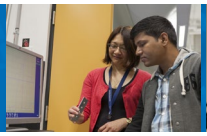

Dealing with Australia's Mathematical Deficit

The mathematical sciences are of critical importance to our human and economic capital. By many measures Australia has been running a mathematical deficit for years: low adult numeracy, falling numbers of trained teachers and worsening school performance, low participation by women, a critically low number of graduates, lack of access for regional and low SES areas and uneven uptake of mathematical and statistical capacity by business.

Demand for mathematical and statistical skills far outstrips falling supply, and maintaining Australia's international competitiveness, security, population health and climate stability requires a mathematically literate population.

New policies and action are needed now to bring Australia into mathematical surplus.

This policy document should be read in conjunction with AMSI's annual Discipline Profile of the Mathematical Sciences **www.amsi.org.au/discipline-profile-2014**. AMSI's 2014 Discipline Profile identifies key priorities for intervention by Australian governments and for action by peak bodies—commercial, educational, scientific and technological. This policy document is structured around these key priorities.

Priority A

Train the unqualified teachers of school mathematics and secure the supply of future maths teachers

Priority B

Reverse the decline in intermediate and advanced maths enrolments at year 12

Priority C

Increase the number of girls studying maths and women employed in the quantitative professions

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The case for action

Priority A

Around 40% of year 7 to 10 maths classes don't have a qualified maths teacher, double the number for science and far in advance of any other subject (see par. 2.5. of the 2014 Discipline Profile of the Mathematical Sciences).

This is completely unacceptable and it is made worse because it is regional and low SES communities that bear the brunt. Many secondary schools don't have a single maths graduate on the staff.

Even if we could magically fill the gap our schools are fully staffed, and displacing current teachers is out of the question. There is only one solution to the immediate problem and that is to provide professional development to the many conscientious and professional educators teaching maths without the requisite content knowledge.

> *We must support the 40% who teach our children maths without enough background.*

Very few undergraduate students in the mathematical sciences aspire to be school teachers. This was not the case when undergraduate numbers in maths were higher.

Why aren't prospective teachers choosing to be maths teachers? Without an answer to this question we will not be able to secure the future supply of mathematically well-prepared teachers. It's not hard to join the dots: is it the quality of maths teaching that is the turn-off? There is no shortage of quality biology teachers and a steady supply of potential biology teachers exists for the foreseeable future.

> *We must act to solve the teacher supply problem.*

Priority B

One of the greatest challenges to the health of the STEM disciplines and professions is the 20 year decline of 34% in enrolments in calculus-based mathematics subjects, often referred to as intermediate or advanced, at year 12 (see par. 2.3. of the 2014 Discipline Profile of the Mathematical Sciences). While it's difficult to identify the original causes, the decline has become self-perpetuating. For example, it led to the weakening of maths prerequisites for university science and engineering courses. This sent a signal to our schools that the subjects were unimportant. Over 20 years we have seen

- Widespread university course realignments to cope with increasing numbers of less mathematically literate students,
- Reduced graduation rates in the mathematical sciences (see par. 3.3 of the 2014 Discipline profile of the Mathematical Sciences), which is all the more apparent when seen in an international context (see par. 3.3.4. of the Discipline Profile),
- Stagnating interest in engineering and science courses, and a concentration of university based research to a small number of institutions dangerously narrowing the support base for research training (see par. 4.1. of the Discipline Profile),

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- Reduced intake of mathematically qualified graduates into teacher training programs, reduced numbers of qualified secondary school teachers, especially in regional and low SES areas, leading to fewer students in calculus-based mathematics subjects at year 12. (see par. 2.3. of the 2014 Discipline Profile of the Mathematical Sciences),
- The unavailability of these school subjects in many regional and low SES areas.

This situation creates a structural impediment to meeting Australia's galloping demand for graduates with sound mathematical and statistical skills and it puts a brake on the national productivity growth enjoyed by other OECD countries where mathematics and statistics graduation levels are, on average, twice as high as those in Australia.

> *Our future as a high technology, research driven economy depends on reversing this trend.*

Priority C

We have lived with low female participation rates in mathematics for too long. The fact that female adult numeracy is below that of males, around 30% in some age groups, is the consequence. (See par. 2.6. of the 2014 Discipline Profile of the Mathematical Sciences). While we often think of mathematics as an enabling discipline the flip side is more important: mathematical illiteracy is disabling. An egalitarian society like ours can't tolerate this endemic disadvantage to women.

In terms of the national economy, it is widely recognised that weak participation by women in many of the STEM professions is handicapping Australia's productivity and competitive advantage. Low female enrolments in year 11 and 12 mathematics are a principal factor.

> *Direct intervention is the only way to reverse this individual and collective disadvantage to Australia's women.*

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Policy measures to reverse the mathematical deficit

The policy and action measures outlined here need to be undertaken in concert by the various stakeholders: it is our strong view that isolated measures will not be successful.

