Submission to the

Senate Inquiry: Teaching and learning – maximizing our investment in Australian schools

from the
Australian Mathematical Sciences Institute

October 2012

Preamble and context

This submission is being made by the Australian Mathematical Sciences Institute in our role as national advocate for our membership, which includes almost all Australian university mathematics and statistics departments, the Australian Mathematical Society, CSIRO, ABS, BoM and the Australian Mathematics Trust. (www.amsi.org.au)

Context

The greatest single challenge to the health of the mathematical sciences in Australia is the long term decline in enrolments in calculus-based mathematics subjects, often referred to as *intermediate or advanced*, at year 12[1]. This decline is both a consequence and a cause of

- Widespread tertiary course realignments to cope with increasing numbers of less mathematically literate students,
- These subjects not being taught in many rural, regional, remote and low SES areas,
- Reduced graduation rates in the mathematical sciences and stagnating interest in engineering and sciences courses,
- Reduced intake into teacher training programs (primary and secondary) of mathematically qualified graduates,
- Reduced numbers of qualified secondary school teachers teaching at all levels, especially in rural, regional, remote and low SES areas, leading to fewer students in calculus-based mathematics subjects at Year 12,
- A significant reduction of the number of institutions offering mathematics and statistics majors with a consequent reduction in staffing.

[1] Barrington, F. (2012). *2011 Year 12 mathematics student numbers.*

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This decline creates a structural impediment to meeting Australia's galloping demand for mathematics and statistics graduates[2] and it puts a brake on the national productivity growth enjoyed by other OECD countries which have no such impediment and where mathematics and statistics graduate levels are, on average, two and a half times higher than those in Australia.

In order for Australia to remain competitive internationally it is crucial to have a skilled workforce that meets demand. The 2011 Research Workforce Study commissioned by DIISR[3] identifies an increase in demand for PhDs in mathematics and statistics of around 55% to 2020 and that the projected growth is supply is zero, while the 2008 Australian Council for Educational Research[4] identifies current shortages in supply of people with quantitative skills in mathematics and statistics. The pipeline problems for mathematics in Australia are entrenched. For example, in 2003 OECD figures showed that only 0.4% of Australian university students graduated with qualifications in mathematics or statistics, compared with the OECD average of 1%.[5]

Australia does not have a full complement of qualified secondary mathematics teachers, nor do we have sufficient numbers of qualified scientists, engineers and mathematicians to help us grow and innovate as a nation.[6] Study after study has pointed to the need for well-qualified teachers. These studies are best summed up by McKinsey and Company: "the quality of an education system cannot exceed the quality of its teachers".[7]

The national strategic importance of our discipline is recognized by government, by the Chief Scientist and by leaders in the field:

"A nation that cannot turn out top-notch mathematicians and statisticians is a nation in deep trouble. Unless we turn around the trends that have bedeviled this discipline over the last decade or so – in schools, in universities and in research – we will not be able to meet our needs for people with a sound knowledge of mathematics." [8]

Kim Carr, 14 Feb 2008

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[2] Department of Innovation, Industry, Science and Research (2011). *Research Workforce Case Study*.
[3] Ibid.
[4] Edwards, Daniel and Smith, T Fred, (2008) *Supply, demand and approaches to employment by people with postgraduate research qualifications in science and mathematics: Final Report*
[5] Ainley, J., Kos, J., & Nicholas, M. (2008). *Participation in science, mathematics and technology in Australian education.* ACER Research Monographs, 4.
[6] Edwards, Daniel and Smith, T Fred, (2008) *Supply, demand and approaches to employment by people with postgraduate research qualifications in science and mathematics: Final Report* [Available: http://research.acer.edu.au/higher_education/9]
Forgasz, H. J. (2006). *Australian Year 12 mathematics enrolments: Patterns and trends past-present.*
Education and Training Committee, Parliament of Victoria (2006). *Inquiry into the Promotion of Mathematics and Science Education.* Government of Victoria.
[7] McKinsey & Company (2007). *How the world's best-performing school systems come out on top.*
[8] Carr, K. (2008) 'Enhancing the quality of the experiences of post-docs and early career researchers'. Address to the Academy of Science

"Good things won't just happen because we are Australian. They will happen because of robust debate, our foresight and hard work – and our deliberate efforts to build the Australia we want – for us all. And we can't do that without first class science, technology, engineering and mathematics." [9] Ian Chubb, 23 May 2012

"A fundamental mathematical education for all of our citizens, founded on the basics, is a crucial ingredient for our future prosperity." [10]

Brian Schmidt, 8 Feb 2012

The 'Making Mathematics Count' report prepared by Professor Adrian Smith in 2004 also found that the number of qualified mathematics teachers was on the decline in the United Kingdom, that teachers were getting older and not being replaced and that fewer students were doing serious mathematics.[11] Recommendations from this report have begun to be implemented and very significant progress has been made. The key to the improvement was the appointment of a government advisor on mathematics and the appointment of an expert committee to guide policy development. These policies included "golden hello" for new teachers, measures to increase enrolments in advanced school mathematics and at university.

