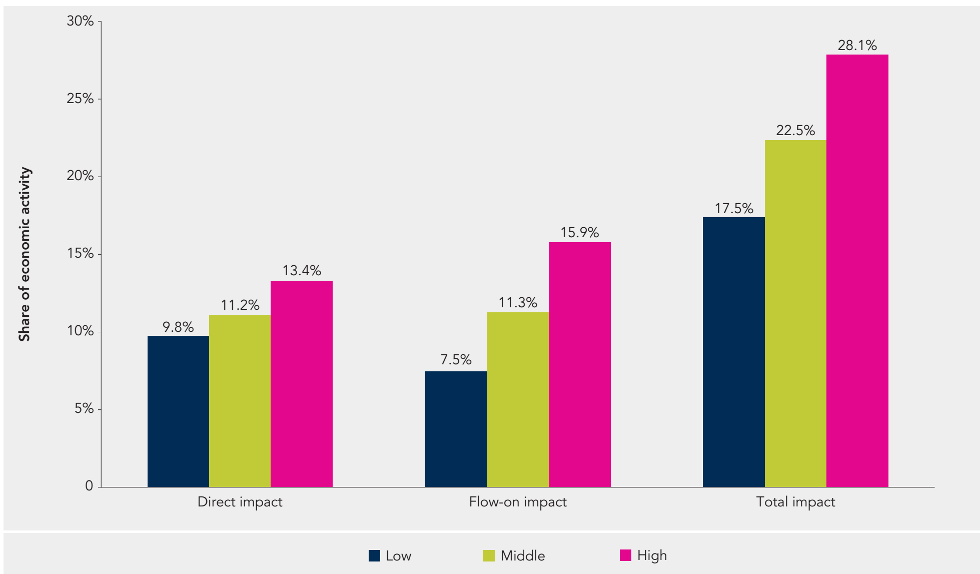
At 1.7%
mathematical sciences have the smallest share of public research expenditure on STEM
page 39

Research in the mathematical and statistical sciences

4.1 THE IMPORTANCE OF MATHEMATICAL SCIENCES RESEARCH FOR THE AUSTRALIAN ECONOMY

The advanced physical and mathematical sciences ("advanced" means based on research undertaken and applied in the past 20 years) contribute substantially to the Australian economy. According to a recent estimate the direct impact of these combined sciences would be worth 11.2 per cent of the economy — that's $145 billion — per year; the flow-on impact runs to an additional 11.3 per cent, $147 billion dollars, per year (see Figure 4.1).

Figure 4.1 The direct, flow-on and total impacts of the APM sciences on the Australian economy (% share of economic activity, $ billion value added)



Note: To express APM sciences based GVA as a share of total GVA, we have excluded from the total the GVA of the *ownership of dwellings* industry, as it is imputed by the ABS and the industry does not employ any people (it makes up 9% of the total).

Data source: The CIE.

APM: Advanced Mathematical and Physical Sciences

Source: Australian Academy of Science, The importance of advanced physical and mathematical sciences to the Australian economy, 2015, Figure 1, page 1.

It is advanced mathematical research in particular which has been central to a large number of industries. Business sectors based on a single core science discipline (such as finance, transport and computing) most often rely on the mathematical sciences, as shown in Table 4.2.

Table 4.3 shows that the dominant industries based on multiple advanced physical and mathematical sciences disciplines (mining, insurance and telecommunications) all rely on the application of mathematical research that has been undertaken in the past 20 years.

Table 4.2 Sector based on a single core science discipline

Industry		Single core science discipline	Science-based GVA ($ billion)
6221	Banking	Maths	5
7000	Computer System Design and Related Services	Maths	5
4610	Road Freight Transport	Maths	4
1841	Human Pharmaceutical and Medicinal Product Manufacturing	Chemistry	2
6240	Financial Asset Investing	Maths	2
6330	Superannuation Funds	Maths	2
1912	Rigid and Semi-Rigid Polymer Product Manufacturing	Chemistry	2
All other industry classes based on a single core science discipline			25
Total			47
Total (share of total GVA)			3.6%

Note: To express APM sciences based GVA as a share of total GVA, we excluded from the total the GVA of the *ownership of dwellings industry*, as it is imputed by the ABS and the industry does not employ any people (it makes up 9% of the total).
Source: The CIE.

Source: Australian Academy of Science, The importance of advanced physical and mathematical sciences to the Australian economy, 2015, Table 8.1, page 57.

Table 4.3 Sector based on multiple APM sciences disciplines

Industry class		APM scientific disciplines	Science-based GVA ($ billion)
700	Oil and Gas Extraction	Maths, physics, chemistry and earth sciences	16
6322	General Insurance	Maths, earth sciences	8
801	Iron Ore Mining	Maths, earth sciences	7
804	Gold Ore Mining	Maths, earth sciences	7
5801	Wired Telecommunications Network Operation	Maths, physics	7
8520	Pathology and Diagnostic Imaging Services	Maths, physics and chemistry	5
5802	Other Telecommunications Network Operation	Maths, physics	4
600	Coal Mining	Maths, physics, chemistry and earth sciences	4
All other industry classes based on combinations of disciplines			37
Total			94
Total (share of total GVA)			7.3%

Note: To express APM sciences based GVA as a share of total GVA, we excluded from the total the GVA of the *ownership of dwellings* industry, as it is imputed by the ABS and the industry does not employ any people (it makes up 9% of the total).
Source: The CIE.

Source: Australian Academy of Science, The importance of advanced physical and mathematical sciences to the Australian economy, 2015, Table 8.2, page 57.

