Women in STEM Decadal Plan Consultation Submission

Consultation questions

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

The reasons girls and women participate less in STEM education at all levels are complex and varied; many of these are centred around some common myths and misconceptions:

- Maths and science are too hard;
- Boys are better at maths and science;
- Scientists are "nerds" and, largely, male; and
- Women do not have successful STEM careers.

To enable more girls and women to participate in STEM education, attitudes towards studying STEM subjects and pursuing STEM careers must be changed. This can be achieved using a multi-pronged approach that breaks down stereotypes and also illuminates the myriad career pathways made available through studying STEM. Ultimately, building girls' confidence to participate in STEM education at all levels will ensure more women will pursue STEM careers.

Although critical for increasing STEM engagement, changes that should be implemented within the education system should go beyond increasing the pool of STEM-qualified teachers and improving teaching methods. Approaches should focus on increasing the visibility of women studying STEM and of raising awareness of the multitude of successful careers available as a result of enhancing STEM capability. **An effective and proven means of enabling increased participation in STEM education is through peer mentoring, where young and engaged STEM students and professionals can build confidence and enthusiasm for STEM and act as role models for those on the cusp of a successful career in STEM**.

The program has undergone several external evaluations. The latest evaluation of In2science shows that having a mentor in the classroom increases student confidence, relevance, enjoyment and awareness of STEM subjects and careers (Australian Council for Educational Research, 2017). When students' attitude towards science learning remains positive, their levels of achievement continue to increase (Ainley et al 2008). This results in an increased interest in career opportunities and further education in STEM; and improved self-confidence and attitudes towards science and maths.

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

Exposure to negative attitudes and stereotypes about STEM professionals and the myriad STEM career pathways are cemented by early high school. In fact, in year 6, 72% of Victorian school students felt that science was important to their future compared to 48.5% at year 9. In year 6 74.8% of Victorian students felt that maths was fun and interesting compared to 41.9% of year 9 students (Victorian Auditor-General, 2012). Moreover, Australian children start to lose self-esteem in maths by grade 4, with girls exhibiting reduced confidence in their maths ability than boys (Thomson et al, 2013). This trend continues in secondary school, which is reflected by year 8 students losing interest in maths. Most strikingly, only 1 in 10

students complete advanced mathematics in year 12 (Office of the Chief Scientist, 2017), likely reflecting further reduced confidence and exposure to negative attitudes in high school including when selecting subjects for year 12 determining career options. These damning statistics underscore the need for changing stereotypes while students are at school. Peer mentoring provides a powerful means of changing attitudes towards studying STEM and pursuing STEM careers. Indeed, sustained mentoring relationships based on consistent and frequent contact over a longer time period have the most impact (Grossman and Rhodes, 2002; Karcher, 2005). It is not enough for female students to have one-off STEM events or a visit from a high-profile women in STEM to increase participation and achievement of female students in STEM subjects.

In2science recognises the importance of targeting each stage involved in embarking on, building and then achieving success in STEM and STEM-related careers. However, in considering the critical shortage of people with STEM skills and the significant underrepresentation of women in STEM careers, we would argue that the Australian Government would have the largest impact by targeting students at a time when they are making decisions about study and career pathways: in years 7-10. This approach will not only increase the number of women pursuing STEM careers but has the additional advantage of addressing the broader STEM skills shortage. One of the best ways to achieve this is through established and successful programs, like In2science, that are proven to improve attitudes towards STEM and related careers.

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

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?

Coordination of resources between organisations is key for successful programs and initiatives that avoid overlap. Since 2004, In2science has successfully built collaborative partnerships with multiple universities and schools working together to improve enthusiasm, aspirations and outcomes in science and maths secondary education. Over the duration of the program more than 2,000 volunteer mentors have worked with over 59,000 students. In2science currently has active partnerships with 67 low SES and regional schools where we have placed 854 mentors from across four Victorian universities working with approximately 9,000 secondary school students in the last three years. In2science shows that having a mentor in the classroom increases student confidence, relevance, enjoyment and awareness of STEM subjects and careers (Australian Council for Educational Research, 2017).

As university representatives working with In2science, an innovative and award-winning Peer Mentoring Program, we have firsthand knowledge as to how universities can bridge the gap between schools, the research community and industry.