In the United States there are similar symptoms. The National Mathematics Advisory Panel implores education departments to address these same issues and recommends a streamlined approach to curriculum in primary and junior secondary mathematics, with clearly outlined topics being taught by knowledgeable and effective teachers.[12]

There is evidence to show that well-constructed careers programs that target the importance of mathematics to the community can be very effective. An early example of this was the 'Maths Multiplies Your Choices' campaign in Victoria in the late 1980s.[13] The program asked parents not to pigeonhole their daughters and was remarkably successful in improving girls' participation in mathematics.[14] More recently, in England, there has been a remarkable turn around in the uptake of mathematics where a component of the strategy to improve participation in mathematics was a well-funded careers awareness project.[15] The success of these schemes is increasingly observed.[16]

Because of the central and fundamental role of mathematics in society and its roots in Australia's schools, the mathematical sciences sector believes that the Senate Inquiry should identify the discipline as one requiring direct and targetted intervention.

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[9] Chubb, I. Address to the National Press Club 23 May 2012

[10] Schmidt, B., Brian Schmidt's mathematical argument. An address to Maths for the Future Forum, Canberra 8 February 2012

[11] Smith, A. (2004). *Making Mathematics Count, The Report of Professor Adrian Smith's Inquiry into Post-14 Mathematics Education.*

[12] National Mathematics Advisory Panel (2008). *Foundations For Success: The Final Report Of The National Mathematics Advisory Panel.*

[13] Government of Victoria (1980). *Maths Multiplies Your Choices.*

[14] Leder, G., & Forgasz, H. (2010). I liked it till Pythagoras: The Public's Views of Mathematics. In B. K. L. Sparrow (Ed.), *Shaping the future of mathematics education (Proceedings of the 33rd annual conference of the Mathematics Education Research Group of Australasia, WA: MERGA).*

[15] Australian Mathematical Sciences Insitute (2010). *Professor Celia Hoyles on Improving Maths in the UK*.

[16] Vasagar, J. (2011). *A-levels boom in maths and science credited to 'Brian Cox effect'*.

This intervention must aim to:

- Increase the number of qualified mathematics teachers and attract new graduates to the profession.
- Raise the content knowledge of secondary teachers teaching mathematics out of field
- Improve the content knowledge of primary teachers
- Add to community knowledge of the benefit of mathematics to Australia through a wide-ranging careers awareness campaign.

The Issues

The Senate Inquiry 'Teaching and learning – Maximising our investment in Australian schools' seeks information on the following issues:
(a) The effectiveness of current classroom practices in assisting children to realise their potential in Australian schools;

(b) The structure and governance of school administration local and central and its impact on teaching and learning;

(c) The influence of family members in supporting the rights of children to receive a quality education;

(d) The adequacy of tools available for teachers to create and maintain an optimal learning environment;

(e) Factors influencing the selection, training, professional development, career progression and retention of teachers in the Australian education system; and

(f) Other related matters.

As a general rule we have responded to the issues above which canvas only discipline-specific issues. We have attempted to restrict ourselves to the issues related to the mathematical sciences. By *mathematical* sciences we mean mathematics and statistics, which is taught in schools as the subject *mathematics*.

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Response

ISSUE A. The effectiveness of current classroom practices in assisting children to realise their potential in Australian schools:

RESPONSE:
Current classroom practices are inadequate. Student results are in decline in mathematics and the number of mathematically able graduates is dropping. Australia has a chronic shortage of suitable qualified mathematics teachers.

Initiatives to improve teaching and learning of mathematics appear not to have addressed these important issues. It is our belief that the practice of placing teachers who are unqualified to teach mathematics in Australian Secondary schools in control of a mathematics class renders that class less than effective. The Productivity Commission puts the number of teachers teaching mathematics in secondary schools who are teaching 'out of field' at between 15 and 25%.[17] Similarly in a primary classroom, a teacher without the capability and confidence in mathematics they need to teach it cannot deliver the mathematics content and pedagogy effectively. Without capable practitioners the effect of classroom interventions (not to mention the expenditure) is wasted.

