AMSI
AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

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Director
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Submission to the National Security Science & Technology discussion paper from the Australian Mathematical Sciences Institute (AMSI)

AMSI is a collaborative venture of the nation's universities, professional societies and government agencies, that seeks to integrate research, education and industry involvement to deliver mathematical and statistical capability and provide a strong base for national innovation.

AMSI is making this submission as we believe that the mathematical sciences are crucial to national security, both as a discipline in its own right and as a foundation for all science, technology and engineering disciplines.

It is important that the national security science and technology policy ensures Australia's future skills and supports the pipeline necessary to resource Australia's future national security requirements.

Yours sincerely,

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The Australian Mathematical Sciences Institute (AMSI) submission to the national security science and technology policy consultation

2.1 Are there other imperatives or drivers that justify the creation of a national security S&T policy and program?

Australia's science and technology capacity is vulnerable at the moment due to defects in the education and training pipeline. A national security policy will go some way towards the removal of these obstructions.

Ensuring long-term national security requires a highly skilled Australian STEM workforce. It has been widely acknowledged that domestic graduates with STEM research skills in Australia are in decline.

The mathematical sciences are crucial to Australian national security advances in areas such as cyber security, cryptography, network modeling and big data analysis to name only a few. But also underpin all science, technology and engineering disciplines.

Over the past 20 years Australia has experienced a serious decline in mathematical sciences capability, a coordinated national approach is required to reverse this growing skill gap. A national security S&T policy will provide an important driver for this development.

See **Appendix 1** for capability statistics.

Q2.2 Are there any other challenges or opportunities that need to be addressed?

Challenge

The underlying weakness in the supply of advanced mathematics and statistics and computational sciences graduates and postgraduates must be addressed.

Often, due to the internal organisation of government agencies mathematicians and statisticians are dispersed among different departments and do not have a clear identity as a specialist group within the agency. This diminishes opportunities for coherent external engagement by the mathematical scientists.

Opportunity

Often existing opportunities for engagement are overlooked. While the paper has identified that there is no formalised mechanism for engagement with DSTO and other S&T providers there are many opportunities for engagement between these groups through programs such as AMSI's workshop program, PhD internship placements and research training program.

Q4.1 Are these the right objectives for a national security S&T policy? If not, how should they be articulated?

- coordinate efforts to best take advantage of investment in S&T and address critical gaps to address immediate and future national security capability, operational and policy needs;

This second objective should more directly address critical personnel and knowledge gaps in research training and the supply of graduates.

Q4.2 Are there other objectives that the policy should address?

A national security S&T policy is considerably weakened unless there is a national STEM policy of the type advocated by the Chief Scientist. As a result one of the objectives of a national security policy would be alignment with a national STEM policy.

Q4.4 What current mechanisms exist or what options are there for new ones that facilitate sharing capabilities that reside outside Government?

DSTO's membership of AMSI is an example of an effective current mechanism for sharing capabilities. This allows DSTO scientists to effectively engage with their university counterparts.

Q4.8 What specific cyber threats and/or mitigations should be considered in developing a cyber S&T program? Who are the key stakeholders that should be involved?

The mathematical sciences are key stakeholders, every effort should be made to maintain effective channels of communication with Australian mathematical sciences researchers in this area.

For example, the new Australian Centre of Excellence for Mathematical and Statistical Frontiers (ACEMS) will be undertaking extensive work on data protection.

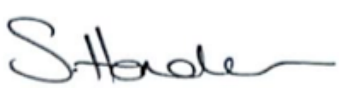
Q4.17 What other barriers to collaboration exist and how might they be managed?

The identification of coherent discipline groups in national security agencies and businesses removes a barrier to wider engagement as a group and effective collaboration across departments.

Q6.2 What baseline data should be collected and how?

Data needs to be collected on graduation rates and areas of research expertise in disciplines strategically important to national security to clearly identify skills gaps.

