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GUEST EDITORIAL

The impact of diversity, bias and stereotype: expanding the Medical Physics and Engineering STEM workforce

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Introduction

The demand for individuals with a science and maths based education is growing worldwide with predictions that over 20 % of all future occupations will require at least a basic degree with a maths or science major [1, 2]. The diversity of jobs is increasing with new occupations also being created; with each year there will be greater competition to persuade talented people to take up ACPSEM (Medical Physics and Engineering) [3] supported careers. In parallel with this general growth is the increasing demand for medical physicists and engineers to meet the health needs of the population aligned to the increasing incidence of cancer and increasing cancer care infrastructure [4].

Attracting students into the science, technology, engineering and mathematics (STEM) fields is challenging in the first place; attracting girls is more difficult than attracting boys. Girls undertake maths and physics at school and university at about a third of the rate of boys and men. The reasons behind the low numbers of girls and women taking up careers based on science and maths is due to a host of factors which start impacting participation in primary school. Numbers drop further as women progress through to university and move into employment. This attrition means a significant cohort of talented women are lost to the science community and it is a loss that we can ill afford. To meet continued need it is imperative to address this loss.

"The most widely asserted argument for the importance of reaching gender balance in STEM fields is based upon economics. The economic imperative drives much of the international debate on STEM enhancement, with concerns for human capital, innovation and productivity at the forefront of this strategy" [5] Women are an under-utilised resource which impacts negatively on economic growth; innovation is fed and experimental capacity peaks when teams are constructed with equal proportions of men and women [6].

To help address these deficits we need to identify the causes, the factors influencing choice and figure out how we can ameliorate against them. This editorial will highlight the key areas of concern and aims to raise the consciousness of the readership to the biases at play. The primary focus will be about engaging women and girls in science and across into ACPSEM careers, but the thoughts and premise can also be applied to other demographic groups.

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STEM and the ACPSEM

In 2015 the ACPSEM conference dedicated a session to its women members. The 2015 World Congress included Women in Biomedical Engineering and Medical Physics as a key theme. The ACPSEM website has dedicated pages to Women, Science Engineering and Medicine. As a person involved in the ACPSEM have you noticed or clicked the link? [3] Have you read the title and glossed over it as unrelated to your work, your gender, your job? A pertinent bullet point is tucked away at the bottom of a page:

> But what a growing number of published studies show is that people who consider themselves to be highly objective might just be the most biased decision makers of all. Until we acknowledge our unconscious biases, we can't address them. This is why we need to think—and talk—about sexism in science.

Women employed in STEM fields still face significant career test points based on their gender. Men face different challenges at work. Men's choices tend toward multiple opportunities and expectations at work; women's experiences rest on too few opportunities and too many barriers to success. Identifying and addressing gender disparities in STEM is a shared responsibility and one the ACPSEM must address to retain relevance in a competitive market.

Grass roots change, individual engagement and awareness of bias is key to improving access and promoting change to address concerns around increasing participation rates of women in Medical Physics and Engineering. Big picture change and policy decisions are critical but individual action promotes cultural change. Consider if you are passively or actively enabling talent to be recognised and encouraged? Do you reflect on your own opportunities and consider if they were fairly "won"? Are you planning for the future of your profession or just planning for your own professional future?

There are many factors at play which influence how people come into science to work and how successful and satisfied they are in their jobs. How the work of Medical Physicists and Engineers is valued and supported externally by government, hospital administrators, universities, the public and students is influenced by our work product, how we promote ourselves and our working culture. How we value our work internally, with our colleagues and how well we work together and collaboratively to improve the outcomes for patients does depend on how well we respect each other. There is plenty of scope for scientists and engineers to acknowledge our bad habits when it comes to accepting the benefits of diversity and to know when we are making presumptive gender based decisions. There are multiple overlapping biases that shape the confidence of females in STEM and for every successful woman there are a number who have stepped back, early or late in their careers, or even before starting, because the negative messages have won out.

You were appointed on merit weren't you?

The concern

A common point of view is that appointments should be made based on merit and that quotas are counterproductive. But what does merit mean, how is it assessed and how are judgements applied? Are quotas a positive strategy? And how do we implement them?

