FUTURE OF WORK LAB

Research and literature review

EMERGING LEADERS' LAB: WOMEN IN STEM

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Outline

The *Emerging Leaders Lab: Women in STEM* pilot program has been designed using evidence-based practice. The aim of the program is to reduce the attrition rate of women in STEM between university and employment. As a critical stage of the 'leaky STEM pipeline', extensive research has helped identify the best approach for increasing the engagement and retention of young women in the industry. While there are many initiatives supporting this sector of women throughout Australia, the *Emerging Leaders Lab: Women in STEM* will be the first program to target young women across all STEM faculties as they transition into their careers. The program will offer leadership training, supportive mentorship, and inclusive networking. This is a critical group for The Future of Work Lab to engage with, as an estimated 75% of the fastest growing occupations and high-status jobs will require a strong STEM background (Redmond & Gutke, 2020). Hence, it is more important than ever that we encourage and support women in STEM. The following research further outlines the program's aim and design.

The ‘leaky pipeline’

Strengthening the pipeline for women in STEM between university and employment.

Policies for women in STEM

Following an assessment and policy analysis of the Australian Governments ‘Advancing Women in STEM Strategy: 2020 Action Plan’, it became apparent that this critical group of women were being consistently overlooked by strategies aimed at increasing their participation in the workforce. For women that were at the stage between tertiary degree completion and career transition, policies such as the 2020 Action Plan failed to recognise that this was the point in which the highest rate of attrition for women in STEM was occurring. Rather than attempting to strengthen this stage of the pipeline, government policies have often addressed the education and employment of women in STEM separately. This was certainly the case for the 2020 Action Plan, as Phase One focused on “Enabling STEM potential through education”, while Phase Two addressed “Supporting women in STEM careers”.

The leaky pipeline

Bilimoria & Liang (2014) describe the leaky pipeline as a metaphor that “has been used to describe institutional level (cultural and structural) impediments to women’s participation and advancement in STEM careers, describing the problems, barriers and resource inequities faced by women at each key transition point in the academic/ career pipeline” (p. 146). Bhatia & Amati (2010) noticed that even with the increase in the number of women obtaining STEM degrees in recent years, the phenomenon of the leaky pipeline shows that the percentage of women declines at each level of education. Dennehy & Dasgupta (2017) identified that the first two years of university is when the greatest rate of attrition from STEM degrees occurs; whilst Marinelli & Lord (2014) noticed that low participation rates are attributed to smaller numbers of women enrolling into STEM courses compared to men and a high attrition rate from the industry post-graduation (p. 101). Furthermore, Male et al. (2018); Male & MacNish (2015); and Redmond & Gutke (2020) each concluded that despite current statistics that women are academically more successful than men as STEM students, they leave the profession at a higher rate than their male counterparts. In 2019, only 36% of women enrolled in an Australian university completed their STEM degrees (STEM Equity Monitor 2021). While women made up more than half of the enrolments and completions in “agriculture, environmental and related studies”, and “natural and physical sciences”, they were considerably underrepresented across “engineering and related technologies”, and “information technologies”. Redmond & Gutke (2020) argue that this underrepresentation is both progressive (working over the course of higher education) and persistent (over time).

Causes of attrition

There are multiple reasons for the high rates of attrition amongst women in STEM. Reinking & Martin (2018) found that negative stereotypes and socialised ideas, particularly regarding STEM capabilities, significantly contribute to women leaving the STEM pipeline and professional field (p. 149). Negative stereotypes and gender bias then filter into workplace cultures and marginalise the professional identities of women in STEM (Male et al., 2018). Low self-efficacy and imposter syndrome often develop as a result of workplace marginalisation. Faulkner (2009) developed the idea of the 'in/visibility paradox', whereby women in STEM are simultaneously highly visible as women, yet invisible as engineers, scientists, and mathematicians (p. 169). Their visibility as women brings contradictory pressures – to be "one of the boys" if they want to be taken seriously in their career, but at the same time "not to lose their femininity" if they wish to promote organisational change and gender equity in the workplace. Despite a large number of STEM businesses introducing initiatives to attract female employees, such as graduate programs, McIlwee & Gregg (1992) discovered that within 10 years of graduating most women occupied lower status STEM positions than similarly educated men.