Professor Geoff Prince
Director AMSI



Simi Henderson
Research and Higher Education Manager

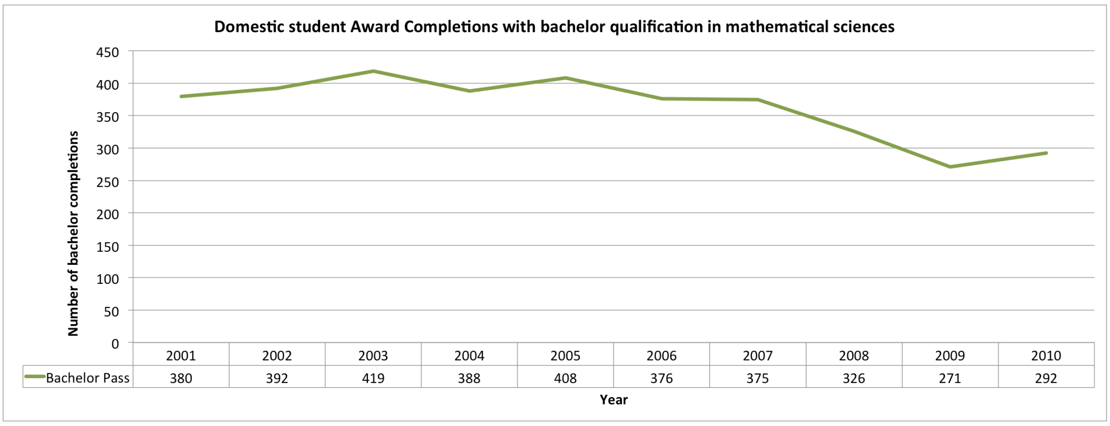
APPENDIX 1
The mathematical sciences in Australia: a summary

1. University mathematics and statistics

Domestic completion data shows that domestic student completions in the mathematical sciences are in decline.

1.1 Bachelor completions

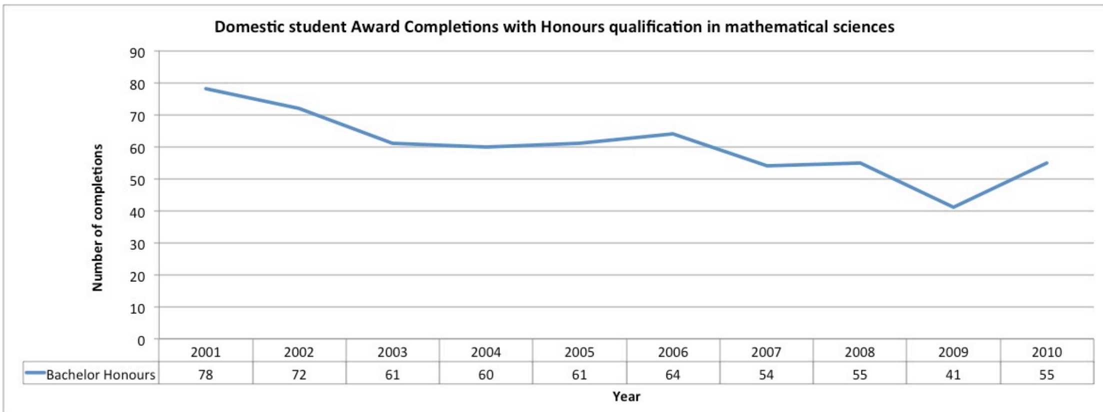
Despite small spikes in 2003 and 2005 the long-term trend is a decline in domestic bachelor completions in the mathematical sciences.



Source: Zhengfeng Li, (July 2012). *Domestic student Award Completions with qualification in mathematical sciences (a) by State, Institution and gender, indigenous status and SES*

1.2 Honours completions

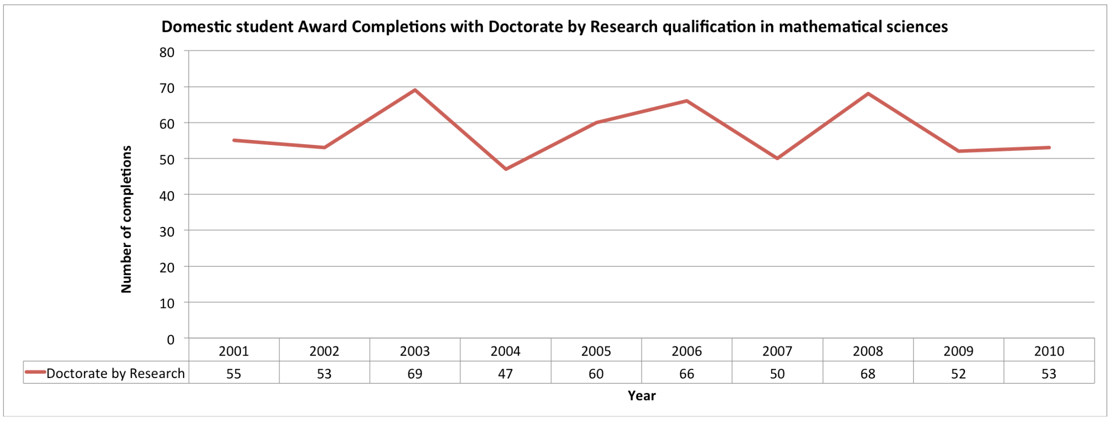
Despite a small spike in 2006 the long-term trend is a decline in domestic honours completions in the mathematical sciences.



