AMSI
AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

July 31, 2015

Response to "Vision for a Science Nation" from the Australian Mathematical Sciences Institute

The Australian Mathematical Sciences Institute congratulates the Chief Scientist and the Ministers for Industry and Science and Education and Training on their resolve to create a genuine STEM plan for Australia.

As a nation we face very considerable structural challenges in all four of the areas addressed in the Chief Scientist's important document "Science, Technology, Engineering and Mathematics: Australia's Future". Many of these have arisen over a long period, almost by accident, because we haven't had a global and strategic plan. Continuing without a plan is therefore not an option.

AMSI, in consultation with its members, has prepared a response to the discussion document, an overall summary of which is attached. Detailed responses under each of the four headings have been submitted online.

We look forward to the developments which will take place over the next months and we hope to be able to make a positive contribution to them.

There is a lot at stake in the realisation of the Chief Scientist's vision and it has our strongest support.

Yours sincerely,

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EXPLANATION OF RESPONSE STRUCTURE

This submission responds to the call from the Department of Industry and Science for further input in relation to the Australian Government's Consultation Paper, "Vision for a Science Nation. Responding to Science, Technology, Engineering and Mathematics: Australia's Future" (June 2015). The Paper can be found here - http://science.gov.au/scienceGov/news/Documents/VisionForAScienceNationRespondingToSTEMAustraliasFuture.pdf

This Consultation Paper is, in itself, in response to the Chief Scientist's proposal, "Science, Technology, Engineering and Mathematics: Australia's Future" (Sept 2014). The Proposal can be found here - http://www.chiefscientist.gov.au/wp-content/uploads/STEM_AustraliasFuture_Sept2014_Web.pdf

The input request focused on the four areas addressed in the Consultation Paper – Australian Competitiveness, Education and Training, Research, and International – and specific questions related to each area.

This submission includes AMSI's overall response to the Consultation Paper followed by responses to each of the four focus areas by addressing the questions raised by the Department.

OVERALL RESPONSE

Do these proposals adequately respond to the Chief Scientist's recommendations – both now and over the longer term?

An overall plan connecting all 4 components with 5 year targets out to 2030 with bipartisan support and clear ownership is the only way to ensure that the proposals will adequately respond to the Chief Scientist's recommendations.

The success of such a plan will depend heavily on the ability of successive governments to plan beyond the election cycle and to avoid the proliferation of disconnected and short term programs.

In general, we find that many of the proposals, and some of the Chief Scientist's recommendations themselves, are quite general and require refinement before their fitness for purpose can be assessed.

We do identify a disconnect between the competitiveness and the education and training components, both in the recommendations and the proposals. To be specific

innovation and entrepreneurship need to figure at a cultural level in Australia's school system, including the training and professional development of teachers.

We do also believe that there are some critical gaps, we have addressed these in the next section.

Do you consider there are any areas that require more urgent action? Have we missed anything?

Adult numeracy. Adult numeracy in Australia has to be part of the STEM agenda and it is absent from this document.

While our performance is close (but lower) than the international average, we can't be happy about this. In particular, women are far less numerate than men and this is clearly unacceptable. Mathematical illiteracy must be regarded as disabling.

Teaching out of field. The document does not explicitly identify this key issue.
The current pathway from school education through to research and innovation through to public and private sector outcomes has a number of major obstructions. These have to be worked on simultaneously and not sequentially. Unfortunately, the times scales for each intervention are different. One of the most persistent and critical obstructions is the shortage of a trained teacher workforce both in secondary and primary schools. For example, nearly 40% of year 7-10 maths classes are not taught by a trained maths teacher! The time scale over which this will be repaired is at least a decade. This a blocker to significant progress on the other obstructions and needs to be dealt with comprehensively and urgently.

Cross promotion opportunities. We suggest that the following proposals be included. The role of STEM in Australia's past, present and future, that is, Australia as a STEM nation, should be identified across the Australian Curriculum and not just in the STEM subjects.

While it is critical that the school mathematics curriculum identify real world contexts where appropriate and relevant, the importance of mathematical studies should be made clear to school students and their parents in their other STEM studies. This would make it clear that science, engineering and technology subjects will use mathematics and statistics in tertiary studies and beyond. Often the question of relevance seems to be addressed solely by requiring the inclusion of additional topics in the mathematics curriculum.

Prerequisites. The document does not explicitly identify this key issue.
The undergraduate supply problem caused by the pervasive lack of prerequisites for entry to science and engineering courses is another major blocker. Fixing this problem will repair some of the imbalance in maths, physics and chemistry enrolments at Year 12, limit ATAR gaming and give some measure of protection to the future supply of STEM graduates by ensuring adequate preparation of incoming students. Phased re-introduction of prerequisites will take some time and has to be matched to

improvement in the teacher cohort and changes in community attitudes. Prerequisites do send an unequivocal message to school communities that universities value these subjects.