Proposed strategies

To attract and retain women in STEM, the International Women in Medical Physics and Biomedical Engineering Task Group proposed the following strategies: '(a) identify and promote female role models that achieve successful work-life balance, (b) establish programs to develop female leaders, (c) create opportunities for females to increase the international visibility within the scientific community, and (d) establish archives and databases of women in STEM' (Barabino et al., 2020). Nowak et al. (2014) agree with the first strategy, that 'an important objective in seeking increased retention rates is to build a critical mass of women who can become role models for women to follow' (p. 57). Atkins et al. (2020) believe that this can be achieved through formal university-led programs (p. 1). Workforce participation and the representation of women in STEM may increase if programs are designed with the intention to foster scientific community, expose students to research and mentorship, and improve academic and career outcomes. Bilimoria et al. (2014) further recognise the importance of these pursuits on the advancement of leadership positions for women in STEM (p. 3). Finally, Clark et al. (2021) stress that initiatives and literature on engaging women in STEM must concentrate on the later stages of the pipeline. While early timepoints are critical in the formation of STEM interests, the mechanisms that predict sustained engagement following initial career investment and demonstrated skill at the undergraduate and graduate level are equally essential for the retention of women in STEM fields. Thus, "research on graduate students is critical for understanding how individuals at later stages of STEM engagement continue to engage with or disengage from their STEM disciplines despite their earlier investment and commitment to STEM" (Clark et al. 2021, p. 2).

Mentoring

Facilitating mentorship between women in STEM that are a stage apart in their career progression.

Identity development

Recent studies show that mentoring is instrumental for underrepresented university students persisting in STEM careers. Wrighting et al. (2021) argue that effective mentoring relationships not only catalyse career development, but also directly and indirectly strengthen identity and belonging in the field. Atkins et al. (2020) similarly recognise that the development of a student's scientific identity through mentoring can improve academic performance, retention, and STEM degree completion (p. 2). With this in mind, mentorship is usually prioritised by programs that aim to increase diversity and support future leaders in STEM fields. For instance, one qualitative study following women of colour in the United States from their undergraduate degree into STEM careers, found that the women's identity was meaningfully shaped by receiving recognition as scientists from others, including from their mentors (Atkins et al. 2020, p. 2). Dennehy & Dasgupta (2017) similarly concluded that same-gender mentoring "during development transition points promotes women's success and retention" in STEM, which yields dividends over time. They reiterate that mentoring whilst at university is an effective intervention to increase belonging, confidence, and motivation. Barabino et al. (2020) reported that a 1-year study from the University of Massachusetts showed "better professional achievements of female engineering students when mentored by women as compared to those that were mentored by males or not mentored at all". Female students paired with female mentors felt more motivated, self-assured, less likely to drop out of their courses and more determined to look for STEM jobs after graduating. While there were some exceptions, it was concluded that men were not able to catalyse feelings of belonging as female mentors could.

Role models

The development of professional STEM identities has also been linked to exposure to STEM role models. Reinking et al. (2018) determined that when students see women working as scientists, engineers, astrophysicists, computer programmers, and so forth, their interest in STEM increased (p. 151). For women early in their STEM education and career, providing high-achieving female role models who have overcome initial difficulties is known to have a positive effect on career development. Studies have also shown the exemplary function of role models amongst women in STEM on goal setting, attitudes and stereotypes, and academic and professional choices in STEM (Stoeger et al. 2013). As the role of a mentor is to support the mentee, share information about their career journey, and to assist in the development of skills mentees would need to achieve their career goals, Redmond & Gutke's (2020) research concluded that "mentors who are close in age to student participants have been highlighted as having the most effect". Stoeger et al. (2013) agree that mentors who are as similar as possible to their mentees, with respect to age, are particularly effective as role models for women in STEM. Thus, our pilot program is seeking to connect student mentees with professional mentors that are one stage apart in their career paths. In sum, Bhatia & Amati (2010) reiterate that mentoring programs for women in STEM provide students with role models that can provide support networks, encouragement, and confidence in their academic and career pursuits.

