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Factors Influencing Women in Engineering in New Zealand

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ABSTRACT

CONTEXT

There is a significant underrepresentation of women in engineering disciplines at the tertiary level in New Zealand, posing both economic and equity challenges. Innovation and creativity, which are crucial to engineering and the New Zealand economy, benefit from diverse perspectives.

PURPOSE OR GOAL

This study investigates the factors influencing women's interest in engineering in New Zealand, drawing insights from current engineering students and high school students. Each study had a slightly different aim; Study 1 aimed to gain insight into domestic and international female engineering students' perspectives on the factors that influenced their study decisions. Study 2 aimed to determine the factors influencing the future career decisions of teenage girls. Both studies are included in this paper to illustrate scope of the issue and related to the same topic: lack if female participation in engineering

APPROACH OR METHODOLOGY/METHODS

A qualitative methodology was deployed in both studies, as it enabled a detailed narrative of individual experiences, providing deep insight into participants' experiences**,** to answer the research question: What Factors Influence Women's Choices in Relation to Engineering in New Zealand? The main methods used were individual semi-structured interviews and semi-structured focus groups. These methods facilitated the exploration of the participants' understandings of engineering and the factors influencing their career decisions related to engineers and engineering.

ACTUAL OR ANTICIPATED OUTCOMES

Key barriers identified include insufficient career guidance, lack of promotion of the engineering profession, and the perception of engineering as a masculine field. Additionally, cultural upbringing, cultural expectations and life experiences play a crucial role in deterring girls from pursuing engineering careers.

CONCLUSIONS/RECOMMENDATIONS/SUMMARY

To make a real difference, cultural shifts are needed, career advice must be timely and consistent, provided to students of both sexes before sex and gender roles become too entrenched. Specific career advice must be given before critical subject choices are made, and messages from the early stages must be continually reinforced as children grow and develop their sense of identity. Students should not be disadvantaged by their school's resources or the quality of career advice they receive.

KEYWORDS

Women in engineering, career influences, attitudes, stereotypical thinking, New Zealand

Introduction

Engineering practice today is increasingly complex, requiring consideration of economic competition, cultural implications, sustainability, environmental impact, and societal factors. Addressing these multifaceted challenges necessitates a diverse and dynamic engineering workforce equipped with collaboration, creativity, analytical thinking, and interdisciplinary approaches (Dresden et al., 2018). Emphasising diversity within the engineering profession is crucial, as it fosters innovative problem-solving and fresh perspectives (Benavent et al., 2020; Hutton, 2019; Perry & Bussey, 1979). A diverse STEM workforce is pivotal for a nation's economic growth and development (Hutton, 2019; Oyserman et al., 2002).

Despite its importance, there is a recognized lack of female participation in engineering and STEM careers globally (Benavent et al., 2020). Women who do enter engineering often gravitate towards fields perceived as socially and environmentally focused, such as environmental and biomedical engineering (Dresden et al., 2018). Gender balance within engineering not only enhances diversity but also incorporates qualities typically associated with females, such as community focus, communication skills, and empathy, which are essential for innovative engineering solutions.

This study aims to explore the factors influencing girls' decisions to pursue engineering in New Zealand, identifying both the barriers and motivations. It draws on data from two qualitative research projects. The first project examined the influences on domestic and international female engineering students enrolled in the Diploma of Engineering, Bachelor of Engineering Technology, and Graduate Diploma program in Civil Engineering at a polytechnic institute. The second project investigated the factors influencing Year 12 and 13 students to enrol in trades engineering courses. Both studies utilised focus group and individual interviews to gain insights into the factors shaping female students' career decisions in engineering.

Literature Review

Gender continues to be a predictor of occupation (Sinclair et al., 2019), and the engineering workforce requires both men and women with diverse characteristics and ways of thinking to foster innovative solutions (Denis & Heap, 2019; Kent et al., 2019). A non-diverse profession misses out on valuable contributions and new approaches that a varied workforce brings (Schäfer, 2006). A highly skilled and diverse STEM workforce is critical for economic growth and development (Chen et al., 2023; Saucerman & Vasquez, 2014). Gender balance is particularly important in achieving this diversity, as it enhances qualities like community focus, communication, teamwork, ethics, and empathy, which are indispensable to sustainable development and cultural change in engineering (Alalouch, 2021).