4.2 RESEARCH FUNDING

Given the crucial nature of advanced mathematics to our economy, it is surprising how little monetary investment is made. Table 4.4 shows that between 2011 and 2012, only a very small — in fact, the smallest — proportion of total spending on research and development was spent on mathematical science research. According to data published by the Office of the Chief Scientist, it is higher education expenditure in R&D (HERD) that contributes the most to mathematical science research ($167 million or 1.7 per cent of STEM funding), followed by Commonwealth funding (GOVERD) at $54 million, 1.5 per cent of STEM funding. The business sector (BERD) spends a minuscule fraction of its R&D expenditure on the mathematical sciences — 0.2 per cent or $29 million.

Mathematical research is highly dependent on university and ARC funding. Fortunately, this sector has been relatively successful in obtaining ARC funding, most notably for ARC Discovery Projects. According to ARC data, between 2001 and 2011 the success rates of proposals in the mathematical sciences were on par or better than those in engineering and information and communication technologies (ICT) (Source: Australian Research Council, ARC Support for Research in the Mathematical Sciences, a Summary of Trends — Submit Years 2001 to 2011). In fact, Figure 4.5 shows that the success rates of proposals for discovery projects in the mathematical sciences considerably outdid proposals in other fields for the three years between 2011 and 2014.

Only in the last funding round did the success rate of proposals in the mathematical sciences fall slightly below those in physical and biological sciences. It is important to note, however, that in the past round the ARC has funded fewer projects in all fields of research. For example, the number of ARC Discovery Projects funded for commencement in 2015 dropped to 665 in total across all sciences, much lower than the long-term average of 860 proposals funded per year. At the same time, the number of proposals for Discovery Projects in the mathematical sciences increased from 171 in 2014 to 196 in 2015, putting further downwards pressure on the success rate of proposals in the mathematical sciences.

The total dollar value of all funded Discovery Projects also dropped. For 2015 it sits at $250 million, down from its long-term annual average of $268 million.

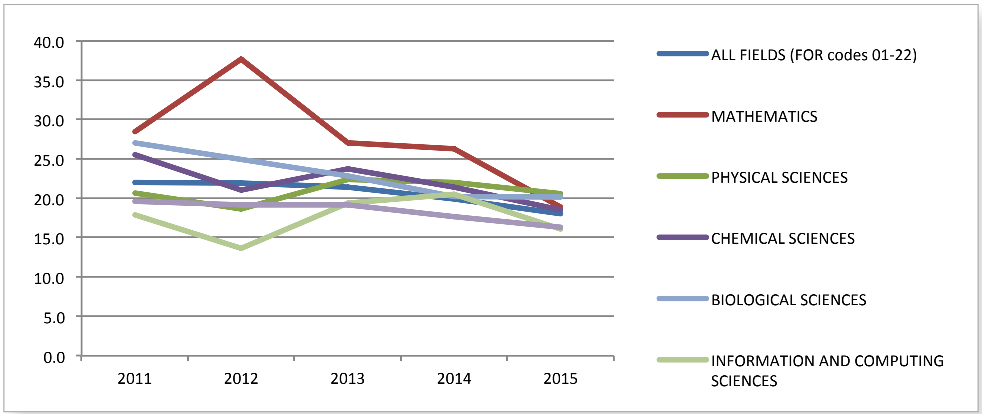
Table 4.4 Australian research expenditure by sector

	HERD (2012)		BERD (2011–12)		GOVERD (2011–12)	
Field	**$ million**	**%**	**$ million**	**%**	**$ million**	**%**
Total	**9 609**	..	**18 321**	..	**3725**	..
STEM	6 978	72.6	17 833	97.3	3303	93.5
STEM excluding Medical and Health Sciences	4 156	43.2	16 891	92.2	2820	79.8
Humanities and Social Sciences	2 632	27.4	489	2.7	230	6.5
Breakdown of STEM	**$ million**	**%**	**$ million**	**%**	**$ million**	**%**
Agricultural and Veterinary Sciences	394	4.1	455	2.5	570	16.1
Biological Sciences	841	8.7	113	0.6	364	10.3
Chemical Sciences	358	3.7	426	2.3	165	4.7
Earth Sciences	288	3.0	122	0.7	207	5.9
Engineering	955	9.9	8 686	47.4	536	15.2
Environmental Sciences	342	3.6	281	1.5	247	7.0
Information and Computing Sciences	331	3.4	5 496	30.0	324	9.2
Mathematical Sciences	168	1.7	29	0.2	54	1.5
Medical and Health Sciences	2 823	29.4	941	5.1	483	13.7
Physical Sciences	312	3.2	47	0.3	238	6.7
Technology	168	1.7	1 235	6.7	115	3.2

.. Not applicable.
Sources: ABS (2012a. 2012b. 2013).

From: Office of the Chief Scientist, Benchmarking Australian Science, Technology, Engineering and Mathematics, November 2014, Table 5-1, page 41.

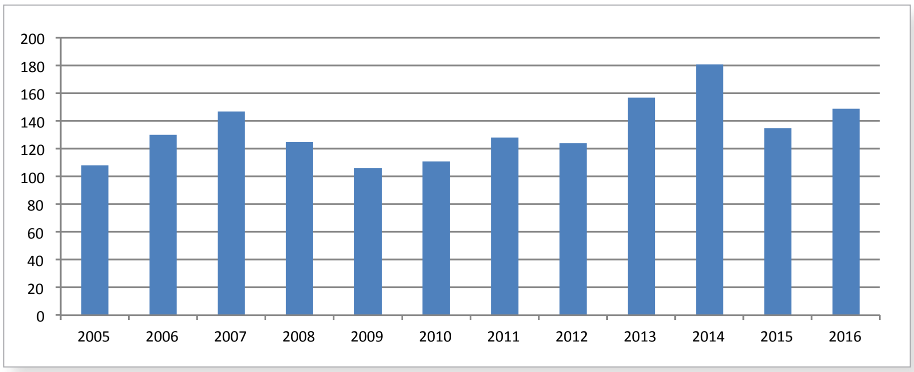
Figure 4.5 ARC success rates of Discovery Project proposals 2011–2015(%)



Source: AMSI, based on ARC datasets.