EVIDENCE:

Student Results
Student results are in decline. The Australian Council for Educational Research found the difference in the PISA mathematical literacy scores between students in the lowest and highest quarters of the distribution of socioeconomic background was 78 points (which is both significant and large). On average Indigenous students had mathematical literacy scores 80 points lower, than that of non-Indigenous students.[18]

An extensive review of international comparisons using the Organisation for Economic Cooperation and Development (OECD) *Programme for International Student Achievement* (PISA), the *Trends in International Mathematics and Science Study* (TIMSS) conducted by the International Association for the Evaluation of Educational Achievement (IEA) and the *National Assessment Program Science Literacy Assessment* (NAP – SL) for Year 6 conducted by the MCEETYA Performance Measurement and Reporting Task Force showed that many students in Australia, as in other countries, complete the compulsory years of school with only minimal levels of mathematical and scientific literacy.[19]

[17] Productivity Commission (2012), *Schools Workforce,* Research Report, Canberra.
[18] Ainley, J., Kos, J., & Nicholas, M. (2008). *Participation in science, mathematics and technology in Australian education.* ACER Research Monographs, 4.
[19] ibid

	PISA Mathematical Literacy			
	2000	2003	2006	2009
New South Wales	540	526	523	512
Victoria	529	511	513	512
Queensland	525	520	519	518
South Australia	526	535	520	509
Western Australia	547	548	531	529
Tasmania	517	507	502	487
Northern Territory	502	496	481	487
Australian Capital Territory	548	548	539	528
Australia	533	524	520	514

Table 1 PISA mathematical literacy scores by jurisdiction

A steady, statistically significant, decline can be seen in the PISA mathematical literacy scores around Australia between 2000 and 2006[20]; Table 1 shows that this trend continued in 2009. This is not the case with the scientific literacy scores which have remained stable over the same period.

Equity in access to mathematical education is also increasingly an issue; the difference in the mathematical literacy scores between students in the lowest and highest quarters of the distribution of socioeconomic background is 78 points (which is both significant and large). On average Indigenous students had mathematical literacy scores 80 points lower, than that of non-Indigenous students.[21]

TIMSS results show that Australian student outcomes have been declining relative to other nations. This is especially true of comparisons with the UK and USA which have similar education systems and workforce profiles. Both countries have problems with under qualified teachers in both primary and secondary schools and problems with supply of teachers at the secondary level. In 2007 a scale average of 500 has replaced the 'all country mean' used previously and this should be noted in the tables below.

	All country mean	Australia	England	USA
1995	485	498	476	476
2003	495	499	531	518
2007#	500	516	541	529

Table 2 Trends in average mathematics scores of fourth-grade students, by country: 1995 to 2007

Year 4 has fewer countries participating and different ages of school commencement could also affect the results. However, the results above indicate that both England and the USA have experienced improvements that have not occurred in Australia.

[20] ibid
[21] ibid

	All country mean	Australia	England	USA
1995*	514	530	506	500
1999**	487	525	496	502
2003***	467	505	498	504
2007****	500	496	513	508

Table 3 Trends in average mathematics scores of fourth-grade students, by country: 1995 to 2007

*Australia statistically higher than England and USA which were not statistically different
**TIMSS repeat – Year 8 only. Australia statistically higher than England and USA which were not statistically different
*** Australia not statistically different to England or USA
**** Australia now statistically below both England and USA

Year 8 has many more countries participating and differences in curriculum and starting ages should have evened out. The decline in country mean (to 2003) is due to the increased participation of poorer nations.

The Number of Mathematics Students

The number of students doing intermediate and advanced mathematics at Year 12 is in serious decline[22] (see figure 1) and in universities across the country there are fewer students undertaking higher levels of mathematics[23].

