

EXPLORING GENDER DISPARITIES IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS: UNVEILING REASONS BEHIND FEMALE DOMINANCE IN THE MEDICAL FIELD IN AUSTRALIA

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ABSTRACT

The underrepresentation of women in science, technology, engineering, and mathematics (STEM) fields has persisted despite recognition of its importance in the Australia's National Science Statement. Low self-confidence to be successful in the science fields and a lack of female role models contribute to this challenge. The Victorian Cytology Services Foundation (VCS Foundation), a leader in research in advancing cytology to improve health services and products across the globe, is a female dominated workplace comprising of female scientists and laboratory technicians. This research explores why female scientists gravitate toward female-dominated fields, their experiences, challenges, and opportunities. The study employs the Scientific and Technical Human Capital (STHC) model, encompassing human capital (education, training, health), social capital (networks, collaborations), and cultural experiences (gender, race, nationality, social status, discipline). Participants were selected for semi-structured interviews to ensure inclusion of scientists and laboratory technicians across all genders and cultural dimensions. Findings reveal that female scientists often join female-majority workplaces to avoid stereotypes and discriminatory practices prevalent in the male-dominated STEM fields. Male scientists show greater interest in joining professional networks, potentially providing them with an advantage. The cultural dimension influences networking, collaboration, and career choices, particularly in a diverse workforce. Technology advancements raise concerns about job security and future career prospects. Female scientists seek female-dominated workplaces to avoid biases and discriminatory practices. The propensity of women to avoid professional networks may hinder their professional advancement. The cultural dimension plays a crucial role in scientists' interactions and career decisions. Future strategies must address cultural factors to boost female participation in STEM fields.

Keywords: STEM, gender disparities, medical sciences and females, Australia, Victorian Cytology Services Foundation,

INTRODUCTION

In 2017, Australia's National Science Statement recognized STEM as vital for future growth, highlighting the government's commitment. It also acknowledged women's underrepresentation in STEM due to early confidence issues and a lack of female role models (AGDIIS, 2019). This commitment is crucial because despite women's academic success, females remain underrepresented in the STEM field. In academics, female students also show an early interest and strong performance in the STEM field, yet their participation in the studies and workforce remains low (Student Edge, 2019). With technology-driven job growth and more women entering the workforce, this commitment is timely (Duncan, Cassells, & Tarverdi, 2018).

Like other sectors, STEM in Australia reflects gender segregation, similar to patterns in the UK and OECD. Despite government efforts, these trends persist, particularly in the leadership and male-dominated sectors. Conversely, female-dominated fields like healthcare and education have seen

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increased representation but still face pay gaps (Australian Bureau of Statistics (ABS), 2018; Workplace Gender Equality Agency (WGEA), 2019).

In Australia, the Victorian Cytology Services Foundation (Established on December 9, 1964) has been a key player in advancing cytology and women's health. Throughout its history, dedicated professionals have worked tirelessly to detect and prevent cervical cancer while promoting gender equality in healthcare and science. Women have played a crucial and lasting role in this journey. Over the years, the Victorian Cytology Services Foundation has undergone significant change, with women leading the way. From its early days in the fledgling field of cytology to today's era of advanced healthcare technologies, women have played a pivotal role in shaping the VCS foundation's path. VCS is guided by a board with 70% female representation, and its executive team is composed of 63% women (Victorian Cytology Services Foundation, 2019).

According to the 2017-18 annual report, the VCS Foundation employed 166 individuals, comprising 102 full-time, 37 part-time, and 27 casual workers. The workforce consists of 75% females and 25% males, with a fairly even age distribution spanning from 20 to 65 years. In the fiscal year 2017-18, the organization underwent changes in technology and staff restructuring, resulting in an 18% voluntary turnover rate and an 8% involuntary separation rate, leading to 27 job redundancies. The foundation boasts a diverse staff representing various ethnic backgrounds and provides equal opportunities for personal and professional development for all employees (VCS Foundation Annual Report, 2018).

This research explored why female scientists tend to work in female-dominated fields, their experiences, challenges, and opportunities. It also examines the roles and motivations of male scientists in female-dominated workplaces, as well as the impact of technology and redundancy threats in STEM.

