Submission to the

Productivity Commission Schools Workforce enquiry

from the
Australian Mathematical Sciences Institute

August 2011

Preamble and context statement

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

As a general rule we have avoided making responses to questions in the issues paper which canvas non discipline-specific issues. We have attempted to restrict ourselves to the teacher workforce in the mathematical sciences.

By *mathematical* sciences we mean mathematics and statistics which is taught in schools as the subject *mathematics*.

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 regional 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 of mathematically qualified graduates,

[1] Barrington, F. (2010). *Updated Year 12 mathematics figures.*

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- reduced numbers of qualified secondary school teachers teaching at all levels, especially in regional 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.

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.

The national strategic importance of our discipline is recognized by government, for example:

"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"

Kim Carr, 14 Feb 2008

The discipline itself actively pursues programs in both schools and universities, supported by government funding, to turn this situation around. Indeed AMSI's very existence is a result of this determination on our part.

Because of the central and fundamental role of the teaching of mathematics in Australia's schools the mathematical sciences sector believes that the Productivity Commission should be cognizant of this situation and identify the discipline as one requiring direct and specific intervention by Australian governments.

[2] Department of Innovation, Industry, Science and Research (2011). *Research Workforce Case Study*.

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Responses

Overall recommendations

In addition to our responses to the Commission's questions we propose the following measures be recommended by the Productivity Commission:

- The chronic teacher supply problem and the extent of teaching out of field in mathematics require immediate, discipline-specific intervention in a nationally coordinated manner. Ideally this should be part of a program addressing the entire pipeline in mathematics education from primary to tertiary and to research training.

- 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.

- Nationally agreed targets for the school leadership of secondary mathematics by graduates with a major study in the mathematical sciences and a mathematics pedagogy study.

- 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.

Responses to the issues paper

2 About the sector

2.1 The schools workforce

Q 2.1 What other features of the current schools workforce and its changing context are important from a policy perspective?

Response part (a): ***The paucity of tertiary qualifications of mathematics teachers***
The Issues Paper identifies persistent undersupply in some areas as a significant feature of the workforce and this is certainly the case in mathematics. It is worth

identifying the features of the mathematics workforce which result from this undersupply.

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.[3]

The Australian Council of Deans of Science report[4] found that eight per cent of mathematics teachers had studied no mathematics at university. One in five teachers had not studied mathematics beyond first year, including 23 per cent of junior school teachers. Many teachers had studied no mathematics teaching methods, including one third of those who taught only junior/middle school.

This will become a bigger issue if steps are not taken to address it, teachers under 30 years of age were significantly less likely than their older colleagues to hold a mathematics major or to have studied mathematics teaching methods.

The report also found that one in four senior school teachers lacked a mathematics major, including 17 per cent of teachers of senior school mathematics at intermediate and advanced levels.

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.[5] 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:

"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."[6]

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

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[3] Australian Council for Educational Research (2008). *Supply, demand and approaches to employment by people with postgraduate research qualifications in science and mathematics*.
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.*
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.

[4] 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.*

[5] Department of Education, Employment and Workplace Relations (2008). *Maths? Why Not?*

[6] Goe, L. (2007). *The Link Between Teacher Quality and Student Outcomes: A Research Synthesis*.

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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.[7]

Response part (b): ***Lack of quality discipline leadership in schools***
With such a significant and increasing amount of teaching out of discipline, it is crucial that each secondary school have an experienced, teacher-trained mathematics graduate acting as discipline leader. Unfortunately this is not the case.

Historically through raised starting salaries and studentships, mathematics teachers with honours or masters qualifications in mathematics were not uncommon and typically had a clear career path to discipline leadership in secondary schools. In addition these graduates typically specialised in mathematics pedagogy in their teacher training year. The lack of incentives and the pressure to teach in more than one discipline has had a serious retrograde impact. *There needs to be a clear employment strategy to ensure that students training to be mathematics teachers have the incentive to complete further study.*

3 Why is the performance of the schools workforce important?

3.1 Student outcomes

Q 3.1.1 What does the available evidence indicate about Australia's education outcomes? How policy relevant are comparisons of literacy and numeracy over time and across countries?

