AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

19 October, 2018

Dr Sandra Gardam
Project Manager – Women in STEM Decadal Plan
Science Policy and Projects
Australian Academy of Science

Dear Dr Gardam,

The Australian Mathematical Sciences Institute (AMSI) welcomes this opportunity to respond the Women in STEM Decadal Plan.

As the national advocate for the mathematical sciences, AMSI has a significant body of policy recommendations and submissions concerning female participation in STEM, the mathematical sciences in particular, which we invite you to review. These documents can be found on our website at https://amsi.org.au/publications_category/publications/

Australia's mathematical sciences pipeline is critical to strategic planning of the national innovation system, underpinning as it does our STEM capacity. But it does far more than support science, it is a direct and crucial contributor to a world so dependent on data acquisition, data analysis, data security, and simulation.

While our discipline has a strong record in individual research and in research training, the pipeline has some major challenges. Significant among these challenges is the under representation of women at all levels; from high school mathematics subjects to university courses and the workforce.

Mathematics is in dire shape in our schooling system with declining number of students studying intermediate and advanced maths at Year 12, the almost complete absence of university mathematics prerequisites for STEM degrees, significant gender imbalance and the worst out of field teaching problem in the OECD. AMSI has been working for some time to address these imbalances, and in 2015 began a 5-year program, with the support of BHP, to invest $22M in initiatives designed to engage more girls and young women with the discipline.

It is the firm view of the discipline, represented by AMSI that we must strategically invest now in women in the mathematical sciences at a whole-of-system level to achieve equity and diversity targets.

We thank you for the opportunity to make a submission to the very important work of the Women in STEM Decadal Plan.

Yours sincerely,

Professor Geoff Prince
AMSI Director

Women in STEM Decadal Plan

AMSI Submission
October 2017

Introduction

AMSI welcomes the opportunity to contribute to the Decadal Plan for Women in STEM. As the leading advocate for the Mathematical Sciences in Australia, and champion of increasing the female participation in mathematics and statistics at every level, we consider the development of this Decadal Plan an important step in the desired direction.

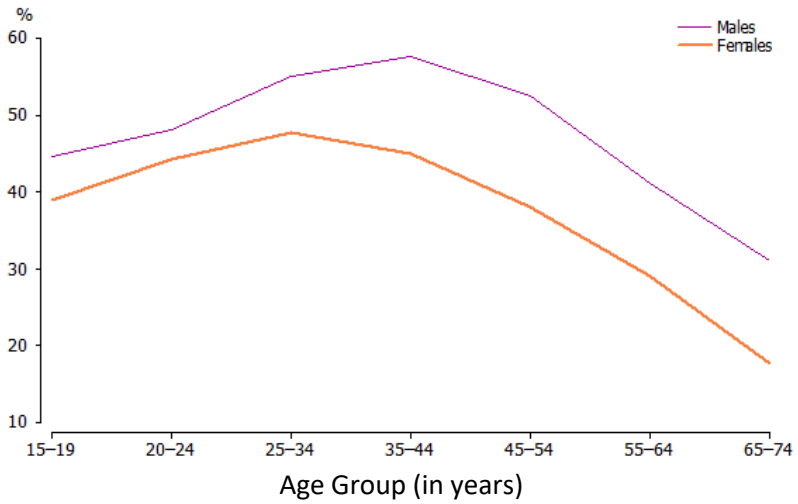
Below we outline our experience in the field, and formulate key recommendations for a substantial, sustainable and long-lasting improvement of the gender balance in STEM. We acknowledge that many issues that have an impact on the participation of women in STEM are of a societal nature. AMSI does not profess to have expertise in social and family policy, and therefore we restrict our responses to issues concerning mathematics, mathematics education and the impact of gender on participation rates in both of these.

This submission includes a number of recommendations which form part of AMSI's existing platform of policy recommendations. For a full overview of AMSI's policy positions and strategies we refer to (https://amsi.org.au/publications/improving-australias-maths-grades/) which outlines our key priorities for the radical improvement of mathematical capacity in Australia.