REVIEW OF LITERATURE

Human Capital

Human capital encompasses an individual's knowledge, skills, ideas, information, and personal well-being, as defined by Becker (1964). Unlike financial capital, it evolves gradually over time (Becker, 2002), making it inseparable from the individual (Becker, 2009). Focusing on education, training, personal experiences, and well-being enhances future human capital. The model assumes rational individuals striving to attain their financial objectives (Becker, 2009; Corley, et al., 2019).

Individually, females encounter stereotypes and social biases from early education onward, which can hinder their informed decision-making regarding education and careers. While it's often assumed that girls struggle in math and science, statistics from the American Association of University Women reveal equal performance between genders, with high school girls even earning more math and science credits than boys. Unfortunately, social stereotypes and feelings of low self-esteem contribute to negative outcomes, causing many girls to disengage from STEM education, often before or during college, despite their strong interest in these fields (Girl Scout Research Institute, 2012).

Additionally, a consensus study underscores that women perceive STEM careers as being heavily patriarchal and hierarchical, exacerbating concerns about workplace issues such as sexual harassment, stereotypes, and gender bias (NASEM, 2018).

Female students encounter bias from both male and female science faculty, impacting their perceived competence and resulting in lower starting salaries and limited mentoring opportunities (Moss-Racusin et al., 2012). These biases often steer women away from STEM fields and toward female-dominated workplaces like the VCS Foundation, as research shows their preference for careers involving interpersonal interaction and helping others (Konrad et al., 2000). Hence, it can be summarized that cultural issues such as bias, stereotyping, lesser opportunities of career counselling and mentoring structure the women's views of STEM from an early age and restrict their career choices. This limitation would ultimately result in compromising the quality of future talent pool and human capital in STEM.

Social Capital

Social capital, as defined by Bozeman et al. (2001), represents the capacity scientists acquire through external social interactions. It encompasses the network of social connections, relationships, and trust formed within both social and professional communities, offering access to valuable resources and opportunities (Putnam, 1993). In a rational sense, scientists leverage their human capital, developed

through education and training, by harnessing social capital throughout their career trajectories (Corley et al., 2019).

Johnson and Bozeman (2012) introduced a five-asset bundle model for underrepresented minority students in STEM, emphasizing the importance of "educational endowments, science socialization, network development, family expectations, and material resources" in enhancing their educational and professional achievements. However, prior research, including studies by Grunspan et al. (2016), Johnson and Bozeman (2012), and von Hippel et al. (2015), has consistently highlighted that the unequal access to these human and social capital resources is a significant factor contributing to the underrepresentation of women and minorities in STEM fields.

Young female scientists can face stereotype threats, which are concerns about being judged based on negative group stereotypes. This can lead to disengagement from fields where such stereotypes exist (von Hippel et al., 2015). Stereotyping threats affect career choices and performance, particularly for minority workers in negatively stereotyped sectors (Nguyen & Ryan, 2008). Female scientists also contend with confidence issues linked to support and reinforcement from influential figures (Grunspan et al., 2016).

Collaboration and mentoring are vital for developing scientific human capital. These partnerships, involving senior and junior scientists, PhD researchers, and students, not only enhance skills and knowledge but also expand social networks. Research shows that many senior scientists prefer collaborating with and mentoring females (Bozeman & Corley, 2004).

Continued progress in this direction may favor women's career advancement. Studies reveal that female scientists are often perceived as less deserving of successful scientist credentials, leading to bias and discrimination (Carli et al., 2016). Consequently, female leaders often face greater hurdles, needing to work 2.5 times harder to prove their worth (Wennera & Wold, 1997). To summarize literature on creation and sustenance of social capital, it can be reiterated that social capital advances the human capital for successful career paths, however, female scientists receive less network and mentoring opportunities because they are perceived to lack skills required for a successful scientist as compared to men. But studies have also shown that some senior scientists do prefer to mentor females as compared to men to increase their participation in STEM field (Bozeman & Corley, 2004).