Assessment of skill set, track record and the opportunities people have had to succeed all feed into assessments of merit. How men and women rate their own skills varies; self assessment is unreliable. Women tend to underestimate their own skills [7] and attribute success to luck and team work rather than directing the focus to their own talent [8]. When women and men are equally capable, women's skills are downgraded by potential employers and mentors [9–11]; women need to do more and be more to be considered equal to men. Women are also cautious and risk adverse when applying for jobs. Women only feel confident when they feel practically perfect [7]. The fear of failure is high for women [12]. Experiences throughout school and university and expectations of women to perform consistently at high levels works in opposition to them taking professional risk. Men are not held back by such concerns. Women's mistakes tend to be noticed more and remembered longer than men's, women learn early to be cautious [8]. Men will apply for a job when they meet 60 % of the key selection criteria whereas women will only apply when they meet all the criteria [7, 13]; thus appointments are not on merit or skill but rather from the pool of applicants which often exclude suitable women. Furthermore, when assessing applicants men are more likely to be promoted on potential, and women more likely to be promoted on proven performance [14]. Thus there are the combined effects of self selecting out of consideration based on lived experiences, prejudicial gendered assessment of potential versus proven ability, and discounting of equivalent skills of female versus male applicants.

Appointment on merit is a fraught term. 'Merit' is subjective not objective. There is no level playing field and failure to consider the implications on the unharnessed talent of women is negligent when trying to appoint on merit. Often women's advancement is dependent on

whether they are lucky enough to have a manager or sponsor who is supportive and inclusive [15].

Use of quota's for appointments are also fraught, but they do accelerate the achievement of diversity that may otherwise only be achieved at glacial pace. "It is almost impossible to break down and redefine merit until you get more women and more people of different ethnicities into (the) group. It's a bit chicken and egg but targets or quotas have consistently worked to breaking down and to make the definition of merit more equitable." [16]. As far as appointment and gender diversity are concerned it would be interesting to break down not just the representation of women across Medical Physics and Engineering but to also look at the appointment levels and the female head count in all health care providers and supporting industries, with an eye on measuring how much diversity is in evidence and to inform where there is room for change.

Countermeasure

Appointment on merit is difficult. Identifying the meaning of merit and how it is measured and accorded value is important in discussing merit per se. Recognizing and acknowledging the experiences of applicants for various roles should stretch an individuals' assessment of their own behaviours and the evaluations that sit behind decision making when assessing others. Recognizing the differences in self promotion and self assessment between men and women should be weighed when assessing the right person for the right job. Actively encouraging women to apply and proactively seeking to diversify the workplace will support a more inclusive, creative and agile workforce.

Organisations could adopt more flexible job descriptions where selection criteria are structured as desirable not essential. Interviewers should also assess interviewees with an awareness of the confidence versus competence difference which may be in play.

One approach to actively increase the representation of women in STEM fields is by only considering applications from suitably qualified female candidates, a strategy aligned with the Victorian Equal Opportunity Act 2010 [17] for "the purpose of promoting or realising substantive equality for members of a group".

A level playing field for men and women

The concern

The low representation of females in STEM employment needs to be addressed and supported by men and women for men and women. Unequal representation has significant economic drawbacks, will stultify innovation and will erode scientific enquiry. To increase representation we need to find ways to transform workplace norms and structures that reinforce gender inequalities [15]. "A study of men working in US universities suggests male scientists hold strong work devotions, yet a growing number seek egalitarian relationships, which they frame as reducing their devotion to work. The majority of men find the all-consuming nature of academic science conflicts with changing fatherhood norms." [18]. This summary could quite readily map across to men [or women] undertaking engineering work, clinical research or commissioning work which often requires unsociable hours. To enhance our workforce, we need to address both sides of the equation and to make the equation equal.

Flexibility needs to be granted to men as well. This enables their female partners to return to work/work longer hours. It also means the workplace is not dominated by full-time males and part-time females. The problem is not just enabling women to work flexibly, but enabling men to as well. This allows women to return to work to a greater extent and "levels the playing field" as both women and men are working flexibly. The dominant culture is that it is acceptable for women to work part-time but not men [19].

Men need space, both culturally and literally, to discuss issues particular to their gender. Often men will not discuss issues that are affecting them openly, such as difficulty accessing flexible work [20].

The countermeasure

Balancing the workforce equation has benefits across the board. Boys engaged in championing gender equity learn understanding, respect and personal responsibility while also being exposed to alternate futures for themselves, when balancing work and life options.

Proactive measures can be undertaken by Industry or Employers to address gender bias [5]. Mooted solutions include scholarship programs for female students, industry events at schools and university campuses, ensured gender pay equity (especially relevant in private enterprise), flexible work practices (including part-time, job share and leave of absence), mentoring programs, child care facilities, management awareness and training, and an organisational mission to recruit equal numbers of male and female graduates.

For many men, gender is something they see as a 'woman's issue'. Until men recognise that they face issues particular to their own gender, and that it is important to address them, gender equality will not be achieved. [20] STEM workforce strategies need to include alternatives for men.