Key Points in this Submission

We have lived with low female participation rates in mathematics for too long. As a consequence, female adult numeracy is below that of males, by around 30 per cent in some age groups[1]. While we often think of mathematics as an enabling discipline the flip side is more important: mathematical illiteracy is disabling. An egalitarian society like ours can't tolerate this endemic disadvantage to women. In our view it is a significant underlying impediment to the participation of women in the STEM-based professions.

Proportion at numeracy Level 3 or above, By sex and age group—2011–12



[1] Wienk, M., "Discipline Profile of the Mathematical Sciences". Australian Mathematical Sciences Institute 2017. Figure 3.3, p 44; source: ABS, Programme for the International Assessment of Adult Competencies, Australia, 2011–2012.

It is our considered view that regulatory change is necessary to deliver systemic improvement in female participation in the STEM and other professions. Voluntary campaigns are also fundamental, particularly in bringing about the attitudinal changes needed to support regulation, but they are not of themselves sufficient.

It is also our firm view that wider participation in, and respect for, the STEM disciplines and professions is the platform from which increased female participation will be built.

The road to gender balance starts at school

Too many of our primary school teachers suffer anxiety about their own grasp of mathematics. The insidious impacts of teacher maths anxiety are known but inadequately acknowledged. For example, the influence of female teachers' attitudes on young girls is well documented. In particular, female teachers' apparent or latent maths anxiety affects girls more strongly than boys and is a partial explanation for girls' disengagement with maths—noticeable in the NAPLAN and TIMMS results between Years 3–5 when the performance gap begins. While maths hurdle requirements for entry into primary teaching are welcome, we must ***assist our practising teachers and ensure that our faculties of education are giving higher priority to mathematical preparation*** in pre-placement training.

In secondary school, between 26 and 38 per cent[2] of Year 7 to 10 maths classes don't have a qualified maths teacher, far too high for a subject that is of central importance. The comparable international average is around 12 per cent. This statistic must be repaired as part of our STEM planning as a whole, as it affects the quality of the teaching and turning girls (and boys) off from the mathematical sciences. Recent work by AMSI that it would take 13.5 years to halve out of field teaching if new, maths trained teacher recruitments matched retirements of all teachers of maths, both qualified and out of field. There is only one solution to the immediate problem, and that is to provide professional development to the many conscientious and professional educators teaching maths without the requisite content knowledge. For the longer term, we need to ***attract more undergraduate students to become school teachers in mathematics***. Why aren't prospective teachers, especially women, choosing to be maths teachers? Without an answer to this question we will not be able to secure the future supply of mathematically well-prepared teachers. The socio-economic and gender demographics that supply prospective teachers are unlikely to be well served by school mathematics, with well-resourced schools being less likely to produce future school teachers. This downward spiral must be arrested.

The 20-year free fall in the enrolment share of the Year 12 calculus-based mathematics subjects, often referred to as intermediate or advanced, seems to have plateaued. However, the 2016 share of enrolments is 29 per cent less than it was in 1996. Moreover, twice as many boys as girls enrol in advanced mathematics at Year 12. These are two of the greatest challenges to the health of the STEM disciplines and professions in Australia and will bedevil plans for Australia to an innovative, science-based economy.

Data about the school teaching workforce is non-existent

[2] Depending on the definition of out of field teaching, see Weldon, Paul R., "Out-of-Field Teaching in Australian Secondary Schools". ACER Policy Insights Issue 6, June 2016.

Women in STEM Decadal Plan

AMSI Submission
October 2017

The Australian school education system has some endemic, fundamental problems which are largely due to its fragmented nature – the Commonwealth graduates teachers from its universities and the jurisdictions employ them in their schools. Along the way we lose critical information, such as the numbers of secondary mathematics teachers who graduate and, of those, who register (as teachers) each year. Without such information, workforce planning is inadequate and the consequences unintended.

This is why Australia has one of the worst out of field teaching problems in secondary mathematics in the OECD. This entrenched problem has been instrumental in lowering participation rates over 25 years in the Year 12 mathematics subjects which lead to tertiary STEM courses. In turn, this has led to the almost complete degradation of the mathematics prerequisite arrangements for tertiary STEM studies and downward pressure on Year 12 intermediate and advanced mathematics enrolments. Only 14% of Australian universities now have mathematics prerequisites in place for their science degrees. Students without the necessary background are known to suffer considerably worse tertiary outcomes across a range of disciplines than those who do. This is a deepening spiral of failure.