At a STEM Industry Summit in Sydney in September 2017, a number of industry representatives said that they felt uncomfortable directly approaching schools to 'improve' STEM education because they were not education experts. They said that they needed 'relationship brokers' to facilitate interactions between industry and schools. Given universities' expertise in working with and administering programs for both school and industry partners, we firmly believe that a university-based initiative like In2science is very well placed to act as a conduit between industries and schools. We are a well-established partnership program

working with underrepresented students to increase engagement in STEM and we are well placed to provide further collaboration and pooling of resources for effective and strong outcomes.

Initiatives that work with low socio-economic schools should be prioritised. Students from high socio-economic status backgrounds outperform students from low socio-economic backgrounds by a difference of three years (Thomson et al, 2017). Furthermore, there are stark gender differences for low socio-economic students. In recent studies from the UK and The Netherlands, female students from low socio-economic backgrounds were less likely than their male counterparts to study STEM subjects to the end of secondary school whereas there was no gender gap in the top third of socio-economic status (Codiroli Mcmaster, 2017; van de Werfhorst, 2017). As such it is key that we focus initiatives that benefit low socio-economic students not just for benefits to gender equity but equity for broad under-represented groups. The STEM gender-divide is more complex than most researchers, policy makers and practitioners give credit.

We have keenly followed the progress of the Superstars in STEM program and believe that their excellent female leaders are outstanding role models, revealing myriad career pathways for young girls to aspire to. However, it is important to note that highly relatable role models and mentors, with respect to age and study/career pathways, are key for high school students to envisage themselves in STEM. Peer mentoring of female students is proven to increase confidence, aspirations, retention and a sense of belonging (Dennehy & Dasgupta, 2017). Not everyone aspires to be a "superstar" and such approaches may even be counterproductive by making STEM careers seem out of reach for some female students.

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

As mentioned in response to question 3, low socio-economic status significantly reduces STEM achievement levels and there are greater differences in STEM subject participation rates between genders for students from low socio-economic backgrounds compared to high socio-economic counterparts. Socio-economic status must be addressed as a key societal issue that also impacts on women in STEM.

There are a number of aspects that may impact the low achievement levels of students from low socio-economic backgrounds and the participation rate of low socio-economic girls in STEM. Students' socio-economic status is related to science capital; students with parents who are engaged with STEM or work in STEM careers are more likely to study STEM (Archer et al 2012). Participation in STEM is affected by the educational background of parents (Codiroli Mcmaster, 2017) and there is evidence to suggest that higher educated parents have more egalitarian views of gender roles (Crompton & Lyonette, 2005). Furthermore, lower socio-economic students are more likely to study technical and business majors (Ma, 2009) and students from lower-income households may be more likely to avoid risky subjects that are seen to be hard (Codiroli Mcmaster, 2017). We address these barriers by providing In2science university mentors to female students from low socio-economic backgrounds. Mentors are relatable role models that provide another voice to not only help students in class but talk through the myriad of career options involving STEM and any personal barriers.

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

To address gender inequity in STEM, changes are required at all career stages and at all stages of education. Evidently, men will be required to concede some of their traditional territory, particularly in senior positions and on boards. It is critical to increase awareness of the research indicating that companies with more women in senior roles leads to improved economic outcomes, which will help combat negative attitudes. It is important to note that many larger companies and multinationals already recognise these phenomena and are actively addressing issues of gender inequity, particularly in leadership positions. Ultimately changes at this level will benefit the leaky pipeline right through to early education through societal shifts.

However, many attitudes and prejudices are engrained from a young age. Many teachers do not encourage, or even (unconsciously or actively) discourage girls from studying STEM, and particularly physics and advanced maths. Awareness campaigns must reach students, teachers and future employers to circumvent backlash and resistance. In2science mentors (or similar), armed with knowledge and statistics that support a role for women in STEM can help change these attitudes from a young age. By acting as role models, they also dispel myths that girls cannot undertake higher education in STEM or pursue STEM careers.

Through mentoring programs like In2science, mentors not only improve students' attitudes towards STEM, but can also enhance teachers' attitudes and awareness of STEM career pathways. In2science actively engages with teachers participating in the program, providing opportunities for professional development. In2science aims to build upon these existing relationships and provided training through additional training resources to address:

-current issues and trends in STEM, focusing on gender equity

-engaging diverse students ie fostering grit and a growth mindset

-ways of developing the entrepreneurial skills students will require by 2030

-correcting the negative perceptions that girls develop at a young age, and recognise the importance of cultivating their potential

Informed teachers will ensure a more inclusive and engaging STEM practice, sharing knowledge across all year levels and with wider school community.