Source: Zhengfeng Li, (July 2012). *Domestic student Award Completions with qualification in mathematical sciences (a) by State, Institution and gender, indigenous status and SES*

1.3 PhD completions

Domestic PhD completions have fluctuated, but remained relatively stable. The number of PhD completions needs to increase if the growing demand for PhD's in the workforce is to be met.

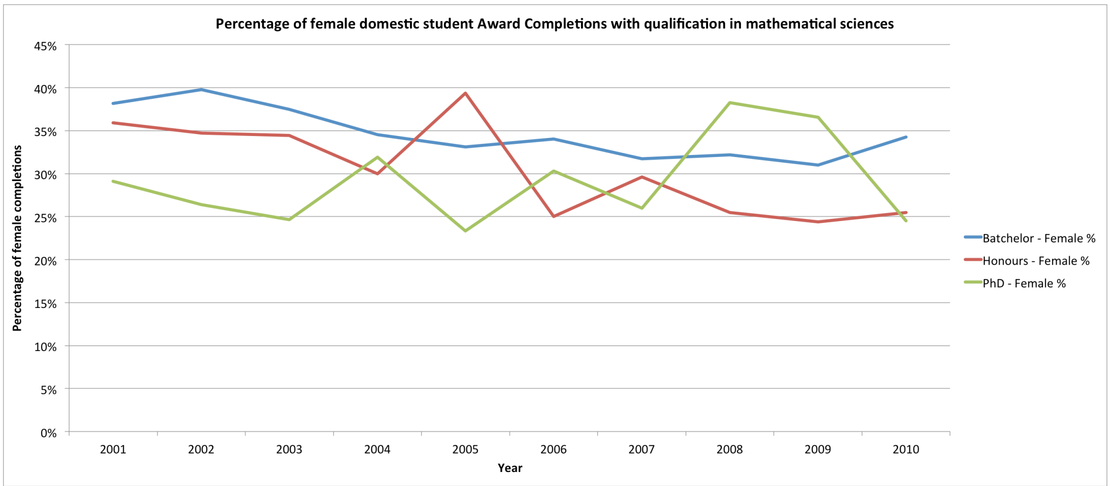


Source: Zhengfeng Li, (July 2012). *Domestic student Award Completions with qualification in mathematical sciences (a) by State, Institution and gender, indigenous status and SES*

1.4 The Gender Gap

The percentage of female completions with qualifications in the mathematical sciences at all levels is between 25 and 35%.

The data indicates a slow decline in the percentage of female bachelor degree completions, this decline is likely to lead to a decline in the future percentage of female honours and PhD completions. This trend must be addressed.



Source: Zhengfeng Li, (July 2012). *Domestic student Award Completions with qualification in mathematical sciences (a) by State, Institution and gender, indigenous status and SES*

1.5 International comparison of enrolment and graduation figures

Entry and graduation in mathematical sciences university degrees is very low in Australia. According to 2009 OECD data (see table 1) the percentage of graduates in mathematical university degrees was roughly half the OECD average. 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 2011 OECD data again confirmed the low figures (table 2). In fact, the number of entrants into a university mathematical degree in Australia was so low it was deemed negligible – i.e. less than 0.5% (which does need to take into account that Australia does not have "vocational" tertiary type b programmes in mathematical sciences)

Table 1: Indicator A4: Which fields of education do students choose?

		Engineering, manufacturing and construction	Science	Life sciences	Physical sciences	Mathematics and statistics	Computing
OECD	**Note**	(7)	(8)	(9)	(10)	(11)	(12)
Australia	1	7.2	**10.6**	3.4	1.9	0.5	4.9
Canada	1	8.5	**13.0**	6.6	2.9	1.4	2.1
Denmark		**11.1**	8.2	1.9	1.9	1.1	3.3
Finland		**20.6**	7.6	1.5	2.0	0.9	3.0
Germany		12.3	**16.5**	3.6	5.1	3.0	4.8
Ireland		8.1	**11.6**	3.9	1.7	0.9	3.6
New Zealand		6.3	**12.5**	5.3	2.5	1.3	3.9
Sweden		**16.4**	7.4	2.8	1.6	0.7	2.3
United Kingdom		9.2	**13.6**	4.3	3.8	1.5	4.1
OECD average		**12.0**	**9.3**	**2.8**	**2.2**	**1.0**	**3.3**
EU21 average		**11.4**	**8.7**	**2.5**	**2.0**	**0.9**	**3.2**

Source: selected data extracted from Education at a Glance 2011: OECD Indicators, Table A4.3b (Web only) Distribution of tertiary-type A and advanced research programmes graduates, by field of education (2009)