To summarise, in comparison with other science fields, the mathematical sciences discipline has held its own and in fact, been relatively triumphant in terms of ARC grant success rates.

Figure 4.6 Number of ARC projects in the mathematical sciences by year of completion 2005–2016



Source: AMSI, based on ARC datasets.

Table 4.7 Number of ARC grants held and hosted 2012–2014

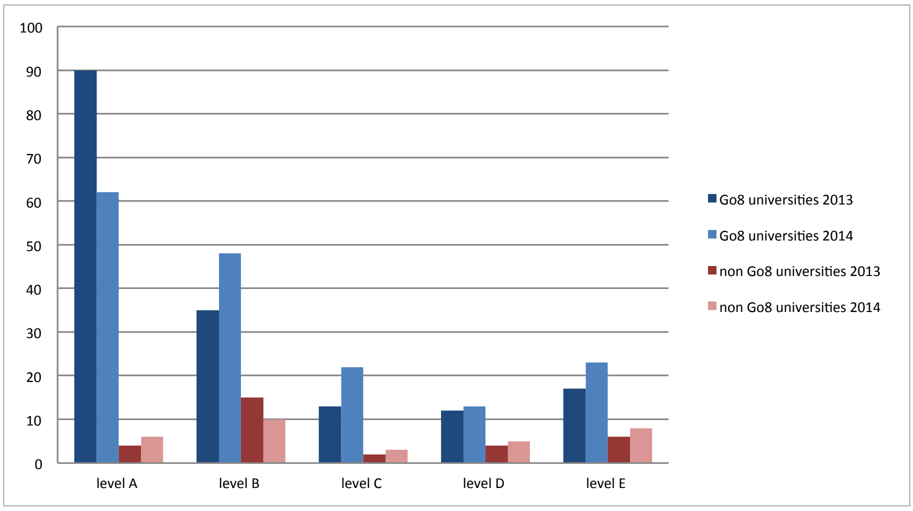
	Discovery Projects			Linkage Projects		
	2012	2013	2014	2012	2013	2014
Total Go8 universities	139	159	133	14	12	4
total ATN universities	14	12	14	6	2	2
total RUN universities	3	3	3	0	0	2
total IRU universities	12	13	13	3	3	10
total unaligned universities	11	11	9	1	1	5
Total all universities	179	198	172	24	18	23

Source: AMSI Member Survey 2013 and 2014, preliminary results.

The actual distribution of ARC funding among universities is shown in table 4.7. Available funding is largely limited to Go8 universities.

On average, Go8 universities estimated their success rate in obtaining ARC funding between 2011 and 2013 to be 33 per cent. Other universities estimated it at 13 per cent on average (and of these other universities, about half reported to have not secured any ARC grants). Figure 4.8 depicts the ARC funded staff levels at Go8 universities (in blue) and other universities (in red), in 2013 and 2014 respectively. From this it is clear that Go8 universities are in a position to employ many more research-only staff, a very high proportion of which are employed at level A and B. From 2013 to 2014 the number of level A staff at Go8 universities has dropped, while the number of staff at level B increased.

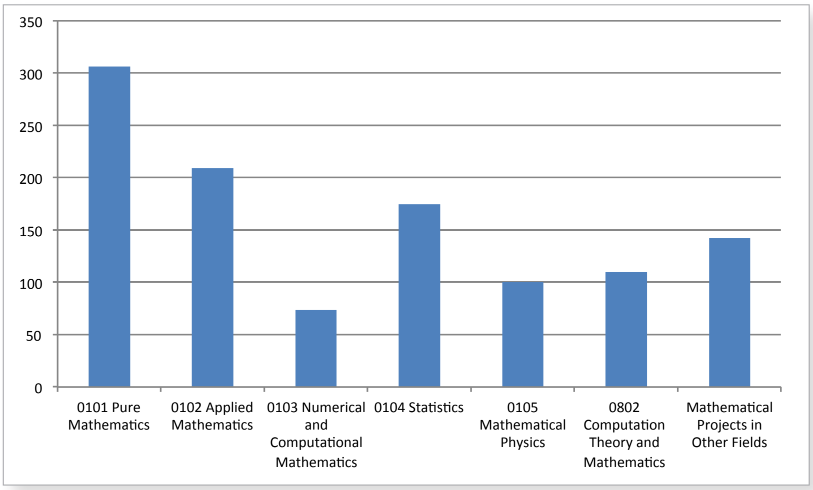
Figure 4.8 Number of ARC-funded staff 2013–2014



Source: AMSI Survey 2013 and 2014, preliminary results.

Figure 4.9. shows the areas of ARC research grants given in the mathematics field of research '01' code and also highlights other fields of research given specific funding for their maths component — further details about these classifications and fields of research (FOR) codes may be found in the 2012 ERA Evaluation Handbook. Areas such as education, engineering, physics, biology and chemistry can contain research with a mathematical component – as shown by the final bar.