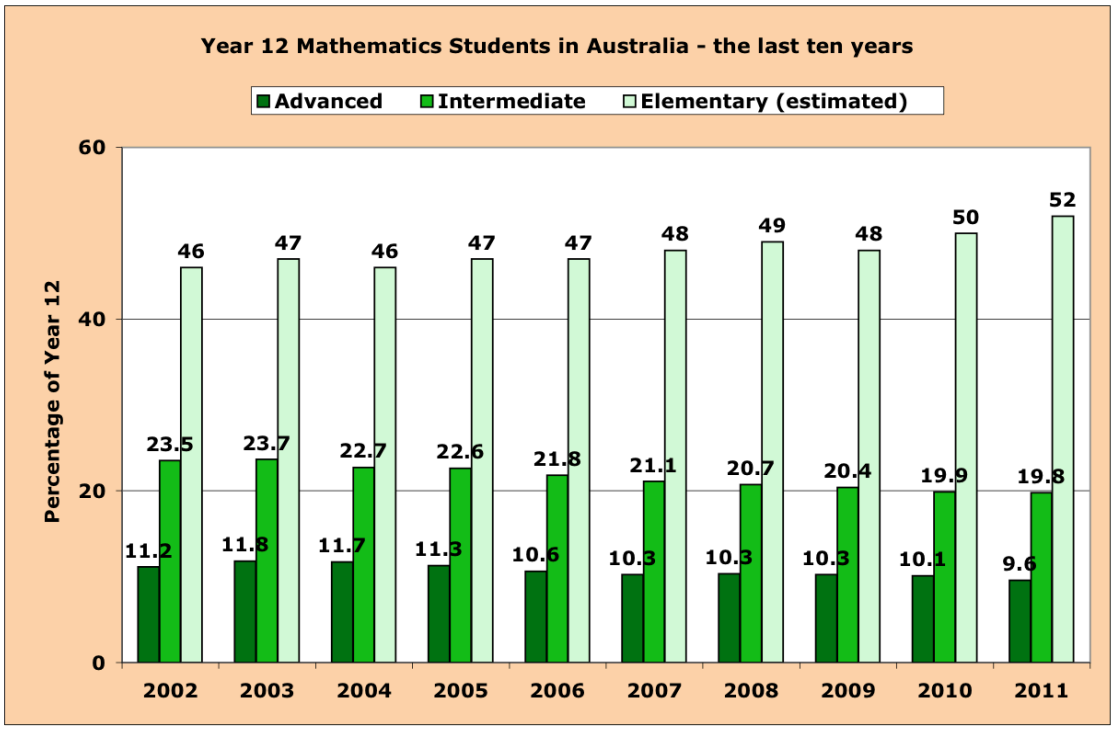

Figure 1: **Participation of Australian Year 12 students in advanced, intermediate and elementary mathematics**

[22] Barrington, F. (2012). *2011 Year 12 mathematics student numbers.*
Australian Mathematical Sciences Insitute (2012). *Discipline profile of the mathematical sciences.* Paper submitted as part of the Forum - Maths for the Future: Keep Australia Competitive, Camberra, February 2012
[23] Rubinstein, H. (2009). *A National Strategy for Mathematical Sciences in Australia.* Melbourne: Australian Council of Heads of Mathematics.

The number of schools able to provide advanced mathematics subjects at Years 11 and 12 is steadily declining and with this the number of students studying advanced mathematics. Without qualified mathematics teachers there will not be the supply of students studying mathematics and statistics at the tertiary level.

The Number of Teachers

The number of students choosing mathematics teaching as a career is also diminishing each year.[24] With less qualified secondary mathematics teachers available, more and more teachers with other specialisations and those with primary teaching qualifications are being asked to teach mathematics in secondary schools.[25] These teachers may have varying degrees of understanding of mathematics and are often not comfortable with their teaching of the subject. This downward spiral must be halted.

In some rural, regional and remote areas mathematics classes are not offered at the higher level, diminishing student access to the subjects and further reducing the potential pool of mathematics teachers, mathematicians and mathematically capable professionals. The Victorian Auditor General found that vacancies were extremely hard to fill in regional schools as shown in table 4.

	Average applications per vacancy (number)			Vacancies with no appointment made (per cent)		
Vacancy type	Metro	Non-metro	State	Metro	Non-metro	State
Science teacher	18.4	8.1	**14.9**	8.5	11.8	**9.6**
Mathematics teacher	21.9	10.8	**17.2**	7.9	24.5	**14.8**
Dual science and mathematics teacher	29.3	12.2	**22.4**	8.1	15.1	**10.9**
Other disciplines	28.2	12.7	**23.4**	5.2	7.5	**5.9**

Source: Victorian Auditor-General's Office analysis of Department of Education and Early Childhood Development data.

Table 4 Average number of applications for science and mathematics teacher vacancies and percentage of vacancies with no appointment[26]

The Australian Council of Deans of Science[27] found that schools in more remote regions struggled to recruit qualified mathematics teachers, finding that this was a particular challenge for Queensland schools. We have included a summary of the Deans of Science report which gives a profile of the profession (see Appendix 1).

[24] Australian Council of Deans of Science. (2006). *The preparation of mathematics teachers in Australia: Meeting the demand for suitably qualified mathematics teachers in secondary schools.* Australian Council of Deans of Science. Joshi, N. (2008, 02 18). *A Disturbing Set of Numbers*.

[25] Education and Training Committee, Parliament of Victoria. (2006). *Inquiry into the Promotion of Mathematics and Science Education.* Government of Victoria.