Research careers. The document does not directly address the strategic management of the enormous volume of research carried out by academics who do not hold research grants.

A very significant part of the publically funded research in mathematics and statistics is carried out by teaching-and-research staff at Australian universities. The current research funding environment excludes many of them and makes them and our research enterprise vulnerable, especially outside the Go8. Australia is one of few countries in the OECD and in our region without a publicly supported national research institute in the mathematical sciences. These institutes have a proven track record of inclusive support of mathematical sciences research of the highest quality. Proposals around research excellence are needed for all workers, not just those in research only positions.

Communication. The document does not address the marked absence of genuine engagement between the STEM community and the mainstream media.

It is our view that the science and science communication community have failed to effectively engage with Australia's mainstream media (medical science excepted). Setting up stand-alone events and channels for science communication is not a substitute for becoming accepted by the mainstream press as part of Australian culture. The "Gee Wizz!" treatment of science marginalises the STEM community and we must deal with this issue in a strategic fashion from both sides of the gulf. Proposals are needed here.

International engagement. The proposals pay insufficient attention to making Australia an attractive international public and private research destination.

We need more international companies to set up research labs in Australia. The current proposals are mainly about Australia reaching out to other countries but we also need to get other countries and their companies reaching out to Australia.

Research in the mathematical sciences is an international enterprise. The document contains some excellent proposals on how to progress our international research engagement, an area which has been neglected for a decade. We are concerned that many of these proposals may constrain international collaborations by placing too much emphasis on focussed investment in specific geographic and discipline areas. Australia needs to be agile in responding to the international engagement programs of other countries. For example, if scientists in the EU wish to engage with workers here on quality projects for mutual benefit and can bring funds to the table we need to be able to reciprocate even if the area is not identified by Australia for international collaboration. This agility will attract international attention.

Which of these proposals will have the greatest impact on Australia's STEM performance?

A comprehensive plan. The implementation of a comprehensive STEM plan of itself will have the greatest impact. Absence of a plan along with piecemeal measures has put us where we are today.

School education measures. Declining enrolments and performance must surely be driven largely by factors internal to the education system. Competitiveness and research are both built on the foundation of school education and so the proposals in this area, along with those needed to fill the gaps we have identified above, must be effective and primary drivers of change.

Private sector employment of STEM Graduates. The proposals which lift both the employment of STEM graduates in the commercial sector and which boost collaboration between the private and public sectors. These proposals have to include both push and pull mechanisms at both ends of the education and career paths.

Long term planning for research. This is fundamental but we suggest refining the 2 year review process. It may be more effective to have headline priorities and developing priorities. Taken at face value, changing research priorities on a time scale less than the length of a PhD seems unwise.

Basic and Applied Research. The proposals which sustain Australia's capacity for basic research across the STEM spectrum in the public system but also reward collaboration with the private sector. The ERA regime is skewed toward scholarly research but we must not be careful to skew a broader system the other way.

International engagement. The mathematical sciences are intrinsically international so proposals which encourage this will have a significant positive impact upon us. However, it is because mathematics knows no national boundaries that too much geographical targeting of engagement will be counterproductive. An agile system of incentives will optimise outcomes.

Which of these proposals will enable you and your organisation to contribute to Australia's STEM performance?

AMSI's mission is:
The radical improvement of mathematical sciences capacity and capability in the Australian community through:
• the support of high quality mathematics education for all young Australians
• improving the supply of mathematically well-prepared students entering tertiary education by direct involvement with schools
• the support of mathematical sciences research and its applications including cross-disciplinary areas and public and private sectors

• *the enhancement of the undergraduate and postgraduate experience of students in the mathematical sciences and related disciplines*

So there is very close alignment of "Vision for a Science Nation" and AMSI's mission.

In particular, the proposals around integrating STEM experts across sectors and building an entrepreneurial culture as part of the university experience will strengthen our efforts, through AMSI Intern, our research training program and our career awareness program, to increase penetration of our graduates into the business sector and to build a vibrant private mathematical sciences research sector in areas such as data science, optimisation and computational mathematics.

Proposals to lift the number of STEM-qualified teachers and to have mathematicians involved in pre-service training of teachers, especially primary teachers, will also have a major impact on our mission to provide equity in the quality of mathematics education. However, the final plan must address out of field teaching and university prerequisites to be viable. In school education AMSI is active in policy development, teacher professional development, community awareness and gender balance and curriculum design. Strong leadership from the Commonwealth on school STEM education will significantly boost our efforts and their impact.