Self-efficacy

Barabino et al. (2020) identified that self-efficacy has the greatest impact on determination and confidence in personal abilities. As a result, research has demonstrated that self-efficacy is augmented by observing successful role models as discussed above. They go on to argue that it is "more useful and enriching if the mentors and mentees are coming from different disciplines and even from different institutions as they can bring new opinions and perspectives and are not bound by processes and relations in the institution of the mentees" (Barabino et al. 2020). This also ensures that a higher number of women are able to participate as mentors in the program. In turn, there is a stronger encouragement for female mentees to follow through with their STEM careers as they are introduced to a wider range of career paths. Consequently, the intention of the pilot program is to engage students across all STEM faculties and industries for this reason. For instance, Atkins et al. (2020) highlight how a 2007 review of strategies to increase diversity in STEM found that mentoring programs for women can lead to higher grade point averages (GPAs), increased self-efficacy, and more clearly defined academic roles (p. 2). Dennehy & Dasgupta (2017) similarly determined that mentorship is particularly important for women during their first years in university, as this is when they are the most vulnerable to self-doubt. As female mentors can promote feelings of belonging and connection with other women, students become more inspired to pursue careers in STEM following the completion of their degree. Ultimately, women's subjective experiences in STEM, notably their feelings of belonging and self-efficacy, influence retention and career intention in the field (Dennehy & Dasgupta 2017).

Organisational change

As mentorship programs encourage relationships that are mutually supportive, with both the mentor and mentee benefitting from participation in the program, an intended outcome of the pilot program is that mentors will be inspired to promote organisational change from within their STEM industries (Redmond & Gutke 2020). Referred to as the 'bifocal approach', this program design transforms mentoring programs from being a career boost for individuals to an organisation change strategy designed to benefit mentees, mentors, and organisations (de Vries, 2010). This approach emphasises facilitating and supporting two-way development mentoring relationships. Within STEM this would see mentors advocating for greater female leadership, and less workplace stereotyping and gender bias. With this, we hope to see an increase in supportive networking for women in the sector to normalise a sense of belonging and inclusion. As there is no one defining 'glass ceiling' moment for women in STEM, but rather many obstacles along the way, de Vries (2010) see's career development for these women as a labyrinth that can be navigated together through mentorship.

Leadership training

Providing accessible leadership training for women in STEM early in their careers.

Gendered barriers

Research on women in leadership within STEM sectors reveals that professional development, networking, and mentoring (receiving and providing) are central to career success and sustainability (Nowak et al. 2014, p. 73). Despite this knowledge, progress into senior roles is best described as slow for women in the STEM workforce. Bilimoria et al. (2014) note that the lack of a critical mass of women in STEM at all ranks and in leadership is well documented. However, they suggest that more research is needed in the area of leadership, as previous studies typically focus on the reasons why women leave or fail to succeed long term in STEM careers more broadly (p. 4). Eagly (2021) notes that in today's climate many social scientists reiterate that "women still face formidable barriers that exclude them from STEM and leadership" (p. 89). Women not only face general exclusion from these fields, but also considerable variability in ease with which they can occupy specific roles within the industry. It is suggested that "because gender stereotypes ascribe greater agency (assertiveness, competitiveness) to men... and greater communion (kindness, compassion) to women, the agentic qualities accorded to many male-dominated roles tend to place women at a disadvantage" (Eagly 2021, p. 91). Nash et al. (2017) similarly comment on the gender difference in leadership styles which often ascribe collaborative and participatory styles to women, while men are often reported as using direct and controlling styles (p. 2). Many female STEM university students internalise these stereotypes and discount their own leadership potential early into their degree, often leaving the academic environment of STEM altogether. Daldrup-Link (2017) suggests that the STEM industry must create a culture where female talent does not drop out physically or mentally (p. 807). As women often report that they need to work twice as hard as men to be viewed as equal in STEM, it is important that the sector works towards eliminating marginalising stereotypes and creating more supportive workplace and educational environments. Daldrup-Link (2017) argues that women in leadership programs could be the catalyst to provide these new perspectives to the STEM workforce (p. 808).

