

# How to Make the Invisible Women of STEM Visible

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Although women make up more than 50 % of the population, they have long been an under-represented minority in science, technology, engineering, and mathematics (STEM). In chemistry, for example, only five of a total of 181 Nobel prizes (2.8 %) awarded over more than 100 years have been bestowed upon women. Closer to home, Professor Frances Separovic – the subject of this special issue of *Aust. J. Chem.* – was the first woman chemist elected to the Fellowship of the Australian Academy of Science. That happened very recently, in 2012. At that point in time, the Academy had been electing Fellows for nearly 60 years. The lack of visible female role models and the absence of women in prominent scientific positions may be one reason why girls and young women do not see STEM as a viable career option. After all, if you can't see it, how can you be it? Here, we present personal accounts of our two quite different research career paths – one starting in 2010 that included a significant career disruption, the other starting 20 years earlier in 1990. We describe the challenges we have faced as women in a testosterone-rich environment, and the circumstances that allowed us to continue. We provide suggestions for addressing systemic, organisational, and social barriers to the progression of women in STEM.

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## Introduction

The 2019 Australian Academy of Science 'Women in STEM Decadal Plan'<sup>[1]</sup> identified many barriers that women must overcome to succeed in science, technology, engineering, and mathematics (STEM). The report found that gender stereotypes and lack of female role models can be key factors early on, at a stage when many girls become disengaged from science at school. Neither of the two authors experienced disengagement at school; no doubt if we had, we wouldn't be women in STEM now. However, the hurdles that impact women later in their career have affected both of us. Here are our stories.

### Dr Maria Halili – PhD Awarded 2010

When I was at school, and when I was an undergraduate, gender equity was not something I thought about. I was fortunate to have many strong female role models around me and a supportive family. I thought I could achieve anything I wanted, could succeed in any career I chose simply through hard work and commitment. It is only now, nine years on from the award of my PhD, that I can reflect on how gender bias and gender stereotypes may have affected my career choices.

Science has always been my calling. During my high school years, I was the only girl in the physics, chemistry, and advanced mathematics classes. That didn't bother me; my classmates were supportive and I did well at school. So well that I was accepted into an engineering degree at university. I thought I would love the mathematics in the course (turns out I didn't!) and I was proud to be one of only a handful of female students enrolled in the course.

Visible role models are important for encouraging women to continue in STEM.<sup>[1–4]</sup> I became disillusioned by my engineering course, as I didn't relate easily to others in the course. The lectures were presented by men, the jobs advertised were heavily geared towards men. Amongst the lecturers, I couldn't see anyone like me, anyone that I could model myself on, talk to about career paths, ask questions of.

I can recall looking for someone I could talk to about my studies and future career path. I found no one in engineering, but came across a female visiting academic who coordinated the biotechnology course. Although I only spoke to her a handful of times, she was the first person I had met at university who showed me that a career path in science was possible for women.

I transferred from engineering to the biotechnology course after my first year, and I did well in that course. The lecturers and tutors were a combination of women and men, who all excelled in their respective fields in academia. I enjoyed the biology training, and was especially interested in the interdisciplinary process required to develop a new drug. I continued my studies through Honours and a PhD, and took up a post-doctoral position immediately after graduation.

It wasn't until four years after my PhD, when my first children were born (twins!) and I took six months of maternity leave, that I really understood the impact of a 'career break'. As much as I wanted to keep my research going, I couldn't find the time or the energy to do that during maternity leave. When I returned to the laboratory, I found it challenging to switch between work mode and home life. The career disruption was especially problematic after a second period of maternity leave.

Upon my return, I couldn't catch up with my peers who had by then established their own independent projects. By comparison, I bounced from short-term project to short-term project over the three years since my twins were born.

Recent research from the US found that nearly half of new mothers leave their full-time work in STEM<sup>[5]</sup> and that caring duties are a primary reason for women failing to move into senior positions<sup>[1,6]</sup>; women find it difficult to balance caregiving while trying to live up to the stereotype of a dedicated full-time scientist. This is the situation I was in after my children were born. It is demoralizing and frustrating to excel in undergraduate and postgraduate degrees and to end up with no job security; to have to search for a new position every year; to continually be required to assess your skills and justify your worth, knowing that with each year beyond the PhD, the window of opportunity slowly closes for grants, fellowships, and competitiveness.

The significant loss of talent as women progress up the academic ranks has been likened to a leaky pipeline, with the field of chemistry identified as particularly leaky.<sup>[7–10]</sup> Although recruitment of women at undergraduate levels has been relatively successful,<sup>[3]</sup> there are very few women in senior positions across all STEM fields.<sup>[1,7,8,10]</sup> Many factors contribute to this leaky pipeline: gender stereotypes, harassment, questioning of self-worth, as well as some factors that have affected me personally – caring responsibilities, lack of job security, and a lack of role models during my early undergraduate studies. At the university level, it has been shown that only a small fraction of executive positions such as heads of schools or vice-chancellors are women, although 61 % of administration and support roles are held by women.<sup>[11]</sup> One study of Australian universities showed that women are more likely to have a teaching position and are likely to stay in a teaching-only track, as balancing research and other responsibilities becomes difficult.<sup>[12]</sup>

I am fortunate now to be in a position of leadership with the opportunity to form my own research group, something I never thought would be possible a few years ago. This happened because the caring responsibility for my children during the work week is now shared: one day for me, several half-days for my partner (who now works part-time) and the rest of the load is shared with my extended family. I am also very fortunate to have had understanding supervisors who have supported me with part-time appointments and flexible hours.