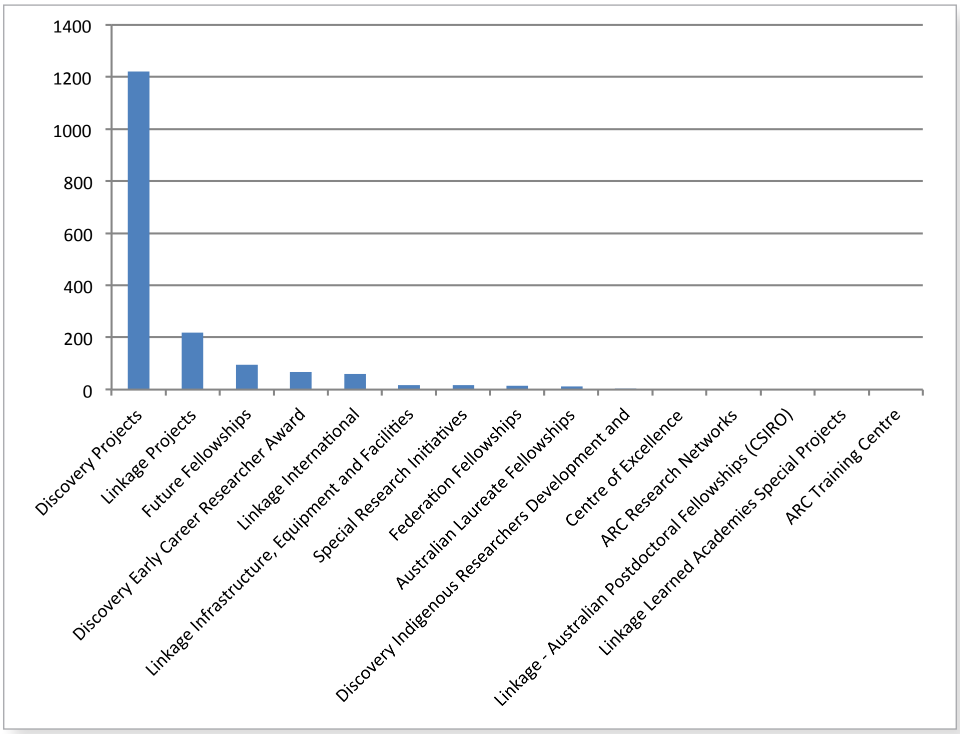
Figure 4.9 ARC projects in the period 2002–2020 by 4-digit FOR code, by year of completion



Source: AMSI, based on ARC datasets.

As previously discussed, the majority of ARC research funding in the mathematical sciences comes in the form of Discovery Projects — this is shown in Figure 4.10. The number of Linkage Projects (joint research projects with industry and other organisations) in the mathematical sciences is surprising at first glance. However, many of these are in education, mathematics and numeracy curriculum and pedagogy. Most others are in the fields of applied mathematics, statistics or computation theory; very few Linkage Projects have a pure mathematics component.

Figure 4.10 Number of ARC projects by project type in the years 2002–2020, by year of completion



Source: AMSI, based on ARC datasets.

4.3 RESEARCH OUTPUT AND QUALITY

In terms of volume output, mathematics in Australia is a small area of research. Table 4.11 shows in the period 2002–2012, the mathematical sciences generated around 20,000 publications — 2.15 per cent of the world total.

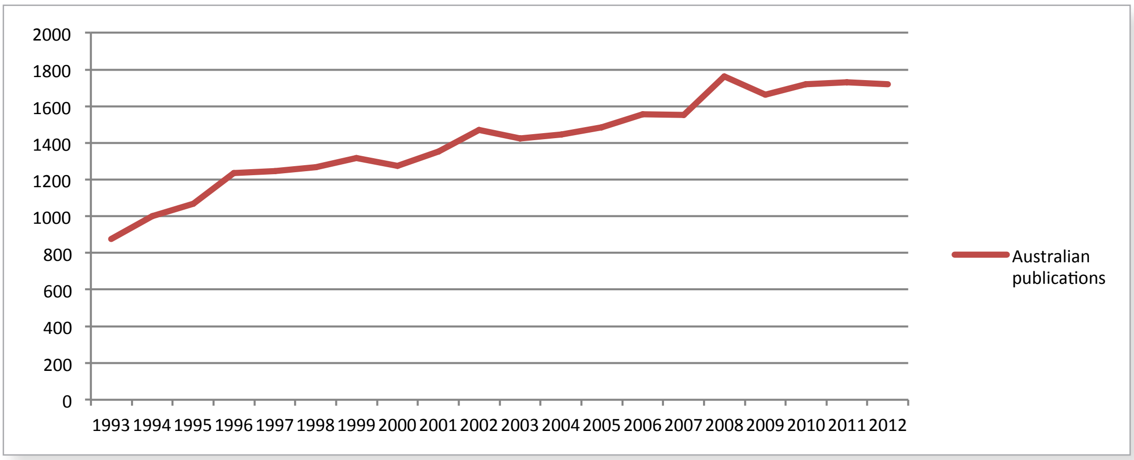
Table 4.11 STEM publications by field, 2002–2012

Field	Australia Total	Australia % world	World total
All STEM publications	429 161	3.07	13 982 435
Biomedical and clinical health sciences	106 949	3.36	3 179 977
Biological sciences	72 213	4.12	1 754 641
Engineering	62 112	2.46	2 521 292
Chemical sciences	36 880	1.98	1 858 227
Physical sciences	34 375	2.26	1 523 329
Agricultural and veterinary sciences	30 553	4.97	614 921
Environmental sciences	20 944	7.49	279 683
Mathematical sciences	20 123	2.15	935 577
Earth sciences	18 917	5.00	378 670
Information and computing technology	17 599	3.13	562 889
Technology	8 496	2.28	373 229

Source: InCites, Thomson Reuters (2012). Global Comparisons Dataset, 2002 to 2012. Report created 12 January 2014; data processed 3 July 2013. Data from Web of Science.

From: Office of the Chief Scientist, Benchmarking Australian Science, Technology, Engineering and Mathematics, November 2014, Table 2-2, page 9.