[26] Victoria. Auditor-General. (2012). Science and mathematics participation rates and initiatives. Melbourne: Victorian Government Printer

[27] Australian Council of Deans of Science (2006). *The Preparation of Mathematics Teachers in Australia*: *Meeting the demand for suitably qualified mathematics teachers in secondary schools.*

In the immediate term we should explore the UK success in forming clusters of disadvantaged schools and grouping students wishing to study higher mathematics to form viable class sizes.[28] This may ensure some equity in student access to the higher-level mathematics.

Teacher Quality

It is recognised that the biggest classroom-based influence on the learning outcomes for a student in an Australian school is the discipline specific knowledge of their teacher. This is particularly true of mathematics, where a capable teacher can engage and enthuse students and encourage them to make the most of their capabilities and interests.

> *"There is one aspect of teacher quality where a consensus across studies has clearly emerged: the effects of teachers with degrees in maths and appropriate certifications [in maths teaching] ... appear to be strongly and consistently related to student achievement in mathematics ... Similar findings were not apparent for other subjects ... [Teacher] experience [also] matters, but it contributes differentially only in the first four or five years of teaching."*[29]

A teacher who is qualified to teach mathematics can do more to influence student's perception of the subject than a teacher who is not.[30] This in turn has the potential to increase student participation rates in mathematics and increase interest in mathematics teaching as a career. To quote the findings of the National Comprehensive Center for Teacher Quality in the USA:

> *"Teachers of mathematics who stay up-to-date with their field and engage in learning for their own understanding are more able to cater to the needs and abilities of the students in their classes. They are more flexible in their teaching approach and more likely to lead their students to a broad understanding of mathematics and help students to develop the ability to apply learning in a variety of situations."* [31]

The Australian Council of Deans of Science report[32] found that eight percent of mathematics teachers had studied no mathematics at university. One in five teachers had not studied mathematics beyond first year, including 23 percent of junior-school teachers. Many teachers had studied no mathematics teaching methods, including one

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[28] Mathematics Promotions Unit (2010). *Trends in Mathematics Education 2000-2010*.
[29] Goe, L. (2007). *The Link Between Teacher Quality and Student Outcomes: A Research Synthesis*.
[30] Australian Association of Mathematics Teachers (2008) Maths, Why Not?
[31] Ma, L. (1999). *Knowing and teaching elementary mathematics : teachers' understanding of fundamental mathematics in China and the United States.* Mahwah, NJ: Lawrence Erlbaum Associates.
Darling-Hammond, L., & Ball, D. L. (1998). *Teaching for high standards: What policymakers need to know and be able to do.* Philadelphia: University of Pennsylvania, Consortium for Policy Research in Education.
Cady, J., Meier, S. L., & Lubinski, C. A. (2006). Developing mathematics teachers: The transition from preservice to experienced teacher. *Journal of Educational Research, 99*, 295-306.
[32] Australian Council of Deans of Science (2006). *The Preparation of Mathematics Teachers in Australia: Meeting the demand for suitably qualified mathematics teachers in secondary schools.*

third of those who taught only junior or middle school. The report also found that one in four senior-school teachers lacked a mathematics major, including 17 percent of teachers of senior school mathematics at intermediate and advanced levels.

The Victorian Auditor General found that

> *DEECD has no data on the number of science and mathematics teachers needed or employed in schools and no data on their qualifications, experience and training needs. Therefore, it cannot develop evidence-based workforce strategies or reliably monitor and evaluate its initiatives. This seriously compromises the future supply of science and mathematics skills and knowledge in the community.*[33]

In summary, recent classroom practices, funded at great expense, have done little to reverse the decline in numbers of students willing and able to take on the demands of mathematics for a range of careers. Some serious investigation of what works and what does not is needed, supported by an awareness campaign to help students, their parents and teachers see the value of mathematics in arrange of careers and everyday life applications.

ISSUE B. The structure and governance of school administration local and central and its impact on teaching and learning:

Increased school autonomy may lead to employment practices that would threaten some disciplines. For example, a principal may choose not to employ a mathematics or English specialist in order to increase staffing flexibility.

ISSUE C. The influence of family members in supporting the rights of children to receive a quality education:

We have no comment to make on this issue.

ISSUE D. The adequacy of tools available for teachers to create and maintain an optimal learning environment:

We have no comment to make on this issue.