Cultural Dimension

Corley et al. (2019) noted that the STHC model overlooks the influence of culture on scientists' careers, despite the undeniable impact of culture on individuals and organizations. Scientists inevitably encounter cultural factors like gender, race, ethnicity, socioeconomic status, and nationality throughout their education and careers as they collaborate with people from diverse backgrounds. Some research and practice (e.g., ABS, 2018; WGEA, 2019) have highlighted the effects of gender and race on scientists' career trajectories, citing reasons like stereotype threats, the absence of role models, work-life balance challenges, and biases in recruitment and promotions, which contribute to the underrepresentation of women and minorities in STEM fields (Corley et al., 2019).

Similarly, nationality and socioeconomic status (SES) can significantly shape a scientist's career trajectory. Foreign researchers, for instance, often possess distinct role identities, community connections, and ethnic experiences compared to native researchers (Libaers & Wang, 2012). Additionally, the phenomenon of reverse brain drain occurs when foreign students return to their home countries after completing degrees in host nations. The increased global mobility of scientists has expanded opportunities for transnational collaborations and network connections across different nationalities. A study in Australia on STHC found that the dissemination of knowledge networks and collaborations has expanded to encompass North America, Europe, Northeast, and Southeast Asia (Turpin, et al., 2010).

MATERIALS AND METHODS

Scientists and laboratory technicians were contacted through the HR department, with approval from Monash University Human Resource Ethics Committee (MUHREC). The study included both female and male participants with diverse ethnicities, ages, and employment types. Data for this qualitative research was gathered through semi-structured interviews, which were conducted on-site at the VCS Foundation, Melbourne, Australia. Careful measures were taken to ensure that the sample included representation from all cultural dimensions, while following the framework outlined by Corley et al. (2019).

The analysis considers human capital (education, training, health), social capital (networks, collaborations), and cultural experiences (gender, race, nationality) within the Scientific and Technical Human Capital (STHC) model. The Scientific and Technical Human Capital model (STHC) is a significant framework in the study of human capital in scientific and technical fields. Developed by Bozeman et al., this model explores the multifaceted dimensions of human capital, including education, training, personal health, social capital, and cultural experiences (Corley et al., 2019), to provide a comprehensive understanding of the factors that influence individuals' contributions and success in these domains. In their work, Corley et al. (2019) argued for the inclusion of cultural dimensions in the STHC model to address the effects of diverse cultural backgrounds, which have gained prominence due to rising migration trends and a more diversified workforce. This modification enhances the original model's relevance, providing a more inclusive assessment of scientists' careers and abilities.

RESULTS AND DISCUSSION

The subsequent sections present the results of thematic analysis performed on the conducted interviews. Themes are social capital, human capital, and cultural dimension, divided into sub-themes.

Human Capital

Education and training

The respondents' existing qualifications and whether they planned to improve them in the future were questioned. All study participants were found to have the same level of education but with unique majors because the VCS Foundation is the only renowned laboratory with a focus on cervical cancer screening. After accumulating enough experience and in accordance with the expected future demands of their jobs, the young scientists intended to further their education. While middle-aged employees desired to transition from laboratory work to research-based employment. A young female scientist responded,

“Possibly yes, in the future; this year is my study break, so I want to work full time for experience in (the field) what I actually graduated in. I do want to further my study but not 100% sure what field I actually want to go in...”

The response of the middle-aged Asian male scientist was,

“Yes, I wanted to enhance (my education), and I will enhance....but you know sometimes you have family and job, and with everything it is difficult but I am concentrating to enhance my study because things are day by day changing...may be in future I would plan to do postgraduate studies...there are many opportunities in the research field...and if I am involved in further studies...I can get opportunities to work in research area or some extra higher position.”

These responses show that employees have faith in the career development opportunities provided by their employer, which include training, workshops, meaningful work, and career growth. They also illustrate the firm's strategic plan to help employees build their human capital and, as a result, retain the best employees for future growth. Overall, all of the respondents appeared content with their workplace's working environment, which was dominated by women.