Overall measures

1. A five-year national awareness campaign for mathematics and statistics targeted at both the school and higher education sectors. This campaign will highlight the importance of school mathematics studies for a wide variety of careers and trades and encourage the provision of effective advice on subject choice at secondary and post-secondary levels. It will include a strong gender equity component. Include professional development for both mathematics and careers teachers. It will also highlight government incentives to study mathematics and statistics. (Action: DoE, DoI, ESA, State governments, research agencies, UA, teacher associations, AMSI, AIG, BCA, AustMS, SSAI, AAS, ATSE)
2. Establish a mathematical sciences committee to advise the OCS's National Science and Mathematics Education and Industry Adviser on all the policy measures in this brief and more. (Action: OCS, DoI, DoE)
3. Establish a national STEM policy as advocated by the Chief Scientist (Action: Commonwealth and State governments, AAS, ATSE, AMSI). AMSI supports the creation of a coherent national science and technology agenda.

Priority A Measures

Immediate measures to relieve the urgent shortages:

1. Upgrade out-of-field teachers, starting in low SES and regional areas and with those teachers needing least discipline content (e.g. biology graduates with some maths/stats). Identify qualification/content providers from amongst the universities. Utilise Commonwealth-State agreements. Make the subjects HECS free. Utilise NBN for online provision. Involve ESA. Set 5-year targets. Provide a "Golden Hello" for teachers completing their upgrade qualification. (Action: SCSEEC, DoE, State governments, DoC)
2. Measures to increase the number of suitably prepared undergraduates who could proceed to teach school mathematics, including the effective advice on subject choice. For example, students undertaking a biology/biological sciences degree and intending to become secondary teachers could be encouraged through concrete Commonwealth incentives to complete sufficient tertiary mathematics and statistics subjects enabling them to teach secondary school mathematics as well as biology. Include incentives for early commitment by undergraduates to pre-placement training. HECS-free honours year for those subsequently completing teacher training. (Action: DoE, deans of science, deans of education, UA)

   NOTE: Year 11 and 12 mathematics subjects should in general be taught by those with a major in mathematics and/or statistics see 4. below.

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Structural measures for long term improvement:

1. Golden hellos for new, qualified mathematics teachers working in "difficult to fill" positions. (Action: DoE, State governments)
2. Jurisdictions to return to offering salary increments/incentives for honours graduates and postgraduates to enter the teaching profession in the public school systems. (Action: State governments.)
3. Every secondary school to have a maths/stats graduate as discipline leader within 5 years. Start with schools most in need and offer incentives to teachers (e.g. the UK's "Golden Hello" scheme) and schools. (Action: SCSEEC, DoE, State governments)
4. In order to teach year 11 and 12 mathematics graduates of pre-service programs must have a 3 year undergraduate sequence leading to a major in mathematics or statistics (50% of total third year enrolment). Statistics must be represented in this sequence with a minimum of 2 subjects (each 1/8 of an annual load), at least one of which must be at second year level. Mathematics must be represented by a minimum of 5 subjects, at least one of which must be taken at third year level. All of these subjects must be taught by the provider's mathematics and statistics discipline. In addition, graduates must take at least one subject of mathematical pedagogical content knowledge as part of a full year's study in education. This may be part of an integrated 4 year program or as part of a 3+1 year degree plus graduate diploma-type combination. (Action: AITSL, deans of Education, State governments)
5. In order to teach secondary mathematics to year 10 graduates of pre-service programs must have at least 2 subjects at first year and 2 subjects at second year in mathematics and statistics including at least one statistics subject and at least one second year mathematics subject. The education year requirements are as for year 11 and 12 already outlined above. (Action: AITSL, deans of Education, State governments)
6. Every primary school to have a mathematics specialist (an individual with appropriate tertiary content qualifications) within 5 years, by appointment or training with "Golden Hello" or incentives upon completion of training. Incentives to schools. (Action: SCSEEC, DoE, State governments)
7. Identify undergraduate degrees with mathematical sciences content and weight these studies in the calculation of GPAs for entry into postgraduate Diplomas of Primary Education. (Action: deans of education, AITSL, UA)
8. Improve and standardise relevant mathematics content in pre-placement training for primary teachers over the next 5 years. (Action: deans of education, AITSL, UA)
    a. Primary Bachelor of Education programs. Conventional entry from year 12 must require a 70% percentile score in any year 12 mathematics subject in the Australian Curriculum: Mathematics except Essential Mathematics or current equivalent. (Action: AITSL, DoE, deans of education, UA)
    b. The program itself must contain 2 subjects of mathematics content, identifiably tailored to the knowledge requirements of primary teachers, at least one of which must be taught in the first year. These subjects should be delivered in conjunction with the provider's mathematics and statistics discipline centre and are the subjects referred to in the paragraph above. In addition, the program should contain 3 subjects of mathematics pedagogical content knowledge. (Action: AITSL, SCSEEC, DoE, State governments, deans of education)

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Priority B Measures

Immediate measures:

1. Set national 3, 5 and 10-year targets for increased enrolments in year 12 advanced mathematics subjects. (Action: SCSEEC, DoE, State governments)
2. Identify regions with low or no enrolments in advanced mathematics subjects in year 12 and coordinate and fund shared provision of these subjects. Use NBN. (Action: SCSEEC, DoE, State governments, DoC)
3. Reinstate universal year 12 mathematics prerequisites for science degrees commencing 5 years after the introduction of the senior Australian mathematics curriculum. DoE incentives to do so. (Action: deans of science, UA, DoE, OCS)
4. Reinstate year 12 advanced mathematics prerequisites for engineering degrees where appropriate, commencing 5 years after the introduction of the senior Australian mathematics curriculum. DoE incentives to do so. (Action: deans of engineering, Engineers Australia, UA, DoE, OCS)

Structural measures for long term improvement:

5. Introduce an undergraduate scholarship scheme for students studying mathematics or statistics. This scheme should contain a component intended for students who wish to study the discipline but have been unable to access advanced mathematics subjects at year 12. The scholarships should be extendable into a postgraduate teaching qualification. (Action: DoE, State governments, UA)
6. HECS-free places in those first year university subjects designed to bridge mathematically under-prepared students into programs requiring mathematics and statistics. (Action: DoE, UA)

Priority C Measures

1. Set 3, 5, and 10 year targets for the number of girls participating in advanced mathematics subjects in secondary school, and women participating in mathematics subjects at university. (Action: DoE, State governments, UA)
2. Implement a nationwide awareness campaign to help female students, their parents, teachers and potential employers as well as the general public understand the value of mathematics in career choice and personal and national prosperity. The key messages are around equity of participation, innovation and prosperity for the nation (increased GDP) and accessing an untapped pool of graduates. (Action: DoE, DoI, ESA, State governments, research agencies, UA, teacher associations, AIG, BCA, AAS, ATSE, AMSI, OCS, AustMS, SSAI)
3. Address directly the shortage of teachers in secondary schools by enticing the oversupply of biology graduates into the mathematics subjects at university that will equip them with the mathematics required to teach. Since these graduates are predominantly women, some understanding of strategies for increasing participation of women will be necessary at university/lecturer level. A second strategy is to entice existing biology teachers to up their skills with a mathematics qualification (Action: DoE, deans of science, deans of education, UA).

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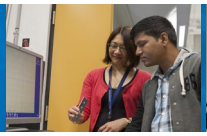

4. Develop a national strategy aimed at retaining and promoting women in STEM academia and identify structural impediments preventing female career progression. Use the Athena SWAN model (UK) to set national standards and undertake a nationwide audit of STEM departments measured against key statistics. Expect university STEM departments to achieve minimum standards, setting 1, 3, 5 and 10-year targets. (Action: AAS, UA, AustMS (WiM), AMSI, DoE, DoI, SSAI)
5. Introduce targeted measures to increase the retention of female students from mathematical sciences undergraduate study to honours, masters and PhD—build national networks through established events and the Women in Mathematics Group. Introduce initiatives to specifically engage and support female students in the mathematical sciences - PhD scholarships, travel scholarships, access to childcare. (Action: DoE, DoI, AAS, AustMS (WiM), AMSI, SSAI)

Further measures to address the shortage of research-trained graduates

1. Provide a dedicated allocation of Australian Postgraduate Awards (APAs) in mathematics and statistics to the universities to improve retention from honours and masters programs. Incentives for universities which provide such a dedicated allocation from their own award program. Especially important in smaller and regional universities. (Action: DoE, UA, deans of science)
2. Targeted HECS-free places for honours and equivalent in mathematics and statistics to improve retention into PhD programs. Only effective for those continuing to higher study. (Action: DoE, UA)
3. Provide a stipend top-up on APAs to improve retention from honours and masters programs. This is particularly important in statistics where employment demand is severely reducing retention. (Action: DoE, UA)
4. Re-weight the funding of PhDs in mathematics and statistics to match those in the physical sciences. (Action: DoE, UA, deans of science)

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May 2014

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List of abbreviations

AAS	Australian Academy of Science
AITSL	Australian Institute of Teaching and School Leadership
AMSI	Australian Mathematical Sciences Institute
APA	Australian Postgraduate Award
AIG	Australian Industry Group
ATSE	Academy of Technological Sciences and Engineering
AustMS	Australian Mathematical Society
BCA	Business Council of Australia
DoC	Department of Communications
DoE	Department of Education
DoI	Department of Industry
ESA	Education Services Australia
GPA	Grade Point Average
HECS	Higher Education Contributions Scheme
OECD	Organisation for Economic Co-operation and Development
OCS	Office of the Chief Scientist
SCSEEC	Standing Council on School Education and Early Childhood
SES	Socioeconomic status
SSAI	Statistical Society of Australia Incorporated
STEM	Science, Technology, Engineering and Mathematics
UA	Universities Australia
WiM	Women in Mathematics

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