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BUSTING MYTHS ABOUT WOMEN IN STEM

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False perceptions about women's aptitude, interest and experience in science, technology, engineering and mathematics (STEM) are holding back progress in science, and society. This paper reviews the facts and debunks the myths.

INTRODUCTION

The 20th Century was a time of incredible progress for gender equality, in science as well as other professional fields. Over the past 100 years, Australian women gained the right to be awarded full university degrees[1], to continue working in the Australian Public Service after marriage[2], and to compete for all but a handful of roles still explicitly reserved for men.

However, work is still needed to reach gender parity. Women are underrepresented in many STEM fields, particularly in mathematics, physics, engineering and ICT; in industry sectors such as construction and transport; and in senior positions. STEM's leaky pipeline—the cumulative attrition of women from STEM careers—is proving stubborn to mend[3].

Girls and women represent untapped talent. Enabling them to realise their potential is about both economic growth and social justice. Recruiting and retaining a diverse set of minds and approaches is vital to harnessing the nation's intellectual capital for innovation and competitiveness[4].

AIMS

Despite overwhelming evidence to the contrary, there is still a suite of pervasive and damaging myths about women in STEM. This paper collects four of the most persistent myths; reviews the evidence base; and sets the stories straight.

The paper aims to provide a foundation for policy makers by collating a clear evidence base that can be used to challenge misconceptions about women working in STEM fields.

✕ MYTH 1

Girls are bad at maths

The idea that girls are bad at maths is widespread[5,6]. Because mathematics is a gateway subject for science[7], this myth has broad ramifications, including the belief that women do not succeed in STEM due to innate differences in ability[8].

✓ FACT 1

There is no gender difference in mathematics ability.

There is no innate gender difference in mathematics ability. However, differing societal expectations for male and female students in many countries result in vastly different experiences of learning, levels of confidence in personal ability, and performance in international benchmarking tests. If mathematical ability were biologically determined, gender differences would be consistent among countries, and over time. This is not the case. In the 2011 Trends in International Mathematics and Science Study (TIMSS)[9], there were no significant differences in the mathematics scores of Australian boys and girls in Year 4 or Year 8. Of particular note, Year 8 girls outperformed boys in mathematics in thirteen countries, compared to only seven countries where boys outperformed girls[10].

Patterns of gender differences in maths ability also change over time, with Programme for International Student Assessment (PISA) data from Australia showing a shift from 2003, when girls' performance was similar to boys, to 2006, 2009, and 2012, when boys were scoring significantly higher in mathematics[11].

Singapore is one of the top five countries in PISA mathematics; and their female and male students perform equally. The Singaporean system is proof that the girls can be world leaders in mathematics when placed in the right education environment[12].

At a glance

- There is no gender difference in mathematics ability.
- Women's participation in engineering careers increases in inclusive cultural environments.
- Women in STEM earn less than their male colleagues.
- While STEM employers have made improvements, sexism is still a challenge.

A meta-analysis of more than 240 studies published between 1990 and 2007 shows no statistically significant gender difference in mathematics performance[13].

In short, maths ability is not determined biologically by sex. So why is there an emerging gender gap in Australia's maths performance?

The answer lies both in social norms and the confidence of students. PISA studies find that gender disparities in drive, motivation, and self-belief play a significant role in determining differences in male versus female mathematics performance[14].

In Australia, girls and boys have vastly different attitudes to studying mathematics; more girls tend to be fearful and cautious while more boys are confident[15,16]. During secondary school a gender gap in self-concept emerges; many girls perceive they have less ability than their achievements warrant, in comparison to boys with the same scores.

WHAT NEXT?

To progress, we need to adopt education practices that encourage girls to feel more comfortable and confident engaging with mathematics.

Teaching students to persevere, and creating a 'mistake friendly' environment provides improved learning outcomes[17]. Encouraging and supporting teachers to focus on the application of mathematics principles to real-world problems will encourage girls' engagement in mathematics, and also their ability to use mathematics to solve problems.

✕ MYTH 2

Most women are disinterested in careers in engineering, physics and ICT.

As the STEM professions advance towards broad gender equality, female university graduates continue to be underrepresented at all levels in Physics (22% of all graduates), Engineering (14%), Mathematics (35%) and ICT (13%)[18]. A frequently cited opinion to explain the dearth of women in these careers is that girls simply aren't interested in these disciplines[19].