Universities must address the issue of pre-requisites

In response to the decline in enrolment share the majority of Australia's universities have dropped mathematics subjects as formal prerequisites for science and engineering degrees while continuing to assume the subject content. This reactive policy has sent a negative and misleading message to schools about the value of these subjects. ***Re-introducing prerequisites*** will repair some of the imbalance in maths, physics and chemistry enrolments at Year 12, limit ATAR gaming by both schools and students and give some measure of protection to the future supply of STEM graduates by ensuring adequate preparation of incoming students. Prerequisites send an unequivocal message to school communities that universities value these subjects. Their phased re-introduction will, however, take some time and has to be matched to schools' access to trained teachers and community culture change.

In 2016 the University of Sydney announced prerequisites from 2019. The resulting enrolment in the relevant maths subjects in Year 12 has seen a 10% increase, at least some of which is attributable to the measure.

Both AMSI and the Academy of Science have in the past advocated for the phased and universal introduction of mathematics prerequisites for university studies in science, engineering and commerce. This position has been publicly supported by the current and former Chief Scientists and by Ministers for Education and Training, nonetheless Australia has no plan to deliver on this aspiration.

AMSI urges the Decadal Plan for Women in STEM to address this and to recommend university and government action on this issue.

Make the M in STEM visible

In a data driven economy Australian businesses, agencies, governments and universities are frustrated with the inadequacy of mathematical sciences graduate supply. While employer STEM campaigns have become common, they have yet to become coherent. Many do not reflect a gender imbalance in the workforce, and this has the effect of turning young women away from what they perceive as a male-dominated workforce. There is not yet a clear and pervasive message that mathematics is integral to STEM and not simply the M on the end.

Women in STEM Decadal Plan

AMSI Submission
October 2017

AMSI's experience in this domain

AMSI has made a considerable contribution to the agenda in this space, in outlining policies and strategies to improve the gender balance in the mathematical sciences - and in STEM more broadly. Our main policy document (https://amsi.org.au/publications/improving-australias-maths-grades/) outlines key priorities for mathematics in Australia. All our programs include a substantial or main focus on improving equity in participation in the mathematical sciences and STEM.

CHOOSE**MATHS**

AMSI's CHOOSE**MATHS** program aims to turn around public perception of mathematics and will contribute to the health of the mathematics pipeline in Australia from school through university and out to industry and the workplace. The program works with students, parents and teachers over five years to turn around community attitude to participation in mathematics, especially for girls and young women.

Since 2015 CHOOSE**MATHS** has been leading the national implementation of key classroom and pipeline strategies to transform Australia's mathematical capability, particularly for young women. With maths essential to a growing number of jobs, it is critical that the understanding of the value and impact of maths is fostered and that students are equipped to embrace these opportunities now and into the future. Working across four key components, the project addresses pipeline challenges through Schools Outreach, Careers Awareness, CHOOSE**MATHS** Awards and a Women in Maths Network.

Securing Australia's Mathematical Workforce

In addition to in-school initiatives, the AMSI "Securing Australia's Mathematical Workforce" tertiary program delivers:

- opportunities for university students in mathematical sciences to advance their knowledge through annual residential Summer and Winter schools as well as through vacation research scholarship placements;
- industry research training symposia in bioinformatics and optimisation engaging students, researchers and industry;
- considerable support to strengthen participation of women and Aboriginal and Torres Strait Islander peoples in graduate programs in the mathematical sciences.

APR.Intern

Australian Postgraduate Research (APR) Intern *(formerly known as AMSI Intern)* is Australia's only all sector—all discipline postgraduate internship program, transforming Australian businesses through university research collaborations.

Working at the interface between industry and academia, APR.Intern is a not-for-profit program open to all universities and industry sectors, including small-to-medium and large enterprise as well as government agencies. APR.Intern provides a platform for industry to further develop and innovate through short-term 3-5 month tightly focused research projects, and gives postgraduate students the opportunity to apply highly analytical research expertise to the project while gaining invaluable

experience in an industry setting. The program is open to all, but with a particular emphasis on Women in STEM as well as domestic, regional, Indigenous and disadvantaged PhD students.