[33] Victoria. Auditor-General. (2012). Science and mathematics participation rates and initiatives. Melbourne: Victorian Government Printer

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ISSUE E. Factors influencing the selection, training, professional development, career progression and retention of teachers in the Australian education system:

There is currently no national data on secondary mathematics teacher graduation rates, nor is data collected about qualifications, age profile and length of service statistics for those teaching mathematics in Australian schools. This is required to assess the full magnitude of the problem. Two of the six recommendation from the 2012 Victorian Auditor General's report into science and mathematics initiatives point to a need for improved data collection so that decisions might be based on hard evidence:

> *"The Department of Education and Early Childhood Development should:*
> *1. establish relevant and appropriate performance measures for science and mathematics education, and obtain the necessary data to measure progress and success*
> *2. complete its workforce data collection framework and collect, maintain, analyse and report on complete, reliable and timely data about science and mathematics teachers, and their qualifications, skills and experience."* [34]

It is AMSI's recommendation that a full audit be put in the hands of a specialist panel which should also advise Australian governments on policy development and implementation. The UK experience in this regard should be examined.[35]

It is generally accepted that there are too few trained secondary mathematics teachers in Australian schools and that the decline in advanced mathematics enrolments in senior secondary schools has both to do with the quality and availability of trained teachers.[36] The national system of accreditation must act as an instrument to improve the Australia's stock of trained secondary mathematics teachers at the same time being cognizant of the short to medium term shortage of suitable graduates.

In Australia the mathematics discipline knowledge of primary school teachers and their exposure to mathematical pedagogical content knowledge is not uniform. Minimum requirements need to be set which transcend the type of pre-service education qualification held by teachers. AITSL's accreditation system should reflect current best practice and rectify the features of some existing programs known to produce under prepared primary teachers.

The key message is that the entire pipeline from primary school through secondary school to tertiary study must be dealt with in order to correct the chronic and acute shortage of mathematics teachers. This is because the shortage of mathematics teachers is perpetuating itself through the degraded experience of students in schools.

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[34] Victoria. Auditor-General. (2012). Science and mathematics participation rates and initiatives. Melbourne: Victorian Government Printer

[35] Mathematics Promotions Unit (2010). *Trends in Mathematics Education 2000-2010.*

[36] Australian Mathematical Sciences Insitute (2012). *Discipline profile of the mathematical sciences.* Paper submitted as part of the Forum - Maths for the Future: Keep Australia Competitive, Camberra, February 2012

Marketing the profession

Unlike many professions with dedicated undergraduate qualifications, such as law and medicine, secondary teacher training is undertaken at postgraduate level through a postgraduate diploma. This creates very real marketing problems and the means of engaging prospective teachers at the very beginning of their tertiary education must be identified and applied nationally.

The role of pre-service training providers in directing aspiring secondary teachers into areas of teacher shortage is inadequate. This is because there is almost no direct advice given to undergraduates about subject choice and its relation to discipline studies in pedagogy in the diploma year. Australian governments may choose to offer scholarships/studentships for undergraduate student teachers in which case the identification comes naturally. This recommendation was made by AMSI in a submission to the Higher Education Base Funding Review.[37]

The international experience of schemes such as Teach for Australia have been positive, but these schemes have not had the same impact in Australia due to low volumes. In our opinion the funds would be better used in mathematics by developing a national and scalable program for increasing the content knowledge of those teaching out of field.

Secondary Teacher training

As with many professional qualifications a coherent route to becoming a secondary mathematics teacher must be obvious when entering university.

Currently there is no connect between a science undergraduate degree and a diploma of education; ideally students should be able to register for a four-year program when they begin study. For example, in Victoria many biology undergraduates are unaware that taking one quarter of their first year and a quarter of their second year in mathematics and statistics will allow them to take mathematics teaching method in Dip. Ed. and hence allow them to teach mathematics. This will certainly radically improve their job prospects given the relative surplus of biology/science teachers. Education faculties also need to build links with mathematics and statistics departments to promote this career path. Undoubtedly national leadership will be needed to ensure that this happens.

AMSI's vision for pre-service training standards was laid out in our recent submission to AITSL[38] and is reproduced in the box on page 14.

We believe that the proposed introduction of mandatory two year postgraduate pre-placement training for secondary teachers by AITSL will have a significant detrimental impact on supply. We have not seen evidence that the duration of the current one-

[37] Australian Mathematical Sciences Insitute (2011). *Submission to the Higher Education Base Funding Review.*
[38] Australian Mathematical Sciences Institute (2010). *Submission to the AITSL proposal National system for the accreditation of pre-service teacher education programs.*

year diplomas is inadequate. This view is supported by the Productivity Commission:

> *"…extending the minimum required length of graduate-entry teacher training to at least two years should not be mandated, due to the lack of evidence regarding the benefits and potential drawbacks. Such a stance is supported by reviews conducted by the OECD (2005) and the Victorian Parliamentary Education and Training Committee (VPETC 2005), which given the costs and the uncertain benefits, considered that it would be better to spend resources on professional development than by extending pre-service training."*[39]

Pre-service Primary Teacher Training

In primary schools, whilst there are many good teachers of mathematics, there are a significant number of teachers who are weak mathematically or who do not have confidence in their own mathematical abilities. There have been many attempts to make changes to this situation through curriculum and pedagogy modifications. [40] Primary teachers are often not required to come into University with a high level of competence in mathematics. A 2005 AMSI survey of university websites indicated that only 4 of 31 universities surveyed stated that they required Year 12 mathematics of any type as a pre-requisite. Only 8 indicated that they required Year 11 mathematics. The remaining 19 did not have any mathematics as an entry requirement or had not specified requirements on their course information websites.