Despite the need for diversity, female participation in engineering remains low globally (Benavent et al., 2020; Chen et al., 2023). Women in engineering often choose disciplines perceived as socially and environmentally aware, such as environmental and biomedical engineering (Dresden et al., 2018). Encouraging women into all engineering disciplines is crucial for fostering diverse and creative thinking. Understanding why women select or avoid engineering is key to addressing the gender imbalance. Research indicates that gender does not impact academic ability in engineering (Alalouch, 2021). However, factors such as stereotypical thinking, socio-cultural environment, self-perception, and teacher influence play significant roles (Lamb et al., 2018), however, enrolment of women in engineering is higher in developing countries, where career choices are influenced more by economic necessity than by stereotypes (Charles, 2011).

Cultural attitudes and values also influence career decisions. In countries like Tunisia and Iran, university admissions are based on examination grades, promoting diversity by policy but limiting personal liberty (Huyer, 2018; Saucerman & Vasquez, 2014). In many Muslim countries,

engineering is culturally normalized for women, supported by societal and parental expectations (Atiq, 2018). Stereotypical views about science careers as masculine persist from early childhood (Levine et al., 2010). Parental influence shapes children's self-perception and career aspirations (Botella (Botella et al., 2019). Girls' belief in their mathematical abilities often diminishes by age ten, influenced by societal norms (Saucerman & Vasquez, 2014). Understanding the socio-cultural environment is crucial, as it heavily impacts girls' career choices (Mozahem et al., 2019).

Bandura (1977)'s self-efficacy theory highlights that people are more likely to pursue tasks they believe they can succeed in. For women in STEM, social persuasion and vicarious experiences are critical in shaping self-efficacy (Zeldin & Pajares, 2000). Teachers significantly influence students' career choices through their attitudes, course design, and interactions (Hill & Thrupp, 2019). Teachers' beliefs about gender abilities in STEM subjects can impact students' self-perception and performance. Female students often model behaviours from same-sex adults, making female teachers' attitudes particularly influential (Perry & Bussey, 1979). Positive teacher attitudes and knowledge about engineering can significantly increase the likelihood of girls choosing STEM careers (Mitts & Haynie, 2010; Weber & Custer, 2005).

The literature emphasis on the importance of diversity in engineering for economic and innovative benefits is clear. Despite recognized barriers and stereotypes, encouraging girls to pursue engineering through supportive environments and informed educators can help mitigate gender disparities. Addressing cultural influences, enhancing self-efficacy, and promoting positive teacher-student interactions are crucial strategies in fostering a more inclusive engineering workforce.

Methodology

Theoretical Framework

The research paradigms of Social Constructionism, a subset of Vygotsky (1978)'s socio-cultural theory, and Feminist Social Research informed the theoretical framework of these studies. These paradigms were chosen to understand and interpret human experience based on the premise that men and women should have equal opportunities and that they are equal but different (Cohen et al., 2011; Neuman, 2011). Results were interpreted with a focus on women's perceptions of their experiences.

A constructionist epistemological stance was adopted, positing that individuals construct meaning through their experiences, the tools they use, and their interactions within a socio-cultural environment (Crotty, 1998). Feminist Social Research, a branch of Liberal Feminism, builds on Interpretive Social Science and is predominantly conducted by women with a feminist self-identity. The liberal feminist theoretical perspective underpinning this research emphasizes that gender and sex should not limit one's potential for self-development (Morton & Zavarzadeh, 1991). Both studies aimed to give voice to women.

Research Design

A qualitative methodology was deployed in both studies, as it enabled a detailed narrative of individual experiences, providing deep insight into participants' experiences (Neuman, 2011). Purposeful sampling was used to identify suitable participants (Neuman, 2011). The main methods used were individual semi-structured interviews and semi-structured focus groups. Additionally, participants completed a short questionnaire. The questionnaire guided the construction of the interview questions. These methods facilitated the exploration of the participants' understandings of engineering and the factors influencing their career decisions related to engineers and engineering and enabled some aspects of exploration of ideas through discussion. In addition. we had limited access to participants in Study 2. Ethical consent was obtained from all three institutions involved.

Study Participants and Aims

Each study had a slightly different aim:

Study 1: This study aimed to gain insight into domestic and international female engineering students' perspectives on the factors that influenced their study decisions. Participants were enrolled in the Diploma of Engineering, Bachelor of Engineering Technology, and Graduate Diploma program in Civil Engineering. The participants in Study 1 ranged in age from approximately 18-35 year of age.

Study 2: This study aimed to determine the factors influencing the future career decisions of teenage girls. Participants were high school students enrolled at their local polytechnic as part of their school programme. One was an international student sent to New Zealand for her secondary education. All participants in Study 2 were 16-17 years of age.

All participants were recruited through the institutions where they were studying. In Study 1 with 10 participants, the students were in a program where one of the researchers taught, while the second researcher came from a local university. In Study 2 with 8 participants, the researchers undertook all interviews. All researchers were female and took care to avoid judgment and remain unbiased during the interviews, as suggested by Cohen et al. (2011). Participation was voluntary, and pseudonyms were used to protect anonymity.