Response: ***PISA and TIMMS***
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.[8]

[7] 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.
[8] Australian Council for Educational Research (2008). *Participation in Science, Mathematics and Technology in Australian Education.*

Table 1: PISA mathematical literacy scores by jurisdiction

	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

A steady, statistically significant, decline can be seen in the PISA mathematical literacy scores around Australia between 2000 and 2006[9], 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.[10]

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 underqualified 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.

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

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

[9] Australian Council for Educational Research (2008). *Participation in Science, Mathematics and Technology in Australian Education.*
[10] ibid

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.

Australia now in group statistically below both England and USA

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

	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

*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.

While it would be brave to immediately relate these outcomes to the 15-year decline in intermediate and advanced mathematics enrolments in year 12[11] , it is a conjecture worth making. Should it be established the policy consequences are significant because of it would connect pipeline issues all the way through to PhD supply with the deterioration in mathematics performance of Australian school students.

Q 3.1.2 Which avenues for reform are most promising for reducing educational disadvantage and improving education outcomes more generally? How important are workforce-related changes relative to other initiatives directed at enhancing children's learning potential?

3.2 Workforce issues

Q3.2.1 What are the strengths and weaknesses of current workforce arrangements? What are the priority areas for policy attention?

Q3.2.2 Are major changes required to address shortcomings, or would gains be better achieved through fine-tuning of existing policy settings?

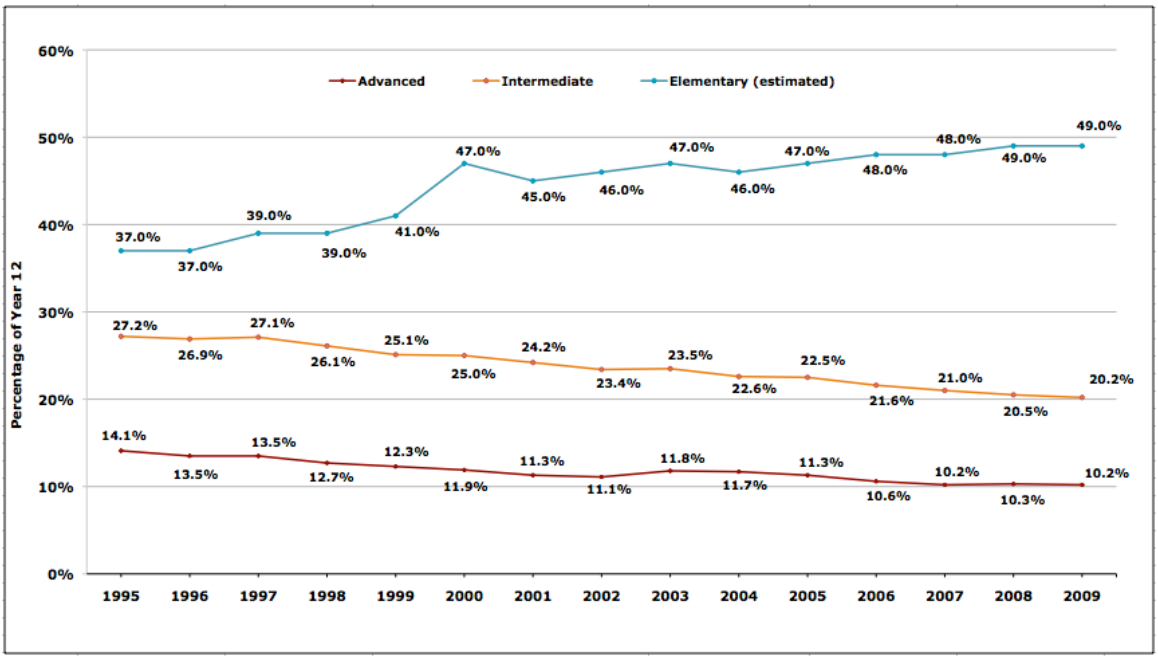
[11] Barrington, F. (2010). *Updated Year 12 mathematics figures.*

Combined Response

Preamble

The number of students doing mathematics at Year 12 is declining[12] and in universities across the country there are fewer students undertaking higher levels of mathematics[13] (see figure 1). As a result, the number of students choosing mathematics teaching as a career is diminishing each year.[14] 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.[15] These teachers may have varying degrees of understanding of mathematics and are often not entirely comfortable with their teaching of the subject. This downward spiral must be halted.