Minimum requirements need to be set which transcend the type of pre-service education qualification held by teachers. The Australian Institute for Teaching and School Leadership (AITSL) accreditation system should reflect current best practice and rectify the features of some existing programs known to produce under prepared primary teachers. AMSI's vision for pre-service training standards was laid out in our recent submission to AITSL[41] and is reproduced in the box on the next page.

[39] Productivity Commission (2012), *Schools Workforce,* Research Report, Canberra.
[40] Education and Training Committee, Parliament of Victoria. (2006). *Inquiry into the Promotion of Mathematics and Science Education.* Government of Victoria.
[41] Australian Mathematical Sciences Institute (2010). *Submission to the AITSL proposal National system for the accreditation of pre-service teacher education programs.*

AMSI's Vision for pre-service training standards

1. Secondary teaching

In order to teach year 11 & 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 a 3+1 year degree plus graduate diploma combination.

This requirement will place significant pressures on the supply of mathematics graduates and should be phased in over five years with a significant recruitment effort by governments.

In order to teach secondary mathematics to year 10 graduates of pre- service programs must have at least two subjects at first year and two subjects at second year in mathematics and statistics including at least one statistics subject and at least one second-year mathematics subject.

2. Primary teaching

Pre-service programs should be four or five years in length. It is our view that the combination of an undergraduate degree containing no mathematics or statistics with a one-year graduate diploma in primary teaching is generally not viable because it is not possible to teach the required mathematical pedagogical content knowledge in a one-year graduate diploma. Preferential entry into graduate diplomas should be given to applicants with qualifications involving English, mathematics, science and ICT.

We concentrate here on the four-year undergraduate program commonly identified as a bachelor of (primary) education. Conventional entry from year 12 must require a 70% percentile score in any year 12 mathematics subject or equivalent. "Equivalent" here means that at the end of the first year of the program the student must have passed the compulsory mathematics content subjects in the program (see below). This means that the effective entry requirement is satisfactory completion of non-terminating year 11 mathematics subjects.

The four-year program itself must contain two 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 three subjects of mathematics pedagogical content knowledge.

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Professional development

Observations and insights gained by AMSI during the delivery of the *ICE-EM Mathematics* program since 2005 and the BlueScope/AMSI program in 2007-09 indicate that a teacher professional development program based on the following factors were regarded as successful by teachers and school administrators

- Collaborative development of carefully prepared whole of school plans,
- Observation and feedback about current practice,
- Developing teacher content knowledge and
- Understanding of the curriculum.

This is supported by Hattie's meta-analysis of research related to achievement in education[42] and by work done at Mid-Continent Research for Education and Learning (McRel)[43] showing that both content and pedagogical content knowledge are needed to enhance teachers' ability to influence student learning for the better.

Teachers teaching 'out of field' in secondary schools require special and focused support to teach mathematics.[44] It is imperative that a program of professional development be introduced to bring these teachers 'up to speed'.

There is strong anecdotal evidence that very few primary and secondary school teachers, including mathematics and careers teachers, know much about mathematics in its research and application context. In particular there is wide ignorance about the use of mathematics and statistics by professionals.[45] Professional development is urgently required for both mathematics and careers teachers that helps them understand the mathematics needed in a variety of careers.

Retention

It is important to consider the highly competitive nature of the global market for some discipline areas. The mean starting salary of a mathematics or statistics three-year graduate is about $50,000 meaning that good graduates in high demand areas can attract a starting salary of about four times this.

Contract duration is also an issue for graduating mathematics teachers; one-year contracts are singularly unattractive.

The UK measures to address mathematics teacher shortages show that problem disciplines must be treated as special cases in order to address supply issues. Evidence from the UK experience indicates that changes to the level and structure of remuneration are effective.[46]

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[42] Hattie, J. (2009). *Visible learning; A synthesis of over 800 meta-analyses relating to achievement.* London: Routledge.

[43] Mid-Continent Research for Education and Learning (2010). *What we know about mathematics teaching and learning.* Bloomington, IN: Solution Tree Press.