Identifying successful leaders of both sexes to serve as mentors to females and provide advice and encouragement based on their own experience, helping them build

networks and encouraging them to embrace career opportunities should be readily achievable within the ACPSEM community.

Acknowledging and closing the gap between thought and action is necessary to equalize numbers of women and men in STEM to create a resilient, flexible workforce.

Unconscious and implicit bias

The concern

Everyone is biased to some extent or another and these biases influence our every day behaviour. Explicit bias is easy to identify whereas the more subtle impact of unconscious and implicit bias on our actions is harder to recognise. Unconscious bias occurs when hidden behaviours influence a decision. It refers to bias that we are unaware of; it happens automatically and is triggered by our brain making judgments and assessments of people influenced by our own background, culture and personal experiences. Implicit bias refers to the same prejudice but questions how unconscious this bias is when we are being made increasingly aware of its existence [21]. Subtle gender biases are held by even the most egalitarian individuals [9] so the concern is how do we account for our own biases and those of others, and how do we identify our 'blind spots'?

Implicit gender biases are more prevalent today than explicit gender biases are [22]. Girls begin to lose confidence in their maths ability and differ increasingly from boys in this regard as they move into high school [23]. Implicit associations between math and gender have been shown to be in place by age 7 or 8 [24]. Our best chance to influence implicit biases may be to expose girls and boys to positive female role models in, science, engineering and computing early in life [25, 26]. A role model's effect on young women's STEM self-efficacy was reported as greater when the role model addressed gender inequity in STEM fields [27]. Consideration should also be to given to the train of thought that when all of the pressure to be a role model is placed on women in STEM, diversification may come to be seen as a female issue rather than a societal issue. Sharing the responsibility with men can ease the pressure on women in the field to assure that their gender is well represented in STEM while allowing them to concentrate their efforts on the retention of other women [28].

Consider if you have ever applied for a job and been tempted to anglicise your surname, remove your female pronoun or delete your date of birth. If so then you are aware that bias may impact your chance of success. Have you ever surprised yourself by assuming the man in the room is the professor or the manager to find out you overlooked the woman in front of you when seeking out the 'expert'? If you have assumed the man in the room is the expert then you have run into some of your own bias.

Unconscious sexist bias is alive and well in science. A very recent example of bias was given by Professor Nalini Joshi, an Australian Laureate Fellow and Professor in the School of Mathematics and Statistics at the University of Sydney, who commented that she is often mistaken for the wait staff if she dresses in a black suit at formal functions. Another female expert, Professor Tanya Monro, Deputy Vice Chancellor Research and Innovation at the University of South Australia offered a helpful tool for identifying double standards. Professor Monro noted that she was often introduced as the "wearer of shoes that I design or the mother of three boys." Try it out with your male colleagues and you'll see how strange it feels [16]. Women are just as susceptible to unconscious bias as men [9] and it is important for men and women to work on eliminating or reducing the influence of bias on decisions.

The countermeasure

Acknowledging that unconscious bias exists will go part way to reducing its effect. Being aware of one's own biases and allowing sufficient time to make in-depth and individualized evaluations based on the person can reduce the influence of gender biases [22, 29–31]. Finding tools and strategies to separate skill set evaluations from gender is beneficial to identifying talent.

Redacting or disallowing personal details [name, gender, age and location] from job applications has been shown to reduce gender bias [32] and is being trialled by the Victorian Government in 2016. In a study testing this approach at the University of Connecticut [33] the following thought was raised whereby "this procedure would eliminate the opportunity for compensatory evaluation of letters from female applicants, in full consciousness that letter writers themselves tend to skew their evaluations positively toward males." This was a difficult argument to counter. Given the lack of data on compensatory positive bias, the committee still felt that "a gender-blind search, although it was not perfect, was a worthwhile goal".

Giving people training and strategies on how to address their biases will empower them to change and to help people know what they are going to do when a bias evident situation arises [21]. A Harvard University supported collaboration "Project Implicit" offers an online tool, the implicit association test (IAT) where a person can test their own bias [34].

Diversifying workplaces creates environments where new associations are formed and 'friendship potential' comes into play. Friendship potential is seen as a key factor

to successfully affecting prejudice, thus enabling heterogeneous teams to be built, which in turn solves problems. Minimising the impact of bias in decision-making is not just a 'nice to have', but something that potentially increases efficiency and quality [21] and delivers superior results to homogenous workplaces.

The Impact of stereotyping

The concern

Stereotype threat is a term used to capture all the nuanced expectations and judgements that stereotypes impose on a person.