Addressing the questions

Many of the issues that have an impact on the participation of women in STEM are of a societal nature, though incredibly important. These may include issues to do with access to day care for children, flexible working hours, support to attend conferences and meetings, support for research to continue whilst the chief investigator is on family leave, breastfeeding facilities and programs that encourage men to participate fully in family responsibilities such as care for children and ageing parents.

Additionally, we wish to respect gender across the spectrum, and recognise that gender is more than the simple and conventionally accepted binary state. In this submission, we recognise women as anyone who identifies as such.

AMSI does not profess to have expertise in social and family policy, and so have restricted our responses to the questions for the submission to mathematics, mathematics education and the impact of gender on participation rates in both of these.

Question 1 – What changes need to occur to enable more girls and women to participate in STEM education at any level (primary, secondary or tertiary)?

There are a number of factors that would assist girls and women to participate more fully in STEM education. Clear campaigns with yearly targets should be set across the mathematic pipeline, pulling levers at the key points will have the most impact.

At the primary school level:

- **Support teachers to be more confident and competent to teach mathematics.** A confident teacher teaches mathematics well, and can engage and enthuse students. Sadly, many primary teachers do not have either the capacity to work within the domain of mathematics or the inclination to do so. This negative attitude, some might say maths anxiety, can be passed on to their students which has the effect of the negative perceptions of mathematics to be consolidated.
- **Encourage parents to engage with their child's school as a partner in the teaching and learning of mathematics.** This could go a long way to address the tightly held public perception that maths is not foundational to our lives and is not needed to function in society or for work and personal financial security.

At secondary school, while the target audience should be girls in Year 9 and 10, the secondary influencers such as parents, teachers, careers counsellors and the media cannot be discounted - enabling the influencers so that they understand the role of maths is crucial here:

- **Australia needs more teachers of mathematics.** Out of field teaching in mathematics is endemic in Australian secondary schools, in Years 7-10 at twice the corresponding rate in science.
- **Promote mathematics using marketing strategies aimed at the secondary school age-group.** Helping students, especially girls and young women, see the importance of maths for their future degree (or career) through a wide-ranging careers awareness campaign targeted at students, parents, careers advisor and teachers and showcasing role models who inspire and motivate.
- **The careers conversation needs to start early**. By Year 12 many students have already opted out of calculus-based mathematics and have missed the discussion about the imperative to keep options open. Events to engage and inform students as young as Year 7 would go a long way to keeping the momentum up, and helping students develop a positive mindset to their own mathematics learning.
- **Make a connection between mathematics and biology.** Australia graduates a large number of biology teachers, mostly female, almost none of whom are also qualified to teach maths. However, these teachers often end up teaching mathematics 'out-of-area' and would benefit from the extra content knowledge of a mathematics focussed professional development (such as a post-graduate diploma) or undergraduate studies in mathematics that would qualify them to teach mathematics upon graduation. Connections between mathematics and biology in the curriculum must be made explicit for teachers with the implementation of modules of work suitable for study at Year 12. In the 21st century, the maths connection with the life sciences is insufficiently acknowledged in the undergraduate biology curriculum.
- **Careers advisors must be better informed.** Advice from careers professionals can lead young women away from mathematics rather than toward it. The thirst for high ATAR scores sees students believing that they might be better off doing an 'easier' subjects and course counsellors advising them to do just that. We believe that careers counselling often is for the benefit of the school (higher scores reported to the community and governing boards) rather than advising *for* the students (improved access to courses and correct required knowledge developed before entry into university).
- **Make industry connections visible.** There are many excellent programs in place and in preparation to grow the engagement of industry with schools both at an individual and corporate level. One of the greatest challenges in mathematics, and probably also in the science disciplines, is the lack of industry exposure available to our teachers when they are/were undergraduates. Few teachers of mathematics have a clear perspective of the roles of mathematically capable professionals in the workforce. This is probably also true of science teachers. This is a serious brake on engagement and it should not be overlooked when planning industry engagement with schools.