[44] Council of Australian Governments (COAG). (2008). *National Numeracy Review.*

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As the number of mathematicians graduating from university does not meet the demand for mathematicians in the workforce starting salaries for graduate mathematicians continue to increase. Salaries for mathematics teachers must be competitive and there must be clear career paths. The "golden hello" initiative in the UK should be examined. Scholarships from year one for undergraduate students majoring in the mathematical sciences and going on to secondary diplomas in education should be developed by Australian governments. There is support from the Productivity Commission for differentiated remuneration for hard to staff areas:

> *The Australian, state and territory governments, as part of broader efforts to encourage greater and more explicit variation in teachers' pay on the basis of shortages, should encourage the trialling of measures that enable principals — under appropriate circumstances — to use explicit remuneration-based incentives for attracting suitably qualified teachers into hard-to-staff positions.*[47]

Recommendations:

- The creation of a nationally coordinated scholarship/studentship scheme for undergraduates taking a mathematical sciences major and intending to become secondary teachers of mathematics.
- The creation of a nationally coordinated scheme to qualify as mathematics teachers the many secondary teachers teaching mathematics out of field.
- Nationally coordinated measures, with enrolment targets, to increase participation in intermediate and advanced mathematics subjects at year 12.
- The retention of single year postgraduate diplomas in education.
- Nationally agreed minimum standards for mathematics content knowledge in the pre-placement training of primary school teachers.
- A full audit of the qualifications, age profile and length of service statistics of those teaching mathematics in Australian schools be conducted by a specialist panel which should also advise Australian governments on policy development and implementation.

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Appendix 1

The 2006 Australian Council of Deans of Science report on the preparation of mathematics teachers in Australia found worrying trends for mathematics teachers in the salient features and trends within the teaching workforce

Incidence of undersupply

- Three in four schools reported difficulties recruiting suitably qualified mathematics teachers. Schools received numerous applications for advertised positions but few applicants had the necessary mathematics background to teach mathematics, particularly at senior school level.
- Schools in more remote regions reported the greatest difficulty. Among the large eastern states, recruitment was a particular challenge for Queensland schools.
- The shortage of available mathematics teachers was seen as a relatively recent and growing problem, predicted to worsen as experienced teachers retire in coming years.

Rising age profile

- The average age of mathematics teachers was 44 years, with a median age of 46 years. Thirty-eight per cent of teachers were at least 50 of age, and 15 per cent were 55 or older.
- Mathematics teachers from government schools were older than their colleagues in the non-government sector. Teachers in Catholic schools were youngest, with a median age of 43 years. Two thirds of the mathematics teachers had more than ten years experience, and 18 per cent
- Had been teaching for more than 30 years. There were also a large number of early career teachers – 17 per cent of teachers had been teaching for fewer than five years.
- Teachers of junior school mathematics were, on average, younger and less experienced than their colleagues.
- Teachers of advanced senior mathematics are most likely to be male, highly experienced and among the least likely to teach non-mathematics subjects.

Increasing portion of teaching staff positions filled by women.

- Male teachers were less motivated by enthusiasm for the discipline, and more by issues of salary and job security, than their female colleagues.

Declining remuneration relative to many other professions.

- Three in five teachers gave the ‘rewarding nature of the profession’ as motivation for choosing a teaching career. Nearly half cited their ‘love of mathematics’, with far fewer teachers reporting ‘salary’ as a motivation.
- Fewer than half the teachers surveyed were confident that they would be teaching mathematics in five years time. Sixteen per cent stated that they would be leaving teaching, and another 39 per cent were undecided.
- Most of the teachers committed to continue teaching had at least ten years teaching experience, and 40 per cent had been teaching for at least twenty-

seven years. This group included nearly equal numbers of men and women, and 40 per cent were between the ages of 40 and 50 years.

- Of the 452 teachers committed to leaving teaching within five years, the majority were at least 50 years of age, experienced teachers and male. More than half stated they were retiring, and another seven per cent explained that they were moving to another profession.
- The youngest teachers expressed the greatest levels of uncertainty about their plans for five years time.

Relatively flat pay scales.

- While salary was not a major factor in their own decision to become teachers, half the teachers surveyed stated that salary improvements were needed in order to attract new people to mathematics teaching as a career. This was a view shared by heads of mathematics departments.
- Scholarships for trainee teachers were suggested by many teachers, while heads called for improved pre-service training and mentoring for early-career teachers.
- Male teachers were less motivated by enthusiasm for the discipline, and more by issues of salary and job security, than their female colleagues.

Shift in employment to the non-government sector.

- Other issues identified in the supply of mathematics teachers indicate that this is likely to be a particular issue for qualified mathematics teachers.