Figure 4.12 Australian mathematical publications (MathSciNet) in the period 1993–2012



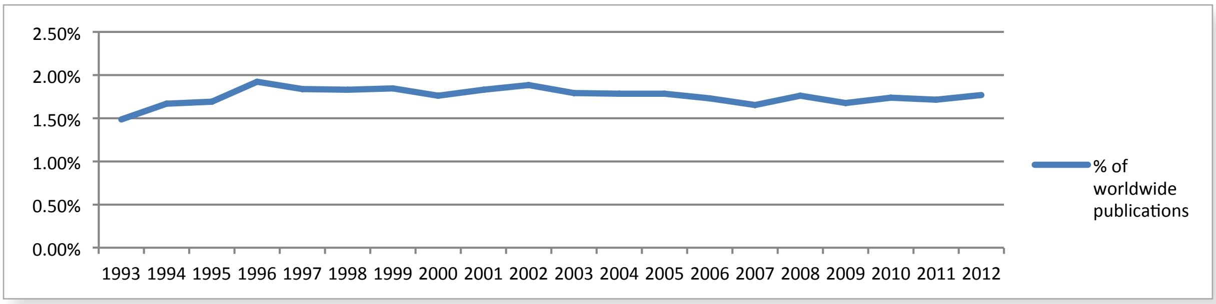
Source: MathSciNet database on publications in mathematics originating from Australian universities, 1993–2013.

MathSciNet is the worldwide database of mathematical publications. Figure 4.12 shows that over the last two decades Australian publications have seen a steady rise.

This rise can be partly attributed to a widening of the journal coverage of the MathSciNet database. As a proportion of worldwide mathematical publications Australia's contribution has been stable. Figure 4.13 shows it has remained between 1.5 per cent and 2 per cent over two decades. The overall percentage in the past decade has been slightly lower when compared to the latter half of the nineties. Overall the percentage is lower than the 2.15 per cent shown in Table 4.5, but this can be attributed to MatSciNet only covering a fraction of scientific papers in statistics and mathematical physics.
If we look at the relative quality and impact of Australian mathematical research, it is clear some areas do very well.

However, Australian mathematical research does not stand out internationally as either particularly strong or weak overall. Figure 4.14 illustrates the relative position of fields of research measured against the aggregated citation data of 15 countries in the European Union (EU). The fields of statistics and applied mathematics are the only two fields with citation rates above those of the EU countries; statistics also has higher citation rates than the United States (Benchmarking, page 15).

Figure 4.13 Australian publications as a percentage of worldwide mathematical publications in the period 1993–2012



Source: Data from MathSciNet database on publications in mathematics originating from Australian universities, 1993–2013.

Figure 4.14 Australian STEM research, by four-digit sub-field, 2002 to 2012

Notes: Publication counts are Web of Science documents classified as article, note or review, by year of publication and assigned to a country based on the institutional address(es) listed in the publication. Each circle represents a STEM subject group (selected using Australia ERA 2012 FoR Level 2 categories) ordered by field-weighted citation rate. Circle area indicates total number of STEM publications, 2002 to 2012. Green circles show sub-fields above the EU15 countries; yellow circles show sub-fields above the world average (1.0) but below the EU15 countries; red circles show those sub-fields that are below the world average.

Source: InCites, Thomson Reuters (2012). Global Comparisons Dataset, 2002 to 2012. Report created 30 January 2014. Data processed 3 July 2013. Data from Web of Science.

From: Office of the Chief Scientist, Benchmarking Australian Science, Technology, Engineering and Mathematics, November 2014, Figure 2-4, page 13.

The best Australian mathematical research can be classified among the best in the world. In the decade between 2002 and 2012, Australian mathematics and statistics research contributed 3.1 per cent of the “best” world research in science, technology, engineering and mathematics (STEM). Table 4.15 defines the 3.1 per cent as the share of the top 1 per cent of global STEM publications by citation rate.

Table 4.15 STEM fields in Australian publications that contribute to the top 1% of global STEM publications, by citation rate, 2002–2012

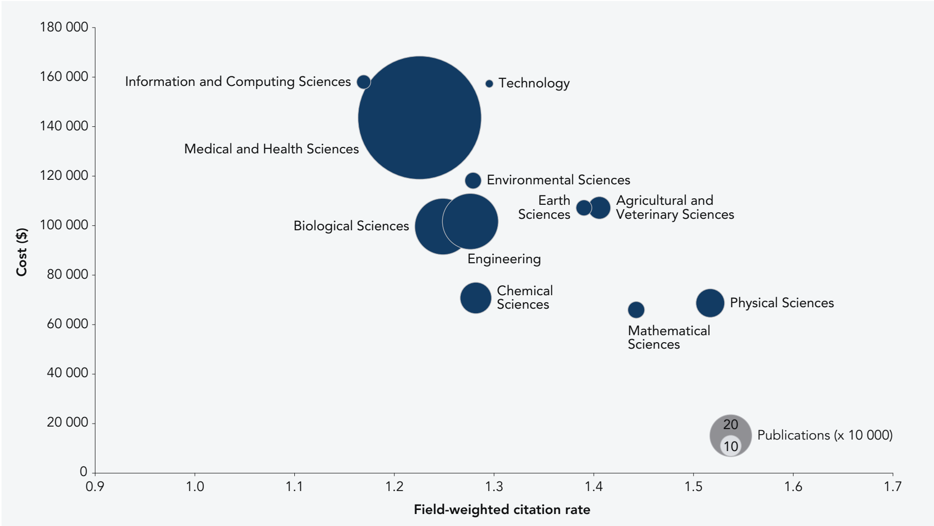
Field of research	Australian share of top 1 per cent of each field (%)
Earth and Planetary Sciences	8.9
Agricultural and Biological Sciences	7.9
Environmental Science	7.3
Veterinary	6.7
Medicine	5.6
Immunology and Microbiology	5.1
General	5.0
Neuroscience	4.5
Psychology	4.3
Biochemistry, Genetics and Molecular Biology	4.0
Energy	3.8
Computer Science	3.2
Physics and Astronomy	3.2
Mathematics	3.1
Pharmacology, Toxicology and Pharmaceutics	3.1
Chemical Engineering	3.1
Engineering	3.0
Materials Science	2.9
Chemistry	2.5