Data Collection and Analysis

Data was collected through video recordings of focus group interviews in both studies and analysis of questionnaire responses. All audio data was transcribed and annotated with additional video data, noting gestures, actions, and facial expressions. Thematic coding and recoding were used within each study to identify key themes. Coding was done collaboratively by the participating researchers to ensure agreement and coding reliability.

Findings

Both studies explored a range of perspectives related to women's selection of engineering as a career. Several common themes emerged: economic prospects, the school system, strong stereotypical views of engineering and engineers, and a lack of female role models and self-efficacy.

Economic Prospects

All participants, except for five international students in Study 1, were educated in New Zealand. The international students indicated that prestige and career prospects were key reasons for selecting engineering. One participant in Study 1 illustrated this by stating, '*I chose engineering, it's good. I can earn money and I can have a good degree which is prestigious.*' Another international student in the same study suggested that education is more highly valued in her home country, saying, "I think there's more of a drive overseas to become more educated."

Another Study 1 participant initially aimed for a medical career but chose engineering after scoring higher on engineering entrance exams. She explained, '*I was to be a doctor. But there were two entrance examinations—one for the medical field and another for engineering in our region. I scored well in engineering but not in medicine.'*

One Study 2 participant was sent to New Zealand for education due to career earnings prospects, highlighting, '*My family is in Fiji, and I was brought here for a better life because the poverty rate in Fiji is quite bad. What drives me is that mechanical engineering, or engineering in general, has good pay, so I want to support my family.'* These findings indicate that prospects and prestige significantly influenced the career choices of international women. None reported being discouraged from engineering due to their gender, schooling, or societal attitudes. This was not necessarily the case for those who grew up in New Zealand.

School System

Participants in Studies 1 and 2 were vocal about their schooling experiences, curriculum, and the messages they received about girls' abilities in math and science. Domestic participants in Study 2 criticized the school system and the lack of career guidance they received, with many stating that

advice was either late or absent. They described career advisor information as "limited and random." One Study 1 participant noted, '*I went to a girls' school, and they talk about nursing and teaching, not engineering.*' Another added, '*By the time a career counsellor talked to us about careers, it was too late because we hadn't selected science or math subjects earlier.'*

Another Study 2 participant mentioned a lack of school facilities and exposure to various activities, leading to limited career options. She explained that her single-sex school offered woodwork when she enrolled, but it was no longer available when she was ready to take it. She said, '*The lack of interest [in engineering] is because they perceive it as a male career. Our all-girls school doesn't have the facilities or programs to learn about it. So only those who really want to do engineering pursue it.*' Participants also discussed the relevance of the math curriculum. They appreciated learning basic math but questioned the relevance of advanced topics. One Study 2 participant stated, '*Why should we be graded on something that we probably aren't going to use in the workforce?*' Another said, *'The basic subjects are alright, but when it gets complicated, it's like, am I actually going to use this?'*

Strong Stereotypical Views of Engineering and Engineers

Stereotypical views were pervasive across both studies, manifesting in perceptions about gender norms and male peers' attitudes towards girls' abilities. Participants in Study 1, who were already tertiary engineering students, recounted experiences with stereotypical advice focused on arts, nursing, and teaching—traditionally female-dominated fields. One participant shared, '*I went to a girls' school, and they talk about nursing and teaching, not engineering.*'

In Study 2, participants recalled early experiences with gender exclusion. One participant noted, *'All my cousins are male except for two, and at family gatherings, I couldn't play with them because I was a girl.*' Another added, "*My nana said that's for boys."*

Participants also faced negative attitudes from male peers, especially in math and science. One Study 1 participant, selected for NASA space camp, described how boys laughed when girls' rockets failed. When boys' rockets failed, they couldn't handle the girls laughing back. She noted, '*You guys need to understand that if you can't take it, don't give it out.*'

Teachers also held stereotypical views. One Study 2 participant's math teacher believed girls couldn't do math and gave them easier problems, which motivated her to prove him wrong. She said, '*There were two of us girls, and he gave the boys hard questions and us easy ones. When we asked for harder ones, he said we probably wouldn't get it. But the boys asked us for help because we knew what we were doing, and they didn't.'*

Lack of Female Role Models and Self-Efficacy

Participants across both studies highlighted the influence of role models. One Study 2 participant noted that presenting female engineering role models as heroes could be counterproductive, making the profession seem more hostile to women. She said, *'If female role models are presented as heroic because they're unusual, it may deter introverted females who don't want to be an anomaly.'*

Some participants felt challenged in male-dominated classes. One Study 1 participant shared, '*When I did a [project management] paper, I was the only girl in the class, and it was very intimidating.*' Participants emphasized the need for confidence to pursue engineering and the importance of networks for female students and professionals.