Many women in STEM have children and have also excelled in their scientific careers. I know many such women who are a little ahead of me in their careers; they are visible role models and mentors for me. When I have questions or doubts about myself or my career, they are my go-to team.

### Professor Jennifer L. Martin – PhD Awarded 1990

Perhaps I was destined to have a career in science and academia. From the day I was born, I had to compete in a testosterone-rich environment (I have five brothers) for a limited pool of resources (I'm one of nine kids) against more-established players (three of my brothers are older than me). As counter-balance, I had many terrific role models as a child: women who had succeeded against the odds in a world made for men.

My mum – bless her – was a natural leader: she was charge nurse in the operating theatre department of a major hospital, and she raised nine children. At high school, I may have been one of only two girls in the physics and chemistry classes, but the teacher who taught those classes was a woman. As an undergraduate, there were as many women as men in the lecture halls. My Master's supervisor had a research team that comprised equal

numbers of men and women. For my PhD research, I had two supervisors – one woman and one man. The department where I undertook that PhD research was populated by internationally renowned female and male research leaders. Indeed, in her late 70s, Nobel Prize winner Dame Professor Dorothy Hodgkin would occasionally drop by to attend seminars. Clearly, there were people like me and ahead of me on the career path, who had excelled in their field. If you can see it, you can be it.

I didn't think that being a woman in STEM could be a barrier to success until later in my career. Until I wondered aloud in a room full of men 10 years ago why there were no other women in that room – and was told, 'we only appoint on merit'; 'we can't let gender equity impact on quality'; 'perhaps we should all wear dresses'. Until I found I was the only one that saw a problem when the people being given platforms/podiums/prizes by my department/society/community didn't reflect the breadth of talent of that department/society/community. Until I experienced, observed, or learned about harassment, intimidation, and bullying in the workplace – often perpetrated by those who were given the platforms/podiums/prizes. #MeTooSTEM

My career success has gone far beyond anything I could have imagined when I was a high school student, an undergraduate, and a postgraduate. Why have I succeeded? Perhaps there are several factors: I had great role models as a girl and young woman, and great mentors (men and women) throughout my career; I had the opportunity to build national and international networks; I have a very supportive partner; and I don't have children. And, for the most part, I have had a safe, respectful work environment.

### What Can Be Done to Address Barriers to the Progression of Women in STEM

The Australian Women in STEM decadal plan describes a leaky pipeline, and proposes recommendations to fix the leaks. The plan outlines six opportunities for government, academia, industry, and education to develop a safe, respectful and diverse workplace by 2030. These are (1) strong leadership and cohesion; (2) evaluate the current situation and establish a national evaluation framework to guide decision making; (3) change the workplace culture to maximize women's participation; (4) increase the visibility of women in diverse STEM careers across all media; (5) support women to study STEM courses; and (6) develop a framework to help guide small and medium enterprises towards gender equity.<sup>[1]</sup>

More broadly, we as a society need to address the implicit bias that most people hold that science is male.<sup>[3,9,13]</sup> The stereotype of the white-haired, bearded male scientist needs to be challenged, and the significant contributions to STEM by women must be acknowledged.<sup>[3,13]</sup> As a society, and as a sector, we need to accept that women and men need flexibility for their changing priorities at different stages of their career. Caring for young children or elderly relatives is a major factor cited time and again for women who leave STEM, but not for men.<sup>[5,7]</sup> If we are to change the situation for women, we also need to change it for men. Fathers and sons should feel just as empowered and supported as women to take time out to care for family. Workplaces need to adopt policies that ensure men have access to and take as much parental or caring leave as women, so that caring as a shared responsibility is normalized.

Role models, sponsorship, and mentorship are critical too. We argue that:

- Senior researchers should be appointed, valued, and measured by how well they support and mentor those more junior

to them, in addition to how many papers, grants or HDR students they have.

- STEM organisations should be assessed, valued, and measured by how well they support diversity in their workforce, and in their media and communications, in addition to traditional metrics for excellence and impact. Several institutions have committed to the Athena SWAN charter to help address this.<sup>[14,15]</sup>
- Addressing the issue of women being under-represented as invited speakers at conferences should be a priority for organising committees. Women should have increased representation in conferences, as panel organisers and as invited speakers and experts, to ensure gender equality.<sup>[16–20]</sup>
- Professional societies and panel organisers must have speaker diversity policies and codes of conduct<sup>[20–23]</sup> to ensure their speaker lists represent their entire community, and that they provide a safe, respectful and inclusive environment for all members to thrive.

## Conclusions

Considerable effort has gone into collecting and analysing the data and identifying contributing factors for gender inequities in STEM. Numerous recommendations have been proposed to combat inequities. It is now up to us – individually and as a society – to enact the necessary cultural and leadership changes to support the career development of women in STEM and the caring opportunities for men. When those changes happen, we will make visible the invisible women of STEM, we will achieve our full potential as a society, and we will be the best we can be.

## Conflicts of Interest

The authors declare no conflicts of interest.

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