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



The chronic shortage of qualified mathematics teachers in Australia is well-known.[16] We have included a summary of results from the Deans of Science report which give a

[12] Group of Eight (2009). *Review of Education in Mathematics, Data Science and Quantitative Discipline*. Barrington, F. (2005). *Comparison of Year 12 Pre-tertiary Mathematics Subjects in Australia 2004-2005.* International Centre of Excellence for Education in Mathematics.

[13] Rubinstein, H. (2009). *A National Strategy for Mathematical Sciences in Australia.* Melbourne: Australian Council of Heads of Mathematics.

[14] 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*.

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

[16] Forgasz, H. J. (2006). *Australian Year 12 mathematics enrolments: Patterns and trends past-present.* Australian Council of Deans of Science (2006). *The Preparation of Mathematics Teachers in Australia: Meeting the*

profile of profession (Appendix 1). Clearly past and current schools and workforce arrangements are failing to address this shortage. The strategic implications of this failure are dire.

In order for Australia to remain competitive internationally it is crucial to have a skilled workforce that meets demands. The 2011 Research Workforce Study commissioned by DIISR[17] 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 report[18] identifies current shortages in supply of people with quantitative skills in mathematics and statistics. The pipeline problems for mathematics in Australia are notoriously 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%.[19]

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.[20] Without qualified mathematics teachers there will not be the supply of students in a position to continue studying mathematics and statistics at the tertiary level let alone increase this number to meet growth demands.

Study after study has pointed to the need for well-qualified teachers. These studies are best summed up by the report from McKinsey & Company[21] that stated: "the quality of an education system cannot exceed the quality of its teachers".

The imbalance in the discipline background of graduating secondary teachers compared with the time in the curriculum, the extent of teaching out of field, insufficient graduates in mathematical disciplines, lack of competency testing of entering primary teachers and lack of mathematical content in primary courses are just some of the issues which require direct intervention by Australian governments.

Conclusion: *Mathematics must be identified as a special case.*

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demand for suitably qualified mathematics teachers in secondary schools.
Education and Training Committee, Parliament of Victoria. (2006). *Inquiry into the Promotion of Mathematics and Science Education.* Government of Victoria.

[17] Department of Innovation, Industry, Science and Research (2011). *Research Workforce Case Study*.

[18] Australian Council for Educational Research (2008). *Supply, demand and approaches to employment by people with postgraduate research qualifications in science and mathematics*.

[19] Australian Council for Educational Research (2008). *Participation in Science, Mathematics and Technology in Australian Education.*

[20] Barrington, F. (2010). *Updated Year 12 mathematics figures.*

[21] McKinsey & Company (2007). *How the world's best-performing school systems come out on top.*

International policy directions

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.[22] 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.[23]

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.[24] The program asked parents not to pigeonhole their daughters and was remarkably successful in improving girls' participation in mathematics.[25] 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.[26] The success of these schemes is increasingly observed.[27]

AMSI recommends the following strategic measures specific to the teaching workforce in mathematics.

a) Training of 'out of field' teachers

Teachers teaching 'out of field' require special and focused support to teach mathematics.[28] It is imperative that a program of professional development be introduced.

Observations and insights gained during the delivery of the *ICE-EM Mathematics*[29] program since 2005 and the BlueScope/AMSI program in 2007-09 indicate that a

[22] Smith, A. (2004). *Making Mathematics Count, The Report of Professor Adrian Smith's Inquiry into Post-14 Mathematics Education.*
[23] National Mathematics Advisory Panel (2008). *Foundations For Success: The Final Report Of The National Mathematics Advisory Panel.*
[24] Government of Victoria (1980). *Maths Multiplies Your Choices.*
[25] 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).*
[26] Australian Mathematical Sciences Insitute (2010). *Professor Celia Hoyles on Improving Maths in the UK*.
[27] Vasagar, J. (2011). *A-levels boom in maths and science credited to 'Brian Cox effect'*.
[28] Council of Australian Governments (COAG). (2008). *National Numeracy Review.*

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[30] and supported by work done at Mid-Continent Research for Education and Learning (McRel)[31] showing that both content and pedagogical content knowledge are needed to enhance teachers' ability to influence student learning for the better.

b) Incentives for further study

As previously discussed, there is no incentive for intending secondary mathematics teachers to study beyond a three-year undergraduate degree prior to a teacher training year. Incentives must be introduced to encourage intending mathematics teachers to continue their study of mathematics beyond undergraduate level in order to guarantee future discipline leadership in schools.

c) Raising the bar on teacher training

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.[32] 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.
A move to two year postgraduate pre-placement training for secondary teachers will only exacerbate the shortage of mathematics teachers.