Source: Research carried out by Coombs Policy Forum at the Australian National University (2014). Data sourced from Scopus using STEM field codes with the top 1 per cent of publications based on citation rate and normalised by the expectation value of citations in the field for each year. The mean of the annual normalised citation rates is shown.

From: Office of the Chief Scientist, Benchmarking Australian Science, Technology, Engineering and Mathematics, November 2014, Table 3-1, page 23.

Figure 4.16 offsets the cost of generating Australian research publications against their citation rates. It shows that the cost per mathematical publication is low and the citation rates are relatively high. This attests to the quality and output of mathematical research, despite the very modest funding made available.

Figure 4.16 Cost per publication and citation rate, by field



Notes: Cost per publication is calculated using 2008, 2010 and 2012 HERD and 2009, 2011 and 2013 bibliometric data to account for the lag between funding and publication. Circle size represents number of publications during the period.

Source: ABS (2013).

From: Office of the Chief Scientist, Benchmarking Australian Science, Technology, Engineering and Mathematics, November 2014, Figure 5-7, page 40.

4.4 EXCELLENCE IN RESEARCH FOR AUSTRALIA (ERA) 2010–2012

Table 4.17 Mathematical Sciences (2010)

Institution	01 Mathematical Sciences	0101 Pure Mathematics	0102 Applied Mathematics	0103 Numerical and Computational Mathematics	0104 Statistics	0105 Mathematical Physics	0199 Other Mathematical Sciences
Australian Catholic University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Australian National University	4	5	4	n/a	3	5	n/a
Batchelor Institute of Indigenous Tertiary Education	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bond University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Central Queensland University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Charles Darwin University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Charles Sturt University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Curtin University of Technology	3	n/a	3	3	2	n/a	n/a
Deakin University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Edith Cowan University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Flinders University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Griffith University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
James Cook University	2	n/a	n/a	n/a	n/a	n/a	n/a
La Trobe University	2	2	3	n/a	n/a	n/a	n/a
Macquarie University	2	3	n/a	n/a	2	n/a	n/a
Melbourne College of Divinity	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Monash University	3	3	4	n/a	2	n/a	n/a
Murdoch University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Queensland University of Technology	4	n/a	4	3	3	n/a	n/a
RMIT University	2	n/a	3	n/a	n/a	n/a	n/a
Southern Cross University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Swinburne University of Technology	n/a	n/a	n/a	n/a	n/a	n/a	n/a
University of Adelaide	3	4	3	n/a	3	n/a	n/a
University of Ballarat	2	2	n/a	n/a	n/a	n/a	n/a
University of Canberra	n/a	n/a	n/a	n/a	n/a	n/a	n/a
University of Melbourne	5	4	4	n/a	4	5	n/a
University of New England	4	4	n/a	n/a	n/a	n/a	n/a
University of New South Wales	4	3	4	5	3	4	n/a
University of Newcastle	3	3	5	n/a	n/a	n/a	n/a
University of Notre Dame Australia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
University of Queensland	4	3	4	5	5	4	n/a
University of South Australia	3	3	3	n/a	n/a	n/a	n/a
University of Southern Queensland	3	n/a	n/a	n/a	n/a	n/a	n/a
University of Sydney	5	4	4	3	3	5	n/a
University of Tasmania (inc. Australian Maritime College)	3	2	n/a	n/a	n/a	n/a	n/a
University of Technology, Sydney	3	n/a	3	n/a	n/a	4	n/a
University of the Sunshine Coast	n/a	n/a	n/a	n/a	n/a	n/a	n/a
University of Western Australia	4	5	4	n/a	3	n/a	n/a
University of Western Sydney	3	3	n/a	n/a	n/a	n/a	n/a
University of Wollongong	3	3	3	n/a	2	n/a	n/a
Victoria University	2	1	3	n/a	n/a	n/a	n/a
Total UoEs evaluated	**24**	**18**	**17**	**5**	**12**	**6**	**0**

Source: ARC/ERA, Section 4, ERA 2010 Institution Report, page 264.

Table 4.18 Mathematical Sciences (2012)