Table 2: Distribution of tertiary new entrants, by field of education

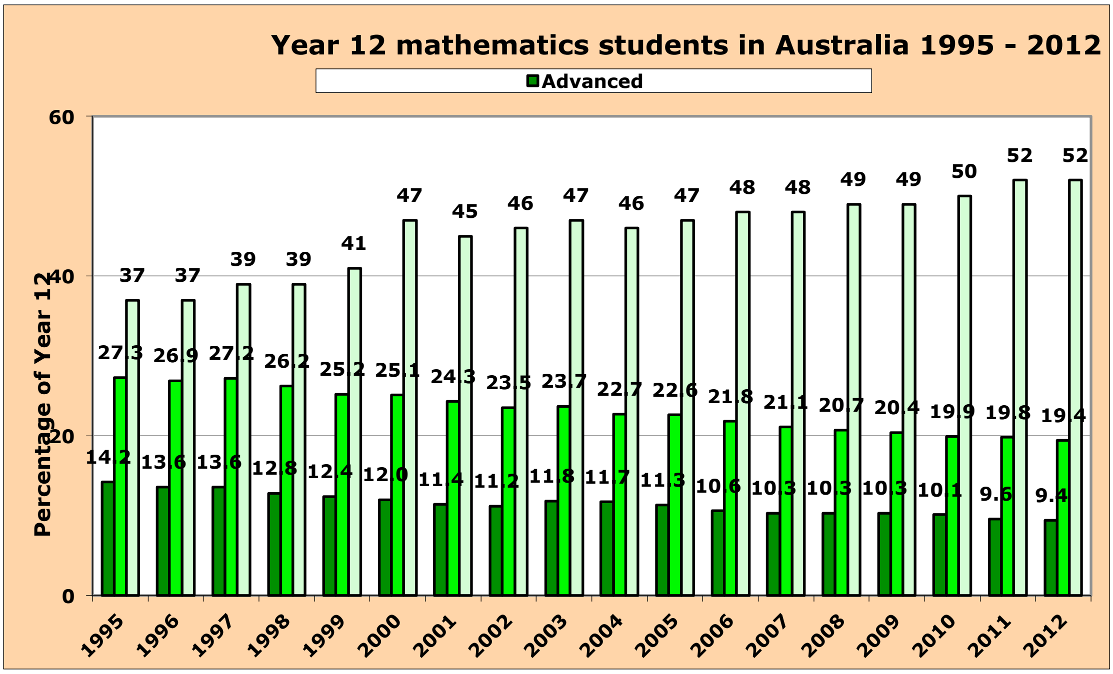
	Engineering, manufacturing and construction	Sciences	Life sciences	Physical sciences	Mathematics and statistics	Computing
OECD countries						
Australia	9	**12**	4	2	n	4
Denmark	12	8	1	1	1	4
Finland	25	9	1	3	1	4
Germany	**16**	13	2	4	2	4
Ireland	11	**15**	4	2	n	6
New Zealand	6	16	5	3	3	6
Sweden	19	11	2	2	2	5
United Kingdom	8	**14**	5	4	**2**	4
OECD average	**15**	**10**	**2**	**2**	**1**	**4**
EU21 average	**15**	**11**	**2**	**2**	**1**	**4**

Source: selected data extracted from Education at a Glance 2013: OECD Indicators, Table C3.3a (Web only) Distribution of tertiary new entrants, by field of education (2011)

2. School mathematics and statistics

2.1 Year 12

There is a persistent and ongoing decline in the percentage of Year 12 students taking advanced and intermediate mathematics. This has serious impact on the number of students with sufficient mathematical knowledge to study STEM subjects at university level.



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

2.2 Teacher profiles and qualifications

Research has consistently shown that there are not enough teachers qualified to teach mathematics in Australian high schools.

- Only 60.4% of year 7-10 teachers teaching mathematics have completed methodology training in the area, suggesting that nearly 40% of these teachers are not fully qualified. In years 11-12 this percentage goes down to a (still very significant) 23.7%.
- Only 64.1% of years 11 and 12 mathematics teachers had at least 3 years tertiary education in the field, down from 68% in 2007.
- Only 45.8% of Years 7 – 10 mathematics teachers had at least 3 years tertiary education, down from 53% in 2007.

Source: Phillip McKenzie, Glenn Rowley, Paul Weldon, Martin Murphy, *Staff in Australia's Schools 2010*, ACER, November 2011

See the AMSI Discipline Profile for more detailed analysis:
http://www.amsi.org.au/index.php/publications-mainmenu/amsi-publications/148-publications/advocacy/1029-discipline-profile-of-the-mathematical-sciences-2013