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.[33] There have been many attempts to make changes to this situation through curriculum and pedagogy modifications.[34] 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

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[29] www.ice-em.org.au

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

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

[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.*
Forgasz, H. J. (2006). *Australian Year 12 mathematics enrolments: Patterns and trends past-present.* Melbourne: Australian Mathematical Sciences Institute.
Education and Training Committee, Parliament of Victoria. (2006). *Inquiry into the Promotion of Mathematics and Science Education.* Government of Victoria.

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

[34] ibid

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's (AITSL) accreditation system should reflect current best practice and rectify the features of some existing programs which are known to produce under prepared primary teachers. AMSI's vision for pre-service training standards was laid out in our recent submission to AITSL[35] and is reproduced in the box below.

d) Financial incentives for mathematics teachers

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.

e) Marketing the profession

Unlike many professions with dedicated undergraduate qualifications, such as law and medicine, secondary teacher training is normally 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.

[35] Australian Mathematical Sciences Institute (2011). *Submission to the AITSL proposal National system for the accreditation of pre-service teacher education programs.*

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AMSI's Vision for pre-service training standards[36]

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 as part of a 3+1 year degree plus graduate diploma-type 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. The education year requirements are as for year 11 and 12 already outlined above.

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.

[36] Australian Mathematical Sciences Institute (2011). *Submission to the AITSL proposal National system for the accreditation of pre-service teacher education programs.*

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4 Recent policy developments

The introduction of a national curriculum is a very positive step, however implementation has been devolved to states, effectively obstructing any national PD programs to assist with the roll out of the curriculum. The Improving Mathematics Education in Schools (TIMES) project[37], delivered by AMSI for DEEWR, was very successful in improving teacher effectiveness in a number of states and now cannot be funded as the funds have been passed to the States as part of the National Partnership Agreements.

Q 4.1 Do the reforms, in train or in prospect, address the right issues?

Response
The reforms fail to address the shortage of mathematics teachers and lack of students continuing to study higher-level mathematics. This is because they are too broad ranging to deal with the very discipline specific issues in mathematics which we have referred to in the previous section.

The recognition of the importance of high standards for teachers of mathematics was a key finding of the National Numeracy Review[38]. This review made some recommendations that informed the TIMES Project

- Students need to be exposed to higher-order mathematical problems.
- Implementation of this requires well-trained, mathematically able teachers.
- Teachers need professional development that focuses on mathematics content knowledge.
- The development of links between schools, education systems and universities is key to enhancing overall expectations of students and teachers.
- Teachers teaching 'out of field' require special and focused support to teach mathematics.

The current NPA arrangements make it impossible for a national body such as AMSI to continue to be involved in the delivery of these measures because it does not have the resources to engage with the State jurisdictions.

Q 4.2 What reform areas should be afforded the highest priorities?

Q 4.3 Are there any significant gaps in the reform agenda, or reforms that are unlikely to be particularly beneficial?

Combined Response
AMSI can only make a limited judgement on this matter, but we do believe that the addressing the workforce issues in mathematics must rank amongst the highest priorities.

[37] http://www.amsi.org.au/school-education/times-project
[38] Council of Australian Governments (COAG). (2008). *National Numeracy Review.*

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- Increase the number of qualified mathematics teachers
- Raise the content knowledge of those teaching mathematics out of field
- Ensure a supply of qualified discipline leaders
- Attract new graduates to the profession

Q 4.4 In the context of the current reform initiatives outlined above, where can the Commission's study into the schools workforce best add value?

Response
A strong recommendation from the committee for a comprehensive profile of mathematics teaching in Australia to be constructed and the installation of a national committee to develop policy and advise on its implementation.