Proposals supporting research careers are fundamental for the mathematical sciences, particularly for women because of the current gender imbalance. The challenge will be to create measures of impact which reward success outside of scholarly publication while continuing to reward success for scholarship. This is particularly important in the mathematical sciences which span a spectrum from applied to theoretical research. AMSI's research, research training and gender balance programs will be more effective with clear policy and funding directions in this area.

Proposals which boost the commercial returns from publically funded research will align and support AMSI's own PhD Industry Intern program, AMSI Intern, which places PhD students, mentored by the academic supervisors, into research projects in the private (and public) sector. Such proposals will also enable AMSI to take further research and research training initiatives directed to industry engagement such as BioInfoSummer which engages the biomedical sector.

Proposals which build and reward international engagement are of great value to the mathematical sciences and to AMSI in particular which supports 20 research workshops annually, all of which bring significant international workers to Australia, seeding and sustaining international collaborations.

Prepared for AMSI in consultation with its membership by

Professor Geoff Prince
AMSI Director

CONSULTATION QUESTIONS

Section 1: Australian Competitiveness

Do these proposals adequately respond to the Chief Scientist's recommendations – both now and over the longer term?

In general, we find that many of the proposals, and some of the Chief Scientist's recommendations themselves, are quite general and require refinement before their fitness for purpose can be assessed.

Proposals to boost the STEM research capacity of the private sector through employment of specialists and engagement with universities and agencies must be based on very careful research in order to be effective. The stark differences between, for example, the UK and Australia which share low private sector employment of researchers but very different levels of collaboration with public researchers must be carefully analysed in order to inform policy.

Do you consider there are any areas that require more urgent action? Have we missed anything?

We do identify a disconnect between the competitiveness and the education and training components, both in the recommendations and the proposals. To be specific innovation and entrepreneurship need to figure at a cultural level in Australia's school system, including the training and professional development of teachers.

Which of these proposals will have the greatest impact on Australia's STEM performance?

Private sector employment of STEM Graduates. The proposals which lift both the employment of STEM graduates in the commercial sector and which boost collaboration between the private and public sectors. These proposals have to include both push and pull mechanisms at both ends of the education and career paths. Commercialisation programs embedded in university research training programs along with research internships will be particularly effective.

Which of these proposals will enable you and your organisation to contribute to Australia's STEM performance?

In particular, the proposals around integrating STEM experts across sectors and building an entrepreneurial culture as part of the university experience will strengthen our efforts, through AMSI Intern, our research training program and our career awareness program, to increase penetration of our graduates into the business sector and to build a vibrant private mathematical sciences research sector in areas such as data science, optimisation and computational mathematics.

Section 2: Education and Training

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In general, we find that many of the proposals, and some of the Chief Scientist's recommendations themselves, are quite general and require refinement before their fitness for purpose can be assessed.
However, we do argue below that the Chief Scientist's recommendations in this category miss some vital issues.

Do you consider there are any areas that require more urgent action? Have we missed anything?

Competitiveness. We do identify a disconnect between the competitiveness and the education and training components, both in the recommendations and the proposals. To be specific innovation and entrepreneurship need to figure at a cultural level in Australia's school system, including the training and professional development of teachers.

Adult numeracy. Adult numeracy in Australia has to be part of the STEM agenda and it is absent from this document.

While our performance is close (but lower) than the international average, we can't be happy about this. In particular, women are far less numerate than men and this is clearly unacceptable. Mathematical illiteracy must be regarded as disabling.

Teaching out of field. The document does not explicitly identify this key, urgent issue. The current pathway from school education through to research and innovation through to public and private sector outcomes has a number of major obstructions. These have to be worked on simultaneously and not sequentially. Unfortunately, the times scales for each intervention are different. One of the most persistent and critical obstructions is the shortage of a trained teacher workforce both in secondary and primary schools. For example, nearly 40% of year 7-10 maths classes are not taught by a trained maths teacher! The time scale over which this will be repaired is at least a decade. This a blocker to significant progress on the other obstructions and needs to be dealt with comprehensively and urgently.

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improvement in the teacher cohort and changes in community attitudes. Prerequisites do send an unequivocal message to school communities that universities value these subjects.

Which of these proposals will have the greatest impact on Australia's STEM performance?

Declining enrolments and performance must surely be driven largely by factors internal to the education system. Competitiveness and research are both built on the foundation of school education and so the proposals in this area, along with those needed to fill the gaps we have identified above, must be effective and primary drivers of change.

Urgent measures to put adequately trained and inspiring teachers in front of every secondary STEM class will have the greatest impact. Similarly, urgent measures to improve the mathematical and scientific competency of primary teachers are necessary to ensure the long term heath of the STEM pipeline.

Raising the participation of girls in STEM study pathways will take considerable time and coordinated effort. This will not only improve the size and quality of the STEM workforce but it will lift female adult numeracy which currently lags well behind that of Australian males. Mathematical illiteracy should be recognised as disabling.