The existence of stereotypes and awareness of stereotypes impacts on a person's ability to rate their own abilities objectively. Stereotypes can have a negative or a positive impact on an individual's self assessment and performance. Recognizing this impact and reducing its influence is the challenge.

"Stereotype threat refers to being at risk of confirming, as a self-characteristic, a negative stereotype about one's social group. When one views oneself in terms of a salient group membership [e.g., "I am a woman. Women are not expected to be good at math." and "This is a difficult math test."], performance can be undermined because of concerns about possibly confirming negative stereotypes about one's group. Thus, situations that increase the salience of the stereotyped group identity can increase vulnerability to stereotype threat." [35]. Stereotype threat can manifest as negative effects on academic performance of females in both school and university [36, 37]. Stereotype threat has been identified as directly affecting the enrolment in STEM subjects at school and university by females.

Stereotype threat has many consequences [38] which can directly impact performance at interview and career progression. Stereotype threat also manifests in the workplace and can lead to a cascade of processes including reduced engagement, reduced or changed career aspirations, higher stress, poorer performance and higher failure rates [39]. Failure can reinforce the stereotype threat [37] and "could be interpreted as evidence of supporting the stereotype" [40].

The countermeasure

Acknowledging the pervasive elements of stereotype threat at both institutional and individual levels should improve workplace success. Even identifying it exists is a step towards reducing its impact.

Increasing personnel diversity, actively identifying similarities amongst group members and actively promoting the value of difference to problem solving are interventions that can be adapted in the workplace to counteract stereotype threat [39]. When teams are made up of people from many demographic groups the 'otherness' of an individual is less apparent.

Confidence, competence and leadership

The concern

The difference in confidence and self-efficacy between men and women is significant. Men are predominantly much more confident in their abilities than women [7]. Confidence is often aligned by individuals and external reviewers as reflective of competence. This relationship is not true and dissolving that perception will result in more women working at their optimum.

Current workforce structures work against women building confidence. Women lack role models, they have to work harder and push against bias and prejudice to be successful and when they are successful they are not lauded. Their confidence is undermined throughout their schooling and throughout their STEM careers. They aren't seen as leaders and they are considered less competent than equivalently skilled men. Their confidence is systematically challenged as they are continually held to high expectations with ad-hoc support. Significant female talent is being undermined and wasted [23, 39, 41, 42]. Even when women display the qualities considered important for leadership they are viewed less favourably than men; there are built in failure points at every turn. Perpetuating the behavioural expectations of men and women limits our STEM workforce and limits progress across the board.

"Not only are women needed in these fields, women are needed to be leaders in these areas both for their own sakes and to serve as role models for the next generation…. in pursuit of the critically important goal of truly equitable participation in STEM" [43, 44].

The countermeasure

Work is needed to build up women's presence in the STEM workforce via a combination of opportunity, access, visibility, acknowledgment of success and acceptance of failure. Building female self-efficacy in the face of multiple challenges will be more readily achieved with wide support. It's not acceptable to leave change to someone else; when opportunity comes down to gender every woman is disadvantaged and every man is diminished. Male champions of change are critical. Men must create ways for women to succeed; women need real opportunities created and barriers removed [45].

Building up women's confidence is required to lever them into roles which optimise their talent. There are a number of way's confidence can be achieved. For example alerting managers to the confidence gap between male and female employees can help managers provide wise feedback as part of performance review and development. Alerting women to the differences in competence and confidence may help them rethink their employability paradigm and encourage them to ask for more, to aim higher and to value their skills appropriately.

Girls need to be engaged from a young age to explore the fields of STEM. Expectations of perfection need to be demolished and we need to give girls confidence in their knowledge base. Encouragement to try and fail and try again needs to be given to girls and we have to praise their attempts [46].

We need to empower girls and teach them about what lies ahead in school and work. Girls who learn about gender discrimination show increases in science self-efficacy and belief in the value of science [27]. Engendering high levels of self-efficacy in girls and women will improve the representation of women across the STEM arenas. It will allow women to reinterpret past negative feedback about their own and females' performance in science to discrimination rather than lack of ability [30]. We need to encourage women to lead and to build their self-belief [39]. "If more women survive and thrive in their careers, you'll have more women and a more diverse leadership, and that also is important for institutional change" [8].

Diversity

The concern

The lack of women in STEM limits progress. How to increase workplace diversity, attraction and retention of skilled women is a key driver for maintaining the relevance of the STEM dependent ACPSEM professions. Embracing diversity allows for the capture of unique opinions and ideas and improved problem solving. Lack of diversity results in sub-optimal 'group-think' [20].