5 Further improvements in schools workforce outcomes

5.1 Balancing supply and demand

Q 5.1.1 What are the key factors, whether across the board or specific to particular areas, that may contribute to current or future workforce shortages? Are all of these factors amenable to policy action?

Response
We have already identified a number of these in earlier sections but 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.

We also 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 year diplomas is inadequate.

Q 5.1.2 Are there weaknesses in specific recruitment and/or retention strategies that could be exacerbating imbalances in supply and demand? Are there any underlying problems in workforce planning strategies?

Response
Yes to both questions. The evidence of continued shortages points to the failure of current strategies.

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Q 5.1.3 What lessons, if any, can be learned from other sectors of the economy in dealing with the staffing challenges in the schools sector?

Response
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. 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. Of course 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 on behalf of the mathematical sciences in their submission to the Higher Education Base Funding Review.[39]

It is our strong recommendation that the UK experience[40] since 2004 be closely examined for pipeline measures which might be undertaken in Australia.

5.3 Training and professional development

Q 5.3.1 What are the advantages and disadvantages of the traditional Diploma and Bachelor of Education entry pathways? Do postgraduate studies in education contribute significantly to teacher quality?

Response
Diploma of Education (secondary)
As discussed previously, there is a disconnect between the three-year degree and the one-year diploma of education, it is difficult for students to identify a pathway to teaching. As previously discussed we oppose an increase in the duration of the length of the teaching qualification.

Diploma of Education (primary)
As above, and in addition entry to many one-year primary diplomas is solely based on a grade point average regardless of undergraduate degree area whereas discipline should clearly be considered (eg maths over marketing).

Bachelor of Education – Primary
In line with the Australian Curriculum in Mathematics, a national standard for mathematics content in the BEd must be developed. See the detail from our AITSL submission presented earlier.

[39] Australian Mathematical Sciences Insitute (2011). *Submission to the Higher Education Base Funding Review.*
[40] Mathematics Promotions Unit (2010). *Trends in Mathematics Education 2000-2010.*

Q 5.3.2 How effectively do pre-service training courses (and the national accreditation standards for such courses) meet the current and prospective needs of the education system and teachers?

Response
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. 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 which are known to produce under prepared primary teachers.

Q 5.3.3 To what extent are employment-based pathways a complement to standard teaching courses? Are such pathways likely to be of a niche nature, or might they have wider applicability in the future?

Response
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.

Q 5.3.4 Is sufficient attention paid to professional development — not only for classroom teachers, but also principals and other school workers? What specific changes, beyond those already in prospect, would be appropriate?

Response
No, 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.[41]

Professional development is urgently required for both mathematics and careers teachers in this area.

We have already discussed the importance of professional development for those teaching mathematics out of field and for primary teachers.

[41] Department of Education, Employment and Workplace Relations (2008). *Maths? Why Not?*

Q 5.3.5 What role do pre-service training providers play in directing aspiring teachers into areas of teacher shortage?

Response
The role of pre-service training providers in directing aspiring secondary teachers into areas of teacher shortage is insufficient. 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. 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. The difficulties lie with the 3+1 system and the inability of education and science faculties to work together.

5.4 Remuneration and performance evaluation.

Q 5.4.1 How important are the level and structure of remuneration for recruitment and retention of teachers? What impact does the level of remuneration have on the capabilities of those entering the teaching profession? Should differentiated remuneration be used more widely to address imbalances in supply and demand?

Response
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.[42]

Q 5.4.2 If a well-designed performance-based pay scheme could be implemented, would it significantly enhance teacher quality and student outcomes? What risks and costs are associated with performance-based pay?

Response
A scheme such as this will have little impact on mathematics outcomes as it does not address the critical issue of the chronic shortage of mathematics teachers.

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

5.5 School leadership

Q5.5.1 Has sufficient policy attention been paid to school leadership and its contribution to education outcomes?

Response
No, as we pointed out earlier the simple observation that widespread teaching out of field in mathematics makes high quality discipline leadership in schools an imperative does not seem to have been made. The public system must return to offering incentives for honours graduates and postgraduates to enter the profession.

5.6 School autonomy

Q 5.6.1 What are the advantages and disadvantages of increasing school autonomy? To what extent can currently centralised responsibilities be sensibly devolved to the school level? What lessons can be learned from approaches in Victoria and other countries, as well as from experiences in independent schools?