Institution	01 Mathematical Sciences	0101 Pure Mathematics	0102 Applied Mathematics	0103 Numerical and Computational Mathematics	0104 Statistics	0105 Mathematical Physics	0199 Other Mathematical Sciences
Australian Catholic University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Australian National University	5	5	4	n/a	n/a	4	n/a
Batchelor Institute of Indigenous Tertiary Education	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bond University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Central Queensland University	5	n/a	5	n/a	n/a	n/a	n/a
Charles Darwin University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Charles Sturt University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Curtin University of Technology	3	n/a	3	3	n/a	n/a	n/a
Deakin University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Edith Cowan University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Flinders University	2	n/a	n/a	n/a	n/a	n/a	n/a
Griffith University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
James Cook University	3	n/a	3	n/a	n/a	n/a	n/a
La Trobe University	2	2	2	n/a	n/a	n/a	n/a
Macquarie University	2	3	n/a	n/a	2	n/a	n/a
MCD University of Divinity	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Monash University	3	3	4	n/a	3	n/a	n/a
Murdoch University	2	n/a	n/a	n/a	n/a	n/a	n/a
Queensland University of Technology	4	n/a	3	4	4	n/a	n/a
RMIT University	3	n/a	4	n/a	n/a	n/a	n/a
Southern Cross University	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Swinburne University of Technology	n/a	n/a	n/a	n/a	n/a	n/a	n/a
University of Adelaide	4	4	4	n/a	4	n/a	n/a
University of Ballarat	2	2	2	n/a	n/a	n/a	n/a
University of Canberra	n/a	n/a	n/a	n/a	n/a	n/a	n/a
University of Melbourne	4	5	4	n/a	4	4	n/a
University of New England	3	4	n/a	n/a	n/a	n/a	n/a
University of New South Wales	4	4	4	3	3	3	n/a
University of Newcastle	3	3	5	n/a	4	n/a	n/a
University of Notre Dame Australia	n/a	n/a	n/a	n/a	n/a	n/a	n/a
University of Queensland	4	4	4	5	5	3	n/a
University of South Australia	4	3	3	n/a	n/a	n/a	n/a
University of Southern Queensland	3	n/a	n/a	n/a	n/a	n/a	n/a
University of Sydney	5	4	3	3	4	4	n/a
University of Tasmania (inc. Australian Maritime College)	3	n/a	3	n/a	n/a	n/a	n/a
University of Technology, Sydney	3	n/a	4	n/a	n/a	3	n/a
University of the Sunshine Coast	n/a	n/a	n/a	n/a	n/a	n/a	n/a
University of Western Australia	3	4	3	n/a	n/a	n/a	n/a
University of Western Sydney	4	3	4	n/a	n/a	n/a	n/a
University of Wollongong	4	3	4	n/a	4	n/a	n/a
Victoria University	3	1	4	n/a	n/a	n/a	n/a
Total UoEs evaluated	27	17	22	5	10	6	0

Source: ARC/ERA, Section 4, ERA 2012 Institution report, page 309.

Compared to the Excellence in Research for Australia (ERA) results of 2010 (Table 4.17), the 2012 ERA results (Table 4.18), show an overall improvement. The ERA Unit of Evaluation (UoE) represents the discipline within an institution, not individual researchers or institutional units. The total number of UoE's assessed at the two-digit and four-digit level went up, only statistics went down. The number of UoE's assessed in statistics declined from twelve in 2010 to ten in 2012. Overall, there were 14 universities (34 per cent), which did not have sufficient, if any, research output in the mathematical sciences to be assessed.

The situation for statistics is anomalous since, alone amongst the mathematical sciences, it has higher citation rates than both the EU and the US. It seems that the ERA is not accurately reflecting our performance in statistics.

At the two-digit level, there were only six disciplines that had fewer UoE's evaluated, again confirming that the mathematical sciences remain one of the smaller research disciplines in terms of volume output. At the four-digit level all disciplines except mathematical physics stabilised or improved their ranking compared to 2010. At the four-digit level 54 out of 60 UoE's perform at or above world standard.

About the 2014 AMSI University Survey

In 2014 universities (members and non-members of AMSI) were sent a comprehensive survey questionnaire with enquiries about their staffing situation, teaching, student numbers and a host of other data. To date, 26 respondents have participated in the survey. This *Discipline Profile* contains the preliminary results.

A final report of the AMSI Member Survey 2014 will be published on the AMSI website later in 2015.

AMSI wishes to thank all respondents to the survey for their cooperation:

Australian National University
Bond University
Charles Darwin University
Charles Sturt University
Curtin University
Deakin University
Federation University
Flinders University
Griffith University
La Trobe University
Monash University
Murdoch University
Queensland University of Technology
RMIT University
Swinburne University of Technology
University of Adelaide
University of Melbourne
University of New England
University of New South Wales
University of New South Wales Canberra (ADFA)
University of Newcastle
University of South Australia
University of Southern Queensland
University of Sydney
University of Western Australia
University of Wollongong

Acknowledgements

Special thanks for the provision of data, assistance and analysis in compiling this document:

Jan Thomas (AMSI)
Frank Barrington (University of Melbourne)
Michael Evans (AMSI)
Peter Johnston (Griffith University)
Joann Cattlin (University of Melbourne)
Mathematical Reviews, for providing data from the MathSciNet database

List of resources

AMSI University Surveys 2012–2014
amsi.org.au/publication-categories/publications/discipline-profiles/

NAPLAN, 2014 National Report
www.nap.edu.au/results-and-reports/national-reports.html

Trends in International Mathematics and Science Study, Selected data from 1995, 2003, 2007 and 2011
www.timss.org

OECD Programme for International Student Assessment (PISA), Selected data from PISA 2000, 2003, 2006, 2009 and 2012
www.oecd.org/pisa/

Sue Thomson et al., Highlights from TIMSS and PIRLS 2011 from Australia's perspective, ACER 2012
www.acer.edu.au/documents/TIMSS-PIRLS_Australian-Highlights.pdf

Sue Thomson et al., Monitoring Australian year 8 student achievement internationally: TIMSS 2011
www.acer.edu.au/research/publications/timss/

Sue Thomson et al., PISA 2012: How Australia measures up, ACER 2013
www.acer.edu.au/ozpisa/pisa2012

OECD, Education at a Glance 2011: OECD Indicators
www.oecd-ilibrary.org/education/education-at-a-glance-2011_eag-2011-en

OECD, Education at a Glance 2012: OECD Indicators
www.oecd-ilibrary.org/education/education-at-a-glance-2012_eag-2012-en

OECD, Education at a Glance 2013: OECD Indicators
www.oecd-ilibrary.org/education/education-at-a-glance_19991487