“I like cytology (my field) because there is involvement of human being to screen the slides, (requires) your own decisions...require more work experience to screen the slides so that's why I chose to work in this field....(In addition) I like to work in laboratory environment...(Currently) I am looking after a completely new thing (work), advanced technology, we are learning day by day...I am just looking forward to learn more things...I like this organization; seniors or juniors, they are friendly, things are good and that is why I am working here for 10 years, professionally and financially I am satisfied...”

Stereotyping

Male and female scientists had diverse opinions regarding stereotypes of women in STEM disciplines. Male scientists claimed that they did not think that stereotypes about women were present in their field and that they did not think that women were less capable than men. However, they also pointed out the

absence of stereotyping in a workplace where women predominate. Female scientists did mention being stereotyped in STEM professions. Male scientists responded as follows,

“The place I worked with (earlier); it was a female majority workplace too.... I don't think so (females stereotyping) because females (scientists) have eyes for details...I do not believe in stereotyping”.

The female scientist's response was different,

“No, (I have not experienced stereotyping), my (male manager) encouraged me to do more in research or PhD. But I found that; most of the people I come through, yes (they experienced stereotyping), a couple of female students we had, yes there is stereotyping...”

These responses point to two conclusions. First, the presence of a large female workforce reduced stereotyping and boosted self-confidence, which encouraged women to join such organizations. Second, the subtle stereotyping in the minds of the male scientists went unnoticed because they were not even aware of it. Both of these arguments were sufficient to explain the barriers that subliminal bias and stereotyping against women in acquiring social and human capital (Corley et al., 2019; Konrad et al., 2000; Moss-Racusin et al., 2012).

Social Capital

Social network ties

It was an interesting finding that respondents of both sexes differed in how they felt about joining a professional network. Young female scientists had not joined or had not given any thought in joining such platforms, demonstrating their lack of interest in participating in such activities. Male scientists, whether they were young or middle-aged, were highly eager to join a relevant professional body or they were already a part of one or more of these networks. They had the impression that these networks would help them advance in their careers. Female scientists may have been prevented from taking advantage of social networks by their lack of drive to join a professional network.

In order to acquire a job in this particular specialty area within the STEM field, personal recommendations are preferred above using any social media and all these scientists had no trouble getting reference letters. Female scientists may not be in a great position to gain strong personal reference letters and networking possibilities to land a decent job given their intents to participate in social networking opportunities and join a professional network. This factor, along with other research findings (e.g., Corley et al., 2019; Grunspan et al., 2016; Johnson & Bozeman, 2012; von Hippel et al., 2015), appears to have a significant impact on females' future career trajectories.

Organizational context for networking opportunities

Additionally, established employees of the company had greater prospects for professional advancement and networking than new hires and recent grads. The company prioritized providing new grads with on-the-job training above connecting them with vital professional networks. Given that this company employed more women, the effect of this policy on potential future career choices could be severe and detrimental.

A young female commented “I have not had experience of that (networking opportunities by organization) at my level, may be the higher up...they have actually given me professional trainings to improve (my work) but (no networking opportunities at my level)”.

The dearth of female role models or mentors at tertiary education institutions and among companies may explain why women are not encouraged to join unions or other professional networks. As a result, individuals might not be aware of how joining professional unions, participating in scientific partnerships, and networking can boost their careers (Johnson & Bozeman, 2012).

According to previous studies (such as Bozeman & Corley, 2004), female scientists prefer to work with female supervisors rather than male supervisors since this environment makes it easier for them to express their opinions in a relaxed setting. However, male scientists in this organization did not share this inclination; they saw them as equally significant persons of contact.

Female scientist: *“Probably, (female manager) because I see her on regular basis....and comfortable with”*.

Cultural Experience

The VCS Foundation is a very diverse organization with a strong representation of Australia's multicultural community. All of the respondents stated that they regularly collaborated with individuals from various nationalities, races, and ethnic backgrounds. The work setting involves extensive incorporation of results and inputs from various departments within the organization. As a result, the staff received extensive exposure to the cultural component. Despite this, men scientists believed that because there are fewer of them, they do not always have the companionship of their male colleagues. As a result, it is still difficult to engage with people of the opposite gender in this type of employment.