Response
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.

Q 5.6.2 What specific governance and regulatory arrangements are needed to support greater school autonomy?

Response
Clear rules should be in place regarding discipline teaching. Minimum standards must be set, for example the number of discipline specialists, etc.

5.7 Meeting the needs of particular student populations

Q 5.7.1 How effective is the current suite of workforce-related initiatives to address educational disadvantage?

Response
Current workforce-related initiatives to address educational disadvantage in mathematics are not effective. More qualified mathematics teachers are required to ensure that all students have equal access to mathematical training.

The Australian Council of Deans of Science[43] found that schools in more remote regions struggled to recruit qualified mathematics teachers, finding that recruitment was a particular challenge for Queensland schools

[43] 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.*

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.[44]

Q 5.7.2 Should the goal of such policies be greater equality in education outcomes or greater equality of opportunity for all students to realise their educational potential? Does the choice between these two alternatives have implications for the nature of the schools workforce policies that should be employed to address educational disadvantage?

Response
We don't understand the question because we don't see these as being alternatives. However, Australia is not a third world country and we should aspire to achieving both.

Q 5.7.3 Are all student groups that are experiencing significant educational disadvantage being given suitable recognition in the current workforce policy framework? Are current measures of socioeconomic status adequate?

Response
No. The Australian Council of Deans of Science[45] found that no real measures have been taken to provide all school students equal access to mathematics.

Q 5.7.4 Are there workforce changes that would assist disadvantaged students make a successful transition from school to work or further education?

Response
The obvious answer is more discipline trained teachers in mathematics. 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.[46] This ensures some equity in student access to the higher-level mathematics.

5.8 The surrounding institutional framework

Q 5.8.1 How responsive is the overall institutional regime to changing circumstances? Is the established culture and practice within education departments and related regulatory agencies, as well as in government and non-government schools, an impediment to workforce reform?

[44] Australian Council for Educational Research (2008). *Participation in Science, Mathematics and Technology in Australian Education*.
[45] 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.*
[46] Mathematics Promotions Unit (2010). *Trends in Mathematics Education 2000-2010.*

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Response
Jurisdictional secrecy about the quality of school mathematics education has hampered remediation of the discipline's problems. The chronic shortage of mathematics teachers shows that the institutional regime has not been successfully responsive.

Q 5.8.2 Does the policy interface between the Australian Government and State and Territory Governments pose challenges for effective schools workforce reform?

Response
Yes. Under the current arrangements it is not possible for a national professional development program to be administered by third parties, such as AMSI, as most funding has been devolved to state level through the NPAs.

Without national assistance it will be difficult to ensure that the National Curriculum standards are met in all states.

Q 5.8.3 What effect will initiatives such as national accreditation and registration requirements, and the introduction of a national curriculum, have on the schools workforce and its capacity to meet the needs of students, parents and the community?

Response
Initiatives such as national accreditation and registration requirements, and the introduction of a national curriculum will only have impact if these standards are set no lower than the highest of the existing State standards. In addition, the Commonwealth must ensure that the States support their teachers and coordinate the repopulation of the mathematics teaching profession.

Q 5.8.4 Is there an adequate focus on the evaluation of programs (including the dissemination of evaluation results), and a readiness to adjust programs if evidence indicates that improvements can be achieved?

Response
No, if this was the case the serious shortage of mathematics teachers would not persist.

Q 5.8.5 Are there particular information and data gaps, either in collection or dissemination, that impede good decision making in education policy? Are the current institutional arrangements for undertaking research on schools workforce policy, and on education policy more generally, adequate? If not, how might they be improved?

Response
There is currently no national data on the qualifications, age profile and length of service statistics of those teaching mathematics in Australian schools, this is required to assess the full magnitude of the problem. It is our recommendation that a full audit be put in the hands of a specialist committee which should also advise Australian

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governments on policy development and implementation. The UK experience in this regard should be examined.[47]

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Figure 1: Barrington, F. (2010). *Updated Year 12 mathematics figures.* Available online: http://www.amsi.org.au/publications/amsi-publications/123-updated-year-12-mathematics-figures

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.