✓ FACT 2

Women's participation in STEM increases in inclusive cultural environments

Using engineering as an example, strong female engagement in other countries demonstrates that women can be interested in these careers. A conducive cultural environment—where there is an expectation that girls will become engineers—improves participation.

For example, women account for 40% of engineers in China[20], 44% of the engineering graduates in Malaysia[21], and accounted for 58% of engineers in the former USSR[22]. In contrast, women are poorly represented in engineering in Australia (14%) and in other Western countries.

So why are there so few women in engineering in Australia?

When it comes to choosing STEM, research has shown that the main influences on students' decisions are identity[23], perceived ability, and aspiration[24].

There are remarkable gender differences in these three areas —see the box on the next page.

WHAT NEXT?

Promoting authentic female role models and advertising that everyone has the potential to succeed would help counteract these stereotypes. A more actively inclusive and welcoming culture in male-dominated STEM fields is an effective way to boost female participation[25].

✕ MYTH 3

The gender pay gap doesn't exist

The difference between men's and women's earnings is known as the gender pay gap. Its existence is not universally accepted, based on arguments that it is: mostly false[26,27]; of insignificant magnitude[28]; or the result of women's tendency to work part-time or in lower-paid careers[39].

✓ FACT 3

Women in STEM earn less than their male colleagues

The existence of a gender pay gap across all fields is supported by a strong evidence base.

The national gender pay gap is currently 16.2% and has hovered between 15% and 19% for the past two decades[30]. In Professional, Scientific and Technical Services, the gender pay gap was 23.5% in Australia in 2016[31]. The gender pay gap was higher among managers (28.8%) than non-managers (20.9%).

When comparing the percentage of STEM graduates in the highest income bracket, 32% of males earn above $104,000, compared with just 12% of females[32]. Fewer female STEM graduates earn in the top bracket regardless of age, or whether their highest degree is a bachelor or PhD. This is true for both full-time and part-time workers, and for women with, and without children[33,34].

Whilst having children impacts female income, gender effects are more significant. In the cohort of STEM graduates (bachelor and above) aged over 30[35], 18.6% of women without children are in the top income bracket, compared with 11.6% of women with children, and 35.4% of men. When considering PhD-holders over 30, 20.7% of women without children earn over $104 000, compared with 19.4% of women with children, and 38.6% of men.

The effects of motherhood don't explain why nearly twice as many men earn in the top income bracket compared with women without children, regardless of qualification level.

More women than men work part-time across most STEM fields[36], resulting in lower overall female wages. However, the wage pay gap still persists once this is accounted for. For instance, for part-time workers with bachelor degrees, there was over three times the proportion of males compared to females in the top income bracket in the 30 and above age category[37].

An element of the pay gap results from women tending to work in lower-paid professions, resulting in lower average female wages. Nevertheless, the evidence suggests that as men move into traditionally female-dominated professions, male salaries and status levels rise above that of the female salaries. A USA study found that as the proportion of male nurses increased in the USA, a gender pay gap emerged, and by 2011, female nurses earned 16% less than their male colleagues[38].

A range of factors contribute to the gender pay gap[39]. These include undervaluation of skills in industries and areas where women predominate, and gender bias—both conscious and unconscious.

Influences on choosing STEM

Identity—is it for people like me?

Under-representation, an absence of female role-models, poor sense of belonging, and poor relative pay create career barriers, and decrease the incentives for women to continue in these fields[40]. In the absence of female role models, girls lack evidence that careers in STEM are for them.

Perceived ability—do I feel confident?

Girls typically suffer from the impacts of low self-confidence in their STEM abilities. For example, a survey of girls studying physics showed that they had lower confidence than their male classmates, despite tests revealing no difference in performance[41]; and that students confident in their maths abilities were more likely to embark on STEM careers. Overall, a mismatch between girls' STEM abilities and their confidence reduces female representation in STEM[42].

Aspiration—can I see possibilities and pathways?

Pervasive cultural beliefs that STEM is a male domain deter women from STEM careers, and prevent early exposure to these fields[43].

For example, all of the parents questioned in every one of ten OECD countries surveyed were much more likely to expect their sons rather than their daughters to work in a STEM field[44]. Similarly, four times as many 15 year old boys as girls expected to be employed in engineering and computing[45].

In communities with higher percentages of women in STEM occupations, the likelihood of girls taking physics compared to boys increases[46].

WHAT NEXT?

Identifying the reasons why pay inequality exists within an organisation is the first step towards fixing the pay gap.