Participants in Study 1 self-identified as ambitious and hardworking. One stated, "I selected engineering because I am a logical person and problem solver, and engineering suits me." Another credited her mother as a role model: '*My motivation comes from my mother, she is a manager and very hardworking.*' A third demonstrated self-efficacy, saying, '*I am ambitious and hardworking, and my motivation comes from fear of failure. Anything I commit to; I give it 120%.*'

In Study 2, participants mentioned role models like a 'nana' who was an electrical engineer, and a mother involved in trades. Persistence was evident in Study 1 participants, with one describing her efforts to secure an apprenticeship: *'I emailed 10 people for work experience and got three responses. One gave me experience and an apprenticeship because I put in the effort.'*

Another participant highlighted her determination to prove a teacher wrong about girls in math: '*I started liking math just to prove him wrong. That was very fun.'*

Discussion

New Zealand is well known for its women's rights movement, being the first in the world to allow women to vote, however this study highlights that it has a long way to go for those who are educated in New Zealand. On 19 September 1893, Governor Lord Glasgow signed a new Electoral Act into law, and New Zealand became the first self-governing country in the world to enshrine in law the right for women to vote in parliamentary elections (Ministry of Women, 2024). Now 131 years later gender still has long-term impact on women's career choices and economic independence.

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The factors influencing women's career choices in engineering are complex and multifaceted. This paper identifies a range of influences on women and girls' decision-making, from broad cultural, political, and economic contexts to more personal factors such as self-efficacy in maths and science and the views of family and friends. The environment in which girls are raised significantly impacts their future self-image (Mozahem et al., 2019). Therefore, the responsibility for enacting change should be systemic rather than resting solely on the affected sector (Cohen et al., 2011).

This study clearly demonstrates that New Zealand aligns with other Western nations where stereotypical views about engineers are still strong. There is a lack of understanding of engineering profession, and engineering is viewed as a male-dominated career and thus leading to a lack of female role models (Fox-Turnbull et al., 2023; Lamb et al., 2018; Levine et al., 2010). These authors agree with Huyer (2018) and Saucerman and Vasquez (2014) that cultural values and attitudes strongly influence career decisions as illustrated by equal number of male and female engineering students in many Muslim countries, because of the cultural normalisation and support by society and parents for women to enter the profession (Atiq, 2018). This study provides further evidence of this. Of all the participants, only the international students mentioned the economic advantages of engineering over other professions. None of domestic participants appeared to be aware of the economic benefits of engineering thus suggesting it is not something they have considered. This highlights the role culture and education play on influencing women's career decisions.

Conclusion and Recommendations

To make a real difference, career advice must be timely and consistent, provided to students of both sexes before sex and gender roles become too entrenched. Specific career advice must be given before critical subject choices are made, and messages from the early stages must be continually reinforced as children grow and develop their sense of identity. Students should not be disadvantaged by their school's resources or the quality of career advice they receive.

This study leads to several recommendations. Career advice must be systematic, accurate, and consistent across all schools, whether single-sex or co-educational. Two other recommendations are closely related: the need for improved school facilities and enhanced teacher professional learning and development (PLD). Many schools have outdated practical facilities that remain siloed by the materials used, such as wood and metal. Technology education, as outlined in the New Zealand Curriculum (MOE, 2017) and a precursor to engineering, is interdisciplinary and requires facilities that provide all students access to hands-on activities free from gender segregation. Teacher PLD is essential, as teachers and school management must advocate for modern facilities and hold unbiased views of students' abilities in maths, science, and technology.

This study demonstrates that stereotypical views significantly impact how girls and young women perceive their place in the world. For example, a male participant in Study 1, despite having a Korean wife who is an engineer, still held stereotypical views of engineers as white, middle-aged men. These views are cyclical and challenging to break. Teachers holding stereotypical views pass them on to students, who grow up to become parents and teachers, perpetuating these biases. Bigler and Liben (2006) argue that interventions to change stereotypical beliefs should occur in early childhood, before firm gender understandings take root. Additionally, Leaper et al. (2012) found that understanding gender inequality and learning about feminism increased girls' academic motivation and achievement.

This study highlights the limitations of a one-pronged approach to addressing the problem. Changing attitudes and stereotypical thinking requires intervention across all the levels in society. Addressing these challenges requires national support and a comprehensive, multi-faceted approach.

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