  It is to be hoped that the current expansion of Work Integrated Learning (WIL) experiences for undergraduates will resolve this problem in the long term, but by 2030 only a relatively small number of current teachers of mathematics will have exited the system and been replaced by WIL experienced graduates.

AMSI believes that teacher professional development is critical to bringing industry context to the curriculum. This professional development should be developed and delivered in conjunction with industry and government agencies.

In tertiary institutions:

- **Re-introduce mathematics subjects at Year 12 as prerequisites for some courses at University.** This announces to the public that mathematics is important and has value and prepares students better for their university coursework than for a student who has not studies mathematics to a senior level at school. Of course, alternative pathways need to be provided to those students without access to the pre-requisite subjects.
- **Engage with school students.** Improved study pathway information is necessary when enrolling students online and for open days and public access days.
- **Mentoring makes mathematics visible.** By bringing the message down the pipeline - with secondary students mentoring primary students, and in turn being mentored by university students, the girls will engage with people at just the right age difference to make an impact at the 'sweet spots' in their decision making and self-belief process time frames.
- **Support young women to continue with mathematics** beyond first or second year of their undergraduate degree. In some institutions, women are well represented in undergraduate years, but the numbers slide dramatically in later years of undergraduate or in postgraduate studies. Female participation in some undergraduate courses reflects the participation in Year 12 advanced mathematics, it is half that of males. In honours courses women are outnumbered four to one. In part, this is because of the increasingly small number of our graduates going on to teaching and the concentration of mathematical sciences graduations in the Group of Eight universities.

For the public:

- **Improve Adult Numeracy levels for Women.** Adult numeracy levels for Australian women are low. This could explain some reluctance on the part of some professions, including primary teachers and secondary teachers teaching out of area, to participate in mathematics fully. It also mitigates the opportunity for mothers to be assisting their children at home, in contrast to literacy where women are marginally more literate than men.
- **Make industry demand for mathematically capable professionals clear to the public.** If students, girls in particular, and their parents can see the jobs exist across STEM, they will apply for courses to head in that direction. In this regard, the endorsement of senior industry figures is a necessity.

Question 2 - What are the most effective things we can do to change inaccurate stereotypes about STEM professionals and the range of STEM careers?

Effective measures are those which are visible, long term, wide ranging and aimed across the STEM pipeline from primary school through secondary school, tertiary study and out to the workforce. Assessment of the impact of such measures is key to driving upward to increased

representation of women at all levels in the pipeline. AMSI has been working in this space for a considerable time, and we have found that the following measures are necessary to securing a well-informed cohort of young women heading towards mathematics and STEM.

- A major Careers Awareness Campaign maintained well beyond its initial impact:
    - Highlight female role models in STEM professions.
    - Create operational links between (female) STEM professionals and students and the wider community.
    - Show where STEM careers/research fits in the community. For example, how is the statistical research being done on the Great Barrier Reef relevant to me?
    - Careers awareness training for maths teachers– to augment the limited information they receive at university about this before heading out to their new jobs.
    - Television, radio and outdoor campaign advertisements that challenge the perceptions that the public has about mathematics and offers young women visible alternatives to the traditional roles and stereotypes they see around them.

Public awareness campaigns have had success in changing public perceptions about mathematics. The 'Maths Multiplies Your Choices' campaign[3] in the 80s had a positive impact on the number of young women selecting mathematics at senior school and undergraduate tertiary level. However, it did not last long enough to reach into the next generation of female students.

- Industry engagement with internships for women. Internships make STEM careers visible to the young women, and the young women visible to the industry partner. Barriers are smashed once these bright young women have made it past the front door of the employer, often they are invited to apply for jobs and stay having successfully challenged the status quo.

QUESTION 3 - What measures should we be using to determine eligibility for career recognition and progression?

A great deal of bias around careers progression for women still exists.

- Criteria for merit must be set by a diverse setting panel or else hiring people 'just like us' results in fewer women.
- Recognition of the Achievement-to-Capacity ratio is particularly important for women in STEM. For example, part-time mothers may publish half the number of papers compared to a full-time academic and as a result be overlooked for progression. Measures that recognise productivity relative to opportunity must be implemented rigorously.
- Universities and other employers need to set targets for greater numbers of women in STEM in order for policy to make an impact.