OECD, Education at a Glance 2014: OECD Indicators
www.oecd.org/edu/Education-at-a-Glance-2014.pdf

Frank Barrington/Michael Evans, Year 12 Mathematics Participation Rates in Australia, AMSI data collection

David GW Pitt, On the scaling of NSW HSC marks in mathematics and encouraging higher participation in calculus-based courses, Australian Journal of Education, 2015, Vol. 59(1) 65–81.
aed.sagepub.com/

ACHMS Survey 2010, 2010
www.amsi.org.au/images/stories/downloads/pdfs/general-outreach/NCMS_Docs/16_ACHMS_survey_Feb10.pdf

Peter Johnston, *Higher Degrees and Honours Bachelor Degrees in mathematics and statistics completed in Australia in 2012*, Gazette of the Australian Mathematical Society, issue 5 2014, pp. 290–296
www.austms.org.au/Publ/Gazette/2014/Nov14/Honours.pdf

ACER, Staff in Australia's Schools 2013, April 2014
docs.education.gov.au/system/files/doc/other/sias_2013_main_report.pdf

ACER, Staff in Australia's Schools 2010, November 2011
foi.deewr.gov.au/node/25764

ACER, *Staff in Australia's Schools 2007*, January 2008
foi.deewr.gov.au/documents/staff-australia-s-schools-2007

Queensland Audit Office, Supply of specialist subject teachers in secondary schools, Report to Parliament 2: 2013–2014
www.qao.qld.gov.au/files/file/Reports%20and%20publications/Reports%20to%20Parliament%202013–14/RtP22013–14Specialistteachers.pdf

National Strategic review for Mathematical Sciences Research in Australia (2006), *Mathematics and Statistics: critical skills for Australia's future*
www.amsi.org.au/publications/amsi-publications/248-national-strategic-review-of-mathematical-sciences-research-in-australia

Office of the Chief Scientist, Mathematics, Engineering and Science in the National Interest, May 2012, Appendix F
www.chiefscientist.gov.au/wp-content/uploads/Office-of-the-Chief-Scientist-MES-Report-8-May-2012.pdf

Office of the Chief Scientist, *Health of Australian Science*, May 2012
www.chiefscientist.gov.au/wp-content/uploads/HASReport_Web-Update_200912.pdf

Office of the Chief Scientist, Benchmarking Australian Science, Technology, Engineering and Mathematics, November 2014
www.chiefscientist.gov.au/wp-content/uploads/BenchmarkingAustralianSTEM_Web_Nov2014.pdf

Australian Research Council, ARC Support for Research in the Mathematical Sciences, a Summary of Trends — Submit Years 2001 to 2011
http://amsi.org.au/publications/arc-support-for-research-in-the-mathematical-sciences/

The importance of advanced physical and mathematical sciences to the Australian economy", Australian Academy of Science, Canberra, 2015
www.chiefscientist.gov.au/wp-content/uploads/Importance-of-Science-to-the-Economy.pdf

Maths prerequisites and assumed knowledge for entry into bachelor of science, commerce and engineering degrees, data collection by the FYiMaths network, 2015
fyimaths.org.au/

Graduate Careers Australia, Grad Job and Dollars and GradFiles
www.graduatecareers.com.au/Research

ARC/ERA, Section 4, ERA 2010 Australian Institution Report
www.arc.gov.au/era/era_2010/outcomes_2010.htm

ARC/ERA, Section 4, ERA 2012 Institution report
www.arc.gov.au/era/era_2012/outcomes_2012.htm

ARC, Field Of Research collection, and ARC Funded Research Projects — Trends Data Set
www.arc.gov.au/general/searchable_data.htm

MathSciNet, Data on publications in mathematics originating from Australian universities, 1993–2013.

Glossary

AAS:	Australian Academy of Sciences
ABS:	Australian Bureau of Statistics
ACER:	Australian Council for Educational Research
APM sciences:	Advanced physical and mathematical sciences encompassing the core physical sciences of physics, chemistry, the earth sciences and the mathematical sciences. 'Advanced' means science undertaken and applied in the past 20 years.
ARC:	Australian Research Council
ATN:	Australian Technology Network, alignment of universities consisting of Queensland University of Technology, Curtin University, University of South Australia, RMIT University, and University of Technology Sydney
BERD:	Business Expenditure Research & Development
CIE:	Centre of International Economics
EFTSL:	Equivalent Full Time Student Load
ERA:	Excellence in Research for Australia
FTE:	Full Time Equivalent
Go8:	Group of Eight universities, alignment of universities consisting of University of Sydney, University of New South Wales, University of Adelaide, University of Melbourne, Monash University, Australian National University, University of Western Australia and University of Queensland
GOVERD:	Government Expenditure Research & Development
GVA:	Gross Value Added
HERD:	Higher Education Expenditure Research & Development
IRU:	Innovative Research Universities, alignment of universities consisting of Charles Darwin University, Flinders University, Griffith University, James Cook University, La Trobe University, Murdoch University and University of Newcastle
MathSciNet:	Mathematical Reviews Database, maintained by the American Mathematical Society
OCS:	Office of the Chief Scientist
OECD:	Organisation for Economic Co-operation and Development
RUN:	Regional Universities Network, alignment of universities consisting of Central Queensland University, Southern Cross University, Federation University, University of New England, University of Southern Queensland, and University of the Sunshine Coast
STEM:	Science, Technology, Engineering and Mathematics
UoE:	Unit of Evaluation (ERA)

AMSI
AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

www.amsi.org.au

Australian Mathematical Sciences Institute
Building 161, Monash
c/- The University of Melbourne
Victoria 3010 Australia

+61 3 8344 1777
enquiries@amsi.org.au