Which of these proposals will enable you and your organisation to contribute to Australia's STEM performance?

Proposals to lift the number of STEM-qualified teachers and to have mathematicians involved in pre-service training of teachers, especially primary teachers, will have a major impact on our mission to provide equity in the quality of mathematics education. However, the final plan must address out of field teaching and university prerequisites to be viable. In school education AMSI is active in policy development, teacher professional development, community awareness and gender balance and curriculum design. Strong leadership from the Commonwealth on school STEM education will significantly boost our efforts and their impact.

Section 3: Research

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Research careers. The document does not directly address the strategic management of the enormous volume of research carried out by academics who do not hold research grants.

A very significant part of the publically funded research in mathematics and statistics is carried out by teaching-and-research staff at Australian universities. The current research funding environment excludes many of them and makes them and our research enterprise vulnerable, especially outside the Go8. Australia is one of few countries in the OECD and in our region without a publically supported national research institute. These institutes have a proven track record of inclusive support of mathematical sciences research of the highest quality. Proposals are needed here.
We also propose that the ARC undertake a review of the effectiveness of small grant schemes elsewhere with a view to possible implementation alongside its current programs. Many in the mathematical sciences believe that such schemes are cost effective in boosting research outputs.

Communication. The document does not address the marked absence of genuine engagement between the STEM community and the mainstream media.
It is our view that the science and science communication community have failed to effectively engage with Australia's mainstream media (medical science excepted). Setting up stand-alone events and channels for science communication is not a substitute for becoming accepted by the mainstream press as part of Australian culture. The "Gee Wizz!" treatment of science marginalises the STEM community and we must deal with this issue in a strategic fashion from both sides of the gulf. Proposals are needed here.

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Which of these proposals will enable you and your organisation to contribute to Australia's STEM performance?

Proposals supporting research careers are fundamental for the mathematical sciences, particularly for women because of the current gender imbalance. The challenge will be to create measures of impact which reward success outside of scholarly publication while continuing to reward success for scholarship. This is particularly important in the mathematical sciences which span a spectrum from applied to theoretical research. AMSI's research, research training and gender balance programs will be more effective with clear policy and funding directions in this area.

Proposals which boost the commercial returns from publicly funded research will align and support AMSI's own PhD Industry Intern program, AMSI Intern, which places PhD students, mentored by the academic supervisors, into research projects in the private (and public) sector. Such proposals will also enable AMSI to take further research and research training initiatives directed to industry engagement such as BioInfoSummer which engages the biomedical sector.

Section 4: International Engagement

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However, we do argue below that the Chief Scientist's recommendations in this category miss some important issues.

Do you consider there are any areas that require more urgent action? Have we missed anything?

International engagement. The proposals pay insufficient attention to making Australia an attractive international public and private research destination.

We need more international companies to set up research labs in Australia. The current proposals are mainly about Australia reaching out to other countries but we also need to get other countries and their companies reaching out to Australia.

Research in the mathematical sciences is an international enterprise. The document contains some excellent proposals on how to progress our international research engagement, an area which has been neglected for a decade. We are concerned that many of these proposals may constrain international collaborations by placing too much emphasis on focussed investment in specific geographic and discipline areas. Australia needs to be agile in responding to the international engagement programs of other countries. For example, if scientists in the EU wish to engage with workers here on quality projects for mutual benefit and can bring funds to the table we need to be able to reciprocate even if the area is not identified by Australia for international collaboration. This agility will attract international attention.

The European Union's IRSES program is an example. The failure of Australia to have a functioning International Linkages program reduced the ability of Australian researchers to participate with European and other international partners in this scheme. While the proposals identify more government to government linkages, in this case they weren't required, just a targeted scheme on our side. Proposals are needed here.

Research Centres. Australia is one of few countries in the OECD and in our region without a publicly supported national mathematical sciences research institute. These institutes have a proven track record of inclusive support of mathematical sciences research of the highest quality. Importantly, they are a principal vehicle for international collaboration. AMSI and its membership along with other partners are in the process of establishing such a centre and the proposals need to accommodate

initiatives of this type which fall outside the ARC's remit but produce the highest quality outcomes and international engagement.

Which of these proposals will have the greatest impact on Australia's STEM performance?

The mathematical sciences are intrinsically international so proposals which encourage this will have a significant positive impact upon us. However, it is because mathematics knows no national boundaries that too much geographical targeting of engagement will be counterproductive. An agile system of incentives will optimise outcomes.

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Proposals which build and reward international engagement are of great value to the mathematical sciences and to AMSI in particular which supports 20 research workshops annually, all of which bring significant international workers to Australia, seeding and sustaining international collaborations.