Impostorism

Women in STEM have frequently cited that they struggle with feelings of impostor syndrome. This refers to "the feeling of being a fake in terms of professional career or academic success" (Dominguez-Soto, Labajo & Labrador-Fernandez 2021, p. 2). There is concern that the impostor phenomenon could inhibit the development of transformational leadership for women in the industry, as employees that feel like impostors typically report less career planning and motivation to lead. Dominguez-Soto et al. (2021) concluded in their research that impostorism negatively influences the interest of minority students in pursuing a career in STEM (p. 1-3). Clark et al. (2021) argues that these feelings of impostorism are greatly influenced by biased and sexist STEM environments (p. 3). Experimental evidence demonstrates that women in STEM fields are particularly vulnerable to developing academic impostorism. They recognise that for women, "being in a numeric minority in an academic field in which negative stereotypes about one's abilities are present and in which natural ability is valued over effort may activate the doubts impostors feel about their skills and successes'' (Clark et al. 2021, p. 4). Consequently, negative stereotypes lead to gender bias in evaluations of competence and potential leadership, as well as in hiring decisions and discussions of salaries. This deeply impacts self-efficacy and sense of belonging, which correlates with higher dropout rates for female STEM students (p. 7). However, many studies have discussed how leadership programs have been developed to help women discover and enhance their own leadership style and become more confident and assertive in order to overcome impostorism (Daldrup-Link 2017, p. 285).

Networking

These cumulative factors highlight the need for and importance of supportive networking for women in STEM. Bhatia & Amati (2010) claim that "equally important to obtaining and succeeding leadership roles is developing support networks with peers". They emphasise that such networks are particularly important for women early in their graduate careers, to help build their confidence and provide them with personal and professional support. Catalino & Marnane (2019) suggest that women-only leadership programs offer women the opportunity to examine their strengths and shortcomings in the psychological safety of their peers. Thus, networking experiences within leadership programs can be used as a springboard for personal and professional development in a supportive and inclusive environment that is free from gender bias and stereotyping.

Professional development

The research discussed above indicates that innovative professional development approaches are needed to address the ongoing lack of women leaders in STEM careers. Van Oosten et al. (2017) stress that "the goal is to provide women with knowledge, tools and a supportive learning environment to help them navigate, achieve, flourish, and catalyse organisational change in male-dominated and technology-driven organisations" (p. 1). Previous organisational efforts to create gender equitable leadership has primarily focused on reducing discrimination and promoting diversity and inclusion through company-wide policies and programs, yet it is becoming increasingly apparent that such initiatives in the STEM sector have failed to create a more gender diverse workforce participation and leadership. Rather, female STEM professionals continue to experience real barriers to advancement, retention, and leadership (Van Oosten et al. 2017, p. 2). Given these barriers, organisations must implement programs for professional development that are tailored to the gendered context of women's careers and education in STEM. Van Oosten et al. (2017) believe that since women learn through shared stories of success and struggle, women-only leadership development programs are the most effective (p. 3). Program learning objectives could include a) helping women in STEM understand the complex factor impacting their careers in male-dominated professions; b) recognising the value women bring to the STEM workplace; c) exploring factors for leadership effectiveness; d) and developing strategies and skills to flourish professionally. Daldrup-Link (2017) suggests that supporting the development of female leadership in STEM could be achieved using a two-pronged approach. First, empowering women through educational training platforms and second, creating an environment in which women are given equal opportunity to develop as their male coworkers (p. 285). Catalino & Marnane (2019) agree with this second point, stating that "the most valuable lessons of women's leadership. programs are those that show organisations where to improve". Thus, STEM organisations can use such programs to not only improve the skills of their female labour force but also to assess and improve the workplace itself (Catalino & Marnane 2019). It is emphasised that such methods should be cultivated in the early stages of a women's career as an undergraduate and postgraduate STEM student. Finally, Nash et al. (2017) concluded that to facilitate the development of women's leadership identities, women-only programs must recognise and address the subtle and pervasive effects of gender bias so these women may establish a stronger sense of self and relationships with other women in the sector (p. 2-5). As such, "a critical point for women, then, is that organisational contexts and/or leadership expectations are gendered and recognising gendered variations in organisational contexts may be key to enabling women to be effective leaders" (p. 13).

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