[3] https://amsi.org.au/publications/maths-multiplies-choices/ The program was reviewed in 1991 by Kathryn McAnalley, Manager Education, training and Employment Programs, Youth Guarantee Branch, Department of Labour

Unconscious bias training should be compulsory in universities and for training teachers. Mentoring should include thesis supervision – thesis supervision should include a supervisor who has training in awareness and unconscious bias. We ask Government to support the implementation of this, and set the example, by training government departmental staff and members of parliament to review their own unconscious bias regarding the capacity of women to work in STEM.

QUESTION 4 - Australia has more than 330 different initiatives to foster the participation of girls and women in STEM. What type of initiatives are demonstrating the most impact in your area of interest?

AMSI supports, and where possible, collaborates with, STA's Super Stars of STEM, the Athena Swan initiative, the Women in Maths Special Interest Group of the Australian Mathematical Society, Engineers Australia's National Committee on Women in Engineering, ATSE's IMNIS mentoring program, Code Like A Girl and Robogals. We admire the advocacy of Chief Executive Women and the Male Champions for Change in the STEM space.

For systemic change, the initiatives must be long-lived, the minimum time scale is probably the end to end educational one, that is, 17 years.

AMSI has a number of its own programs which address gender imbalance in the mathematical sciences and in STEM more generally:

CHOOSE**MATHS** choosemaths.org.au

Careers Awareness campaign https://careers.amsi.org.au/

This is the probably most significant STEM careers campaign running in Australia. It has a heavy emphasis on women's participation in the quantitative professions. Through the mainly female CHOOSE**MATHS** Ambassadors, careers packs for every Australian school, physical advertising in State capital cities, radio and online messaging, the campaign showcases the range of STEM professions which use mathematics and statistics on a daily basis. The annual campaign is strategically timed to influence student subject and course choices.
Women in Mathematics Network Mentoring program https://choosemaths.org.au/mentoring/

Currently running in five states, CHOOSE**MATHS** Mentoring is linking Australian maths professionals with high school girls aimed at strengthening engagement of girls and women in maths.

Assigned to groups of 10–15 students from Years 9 & 10, the volunteer maths champions connect with students via an online forum to support learning and answer questions the students may have about mathematics in school, university and beyond. Students are able to ask questions, seek advice and explore career avenues from professionals across the country.

*CHOOSE**MATHS** Awards*

Now in their third year, the BHP Billiton Awards for Excellence in the Teaching and Learning of Mathematics celebrate the achievements school teachers of mathematics. The major teacher award is for Mentoring Girls in Maths https://schools.amsi.org.au/2018/09/10/6860/

*CHOOSE**MATHS** Travel Grants*

These grants support our female mathematical sciences students and early-career researchers from AMSI member institutions to build and extend their skills and professional networks by providing full or partial financial support towards travel and caring responsibilities to assist them to attend AMSI Flagship (higher education) events.

*CHOOSE**MATHS** Days* Schools Outreach

Teacher Professional Development is delivered on-the-ground in 120 Australian schools. Based on a cluster arrangement, where a secondary school and up to three of its feeder primary schools are formed into a professional development group, teachers work with an AMSI Specialist to focus on enhancing content knowledge in mathematics. This is of vital importance to teachers who feel less than confident in their own mathematical content knowledge. Given that women make up a large proportion of the teaching workforce, this support helps female teachers value the effort to enhance their skills.**APR.Intern** APRIntern.org.au

APR.Intern delivers the Commonwealth funded '*Supporting more women in STEM careers: Australian Mathematical Sciences Institute (AMSI) – National Research Internship Program*' (NRIP).

As part of the NRIP delivery we run major campaigns directed at female PhD students in STEM disciplines. Most recently these have included:

- The Women in the STEM Workforce event on 4 September at Engineers Australia and broadcast nationally
- Women in the STEM Workforce campaign – digital and online

Relative to their representation in the STEM PhD cohort, women are more likely to apply for our internships than men. In 2018 women make up 39% of our placements, most of which are in ICT, engineering and the mathematical and physical sciences.