Addressing the gap could include encouraging all employers of STEM graduates to comply with best practices as recommended by The Fair Work Ombudsman. Options include ensuring that remuneration policies and practices are transparent, and that employees on flexible working arrangements have access to quality work and the same opportunities as full-time employees[47].

Furthermore, organisations should be encouraged to lead by example, and foster a culture where senior leaders sponsor young women. Distinct from mentors (who provide psychological support and career advice), sponsors actively advocate for their protégé's career advancement. As well as accelerating career advancements and pay increases, sponsorship helps to address female representation at senior levels[48].

✕ MYTH 4

The battle against sexism in science has been won.

The idea that the battle against sexism in science has been won emerges regularly. For example, in 2014 two Cornell scientists published an op-ed in the New York Times announcing that 'academic science isn't sexist'[49].

✓ FACT 4

While there have been improvements in the treatment of women in science, there is still a long way to go[50,51].

Women face significant attrition as they progress through their scientific careers. Women hold 52% of undergraduate and 50% of postgraduate degrees in the Natural and Physical Sciences[52], yet only 17% of professors are women[53]. At current rates, gender equality at Professor level (Level E) in Natural and Physical Sciences will not be achieved until at least 2060, despite having had around 50% female representation at entry level (Level A) since 2001[54].

There are strong systemic deterrents to women in scientific research, including a lack of career prospects, job insecurity from one-year (or shorter) contracts, and the impact of leave and part-time work on their careers[55]. Unconscious bias also hinders women's employment in STEM.

A 2012 study assessed employer attitudes to a CV submitted for the position of laboratory manager, which was assigned either a male or female name. The male applicant was rated as significantly more competent than the (identical) female applicant, and was offered a higher salary[56]. This bias was evident among both male and female assessors.

The Australian Human Rights Commission's 2012 national telephone survey found that 25% of Australian women had experienced sexual harassment in the workplace between 2008 and 2012[57]. Sexual harassment is clearly an issue for Australia as a whole, but how does it affect the STEM-qualified workforce?

Although there aren't readily available Australian data, the international outlook is bleak. A US study found that 34.5% of women working in science had reported sexual harassment. Scientists conducting fieldwork were at even greater risk, with two-thirds (64%) of researchers surveyed internationally experiencing sexual harassment[58], mostly at the hands of a senior researcher. Women were 3.5 times more likely than men to report being subject to sexual harassment[59].

Sexism is a problem in science, and society, which has not yet been solved.

WHAT NEXT?

Leaders and institutions must take an active approach to improving equality and diversity, and tackling both conscious and unconscious bias. At a national level, we must regularly report sexual harassment in science[60].

Examples of Current Programs Addressing the STEM Gender Imbalance

- Choose Maths is an AMSI and BHP Billiton Foundation initiative to improve student engagement, increase participation and change community attitudes towards maths—especially for girls and young women.
- The Male Champions of Change for STEM group is a high-profile coalition of influential men striving to achieve STEM gender equality in organisations and communities.
- The SAGE Pilot of Athena SWAN improves gender equality and diversity by rewarding STEM institutions for rigorous data use, self-reflection and organisational planning.
- Robogals is a student-run not-for-profit that runs engineering workshops to inspire, engage and empower young women.

CONCLUSION:

Women are not inherently less capable or less interested in STEM than men, and the problem of gender imbalance is not impossible to solve. There is nothing inevitable about inequality.

Systemic biases limit the range of career options that many women aspire to. These biases come into effect early, impacting girls and women throughout their education before following them into the workplace.

Once in the workplace, pay, progression and security issues are barriers to women reaching the higher levels of STEM professions.

Impediments to women in STEM have deep societal, cultural and institutional roots, and no single strategy can entirely plug the leak. Debunking the myths and spreading the facts is a start, but Australia requires a multi-faceted approach across all levels of education and the workforce.

It may not seem problematic if girls and boys develop different interests and careers.

However, divergent attitudes formed by girls and boys in childhood—such as confidence in their abilities to apply mathematics to problem solving—have far reaching implications for the opportunities available to them in adulthood.

Australia's future wellbeing and advancement will be built upon a STEM literate workforce: to succeed, this workforce must fully engage women[61].

REFERENCES AND NOTES

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These occasional papers from the Office of the Chief Scientist aim to bring to the public's attention scientific issues of importance to Australian society. Each issue has been prepared by a multi-disciplinary team and has been through an external review process. We would like to thank Dr Terry Lyons, QUT and Dr Wafa El-Adhami, SAGE, Academy of Sciences for reviewing this paper.

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