One of the respondents expressed concern about a workforce that is extremely diverse. Concerns centered on cultural sensitivity and disputes resulting from lack of exposure or training for working with coworkers from diverse origins.

A scientist's comments on cultural diversity; *“Well, in the lab, there are only two guys. We work on rotations...majority of the people at VCF are from different nationalities or born overseas. I think I am the only one, now, born in Australia...”*

“(understanding) ethnicity and cultural backgrounds (are a challenge). The way I say something might be offensive to them and vice a versa.”

Significant coordination and collaboration between workers from various backgrounds will improve networking opportunities, especially for women, helping them build their social capital and increase their prospects of career success. Additionally, by providing them with these possibilities, young female scientists may be able to strengthen their self-confidence and explore various career options while working in a supportive workplace. However, the concentration of women in one location also raised the concern that it would worsen the problem of a lack of networking opportunities and role models in the same industry or organization.

Furthermore, the cultural dimension clarified how people of various nations and backgrounds acquired their human capital and what kinds of responsibilities they had on the family's side that ultimately influenced their decision-making regarding their educational and career paths. For instance, a male Asian scientist recently accepted a lower-level position to avoid being laid off since he could not afford to leave his work due to financial obligations to his family. Asian male scientists may have previously compromised their educational goals due to such financial restrictions. As a result, for the human and social capital elements, the cultural factor is important in identifying the causes and motivations behind certain career choices.

Impact of technology

The study revealed that changes in technology have had a substantial impact on the organization's structure and the way ordinary tasks were previously performed. The participants' responses showed that they had welcomed technology for the benefit of the organization and themselves, however, they were worried to some degree about their future at the workplace. Here are a few extracts from their reactions to the introduction of technology,

“Everything we do in lab is high tech... (technology replacing humans) is an issue, whether it's a male or female... I feel like technology is developing and there is less human intervention really”.

“...we are getting more machines and need less humans. That is an industry trend, the automation, that require less human input...affects both males and females equally...there is always uncertainty because new machines are coming in that can do work that was previously done by hand...people do get worried about am I going to lose the job or not...Technology take out human error.”

“Scary! in a way because I feel like I have to do like something else outside of science, I have looked the teaching science and other things like a fall back.”

CONCLUSION

In summarizing the research's findings, it has been determined that female scientists prefer to join workplaces with a female majority even though they are underrepresented in STEM fields. This is because these work environments help them avoid the effects of stereotyped attitudes and discriminatory practices in hiring, promotions, and networking opportunities. Workplaces that employ women in majority offer these female scientists a welcoming and comfortable environment where they can readily discuss and find answers to the issues that arise in managing work-life balance. Such organizations (in this case, the VCS Foundation) create its policies that aligns with the needs of women in mind, which makes women feel at ease and understood better. Males, on the other hand, might be at a slight disadvantage.

Compared to men in the same field, women scientists typically lack the drive to join professional networks. This propensity makes women scientists less likely to succeed professionally, particularly in a field where hiring managers most often rely on personal recommendations. Due to a shortage of female role models and mentors, the younger female scientists are unaware of the advantages of joining such platforms.

The STHC model's cultural dimension is one of the crucial elements to comprehend in order to fully appreciate its other two dimensions—human and social capital—which have a considerable bearing on and influence over them. Scientists' interactions with members of their own culture as well as members of other cultures influence how they collaborate, network, and see other scientists. With a workforce as diverse as VCS Foundation, this factor becomes more challenging and necessitates further research. Because they perceive threats to their self-confidence, formative experiences throughout their lives, and endorsement or disbelief of their ability to succeed in their field during significant life transitional phases. Therefore, female scientists tend to withdraw from male-dominated sectors and accumulate in female-dominated STEM sectors such as medical and health sciences. Social interactions with others and interactions with their work environments have a significant impact on these variables. In order to address these challenges in the cultural dimension, Diaz and Jerrard (2018) proposed various comprehensive strategies to increase the participation of women in the STEM fields while comparing a developed country with an underdeveloped country.

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