Securing Australia's Mathematical Workforce Program https://highered.amsi.org.au/

This higher education program is unique in drawing together students of all genders and giving them at least one annual national opportunity to learn new mathematical sciences subjects, network with peers and discover career opportunities. Overall the program aims to stop the severe decline in Australia's mathematical workforce now and into the future. This program is creating impact by funding participation by women for travel, accommodation and carer's grants. We also provide role models to students with women teaching half of the subjects taught at our events

Women in STEM Decadal Plan

AMSI Submission
October 2017

QUESTION 5 What societal and regulatory issues (i.e. not STEM-specific) will have the greatest impact on women in STEM, and how should we address those that are barriers?

Society, including employers and governments must accept that low female participation in many professions, and in senior management is not the responsibility of women alone. This acceptance goes beyond structural changes in the workplace we have seen to date -- men must embrace flexible working arrangements as well as women. This will not only lower the parenting load on mothers, it will change the rules concerning career progression.

This is not to say that the current campaigns for gender balance in governance and management should not continue, they still have a lot to achieve.

While Australia must work with all ages and genders, leaders should be careful not to forget or sideline young male champions of change. Young males (particularly under the age of 30) find it difficult to define their role in this societal change as they are also in a weak position - with little control of the current system. Further, advice and solutions are currently targeted to those in positions of power. Engaging young men whilst they also learn about these issues and progress into leadership positions, is pivotal to the success of their female peers now (at university and in early career) and into Australia's future.

We also believe that the restoration of school teaching as a career of choice will have a positive impact on female participation in STEM and, in the long term, on adult female numeracy.

QUESTION 6. Progress towards gender equity in STEM will require changes. How do we address the challenge of backlash and resistance to these changes?

There must be clear endorsement of, and commitment to, change by community and business leaders and bipartisan political support. The STEM peak bodies and the chief scientists along with peak business groups should collectively lead the campaign for this. Coherence is critical.

In particular, progress should be celebrated and rewarded publicly. And the use of historical role models should emphasise the innate capability of women to be STEM professionals and the impact of their work.

QUESTION 7 - If Australia is to take a strategic approach to improving the participation of girls and women in STEM, where would effort best be placed?

First of all, it is important to acknowledge that there is no silver bullet. A range of measures with a coherent and publicly recognised aim is critical.

Nonetheless, working with the education system, especially schools, is central and vital as we have already identified. This will require regulatory change, difficult in Australia with so many jurisdictions in play. This makes the formation of national alliances of peak bodies even more important.

In parallel with the repair work in schools, a national career awareness campaign is required. It should highlight diversity and role models, it should have clear employer endorsement and it must evolve and run well beyond initial appearances of success. However, a one size (STEM) fits all approach requires caution because, for example, physics students won't be attracted by messaging that focuses on the wet bench sciences, and ICT and mathematical sciences students are not engaged with the pervasive science imagery of STEM outreach.

Finally, Australia must set targets for improvement across a range of metrics and time scales and the key players must sign up delivering on those targets. This will require a far more comprehensive evidence base than is currently available.

Question 8 - Is there anything else you have not yet covered in your response which could improve gender equity in STEM?

STEM is a construct and it is important not to let it overwhelm the identities of the individual component disciplines. For example, in the life sciences most PhD students are female, in engineering, ICT, the mathematical and physical sciences female PhD students make up no more than 25% of the cohort. Moreover, international student enrolments can mask underlying trend, for example, in the mathematical sciences domestic female PhD (and honours) numbers are declining but balanced by international female enrolments.

Amongst the AMSI member university departments there are those that have long achieved gender balance in their student cohort, right through to PhD. And there are those with long term minority representation of women. This may also be true of other disciplines. We believe that there is a case for mounting a major study of those departments exhibiting such gender balance.

We also believe that Australia should look internationally for relevant best practice in delivering both regulatory and structural change and public awareness campaigns. ACOLA's STEM: Country Comparisons review of 2013[4] is a good starting point in this respect.

Finally, it must be recognised that wider participation in, and respect for, the STEM disciplines and professions is the platform from which increased female participation will be built.

[4] Marginson, S, Tytler, R, Freeman, B and Roberts, K (2013). *STEM: Country Comparisons*. Report for the Australian Council of Learned Academies, www.acola.org.au