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?

- Coordinating the approach of all stakeholders
- Implement structural changes e.g. measures of academic success or support for women returning from career breaks, not only will allow for better retention and career progression of women in STEM careers but it will encourage female students to continue in STEM. Strengthening the ability for In2science mentors to convey success stories and possible pathways to high school students.

- Govern mathematics as a compulsory prerequisite for STEM university degrees. At some institutions, many STEM degrees in areas of greatest gender disparity (Maths, IT, Physics and Engineering) don't have advanced mathematics as a prerequisite. However, these courses still require high school advanced mathematics or an equivalent bridging course for successful completion of the degree. Bridging courses combine up to 2 years of advanced high school mathematics into a 12-week course. Partaking in a bridging course is a potential barrier and disincentive for many students entering these areas, especially female students who have lower participation in advanced mathematics. We agree with our Chief Scientists that there should be a phased in reintroduction of mathematics prerequisites for relevant courses. Mathematics is the language of science and mathematics skills need constant development and cannot be acquired effectively in a short bridging course.

- Fund non-government initiatives that aim to address these issues and include a mandatory evaluation requirement to ensure that the Government is able to make an informed move from funding pilot programs to funding programs that work best. Also, current funding is geared towards pilot programs (1-2 years), but little federal funding is available to keep effective programs going past this point. Given the range of programs now in operation, this may be a good time to shift the focus to identifying which are the most effective, ultimately and providing sustainable funding for these existing, proven initiatives.

8. Is there anything else you have not yet covered in your response which could improve gender equity in STEM?
No

References

Ainley, J., Kos, J., & Nicholas, M. (2008). Participation in science, mathematics and technology in Australian education. *ACER Research Monographs*, 4. Access: https://research.acer.edu.au/cgi/viewcontent.cgi?article=1003&context=acer_monographs

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B. & Wong, B. (2012) Science aspirations, capital, and family habitus: How families shape children's engagement and identification with science, American Educational Research Journal, 49(5), 881–908.

Codiroli Mcmaster, N. (2017). "Who studies STEM subjects at A level and degree in England? An investigation into the intersections between students' family background, gender and ethnicity in determining choice." British Educational Research Journal 43(3): 528-553.

Crompton, R. & Lyonette, C. (2005) The new gender essentialism–domestic and family 'choices' and their relation to attitudes, British Journal of Sociology, 56(4), 601–620

Dennehy, T & Dasgupta N (2017) Female peer mentors early in college increase women's positive academic experiences and retention in engineering. PNAS 114(23) 5964-5969

Grossman and Rhodes (2002) The Test of Time: Predictors and Effects of Duration in Youth Mentoring Relationships. American Journal of Community Psychology 30(2) 199-219.

Karcher, M. J. (2005). The effects of school-based developmental mentoring and mentors' attendance on mentees' self-esteem, behavior, and connectedness. Psychology in the Schools, 42, 65–77.

Kos, J., Krakouer, J., & Rothman, S. (2017). Evaluation of the In2science Peer Mentoring Program. Access: https://in2science.org.au/wp-content/uploads/2017/05/In2science-ACER-evaluation-2017.pdf

Thomson, S., De Bortoli, L., & Buckley S., (2013) PISA 2012: How Australia measures up, Australian Council for Education Research Accessed: https://research.acer.edu.au/cgi/viewcontent.cgi?article=1015&context=ozpisa

Thomson, S., De Bortoli, L. & Underwood, C., (2017) PISA 2015: Reporting Australia's results. Australian Council for Educational Research. pp. 51 and 183. Accessed: https://research.acer.edu.au/ozpisa/22/

van de Werfhorst, H. G. (2017). "Gender Segregation across Fields of Study in Post-Secondary Education: Trends and Social Differentials." European Sociological Review 33(3): 449-464.

Victorian Auditor-General Office (2012). Science and Mathematics Participation Rates and Initiatives. Accessed: https://www.audit.vic.gov.au/sites/default/files/20120606-Science-and-Maths.pdf

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