The countermeasure

Diversity in work groups and the increased participation of women is widely linked to positive outcomes, such as greater innovation and productivity and improved economic benefit. Increasing female representation is not easy as it requires a multitude of subtle and sometimes overt biases or detractors to be identified and overcome. Useful transformation requires all people, and particularly people of influence to make changes in their workplace, their teams and their organisations. It's likely that a certain amount of cultural change is needed to make progress. People often feel more comfortable with others like themselves however there are significant and measurable gains to be had by diversifying groups. The alternative, where there is homogeneity within groups, has been shown to hamper the exchange of different ideas [44, 47].

Numerous studies have connected a higher representation of women at all levels of organisations, from board members to employees, with better outcomes [22]. To enhance productivity and creativity, diversity must be increased and more women are needed. Creating a more inclusive and diverse workforce is a prime concern in expanding the ACPSEM workforce.

Diversifying the ACPSEM workforce must occur to maintain a critical number of properly skilled members. The numerous challenges to enabling diverse recruitment have been reviewed above. To improve physicist and engineering numbers deliberate actions to support and promote women need to be undertaken at all levels. Reorganisation of workplaces, work paradigms and recruitment strategies along with personal introspection will be required to open up opportunities to previously discounted women.

Other non-workforce strategies for inclusiveness should be easy to achieve. Relatively simple considerations such as being mindful of office decor and setting the tone for workplace diversity should be reviewed. Halls decorated with photos of senior management and executives that represent Caucasian males may trigger doubt that women and minorities can advance in an organization [39]. Other images should also be reviewed from the point of view of 'the other'. Take these images down.

Increasing the diversity in key note speakers at conferences and on professional councils is a public demonstration of diversity embraced. Diverse interview panels and flexible work places should help retain men and women. Having a mission statement which identifies diversity as a goal or aspiration can help set the tone for an organisation and behaviour. Training people to recognise the value of diversity and giving them the skills to make change is needed; we need people at all stages of their careers to talk-the-talk and walk-the-walk.

The finkbeiner test

The concern

What matters in stories about women scientists? How can we quickly review the different ways in which women and men are considered? When it comes to considering 'the

other' point of view the following test highlights some very common habits when reporting on female success.

The Finkbeiner test [48] was developed to help journalists avoid gender bias in media articles about women in science. To pass the test and to measure gender bias a story cannot mention

- The fact that she's a woman
- Her husband's job
- Her child care arrangements
- How she nurtures her underlings
- How she was taken aback by the competitiveness in her field
- How she's such a role model for other women
- How she's the "first woman to…"

The above test may appear to be in opposition to raising the profile of women in science; by not highlighting that they are women. However the somewhat tongue in cheek goal is to highlight the different measures and questions asked of women and men.

The countermeasure

Applying some of these simple questions to all candidates for a role can help flesh out the validity of judgements being made between male and females. "The solution here is not to start excluding those points from profiles of women, but to start including them in profiles of men" [49]. We need to broaden our expectations of role and listen for gendered language judgements.

Conclusion

Ideally everyone would enjoy the same opportunities to succeed, but they do not. The pathways to success in STEM careers are strewn with potholes and pebbles for women while men benefit from more evenly paved and signposted routes. Addressing the disparate experiences of men and women will bring about positive improvements for all. Positive action and policies will harness the best skills and knowledge available to tackle the economic imperative which requires diversity to be achieved.

Demand for skilled workers in STEM fields will increase every year. Medical physicists and engineers need to build work environments and cultures that are attractive for all. The ACPSEM has a distinct role in setting the tone and professional expectations of its members. A revamp of the code of ethics would be timely with a greater emphasis placed on establishing workplace diversity. An aspirational mission statement in support of expanding opportunities for all ACPSEM members, and disavowing bias could set a fresh framework of expectations. To maintain relevance and market appeal we need to grow our numbers and increase our market appeal to future members to expand our range of talented people.

As scientists and engineers we should acknowledge the impediments facing girls and women, based on the evidence, and work on solutions to the problems. We need to continue to talk about sexism in science. We need to acknowledge the systematic challenges females face; the messages they receive which do not enable them nor result in the best use of their talent; messages and experiences which do not engender innovation and quality improvements. We should advocate as individuals and as an organisation; through policy and action to attract and retain talented women in physics and engineering. We should call out inappropriate commentary; we should recognise the power of language and the value of diverse and equal representation. We should not settle for the status quo but rather aim for workplaces which are genuinely equitable for both women and men. We should not rely on somebody else to make the change.

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