

## **Female engineering students' experiences and career decisions: a case study in a regional Australian university**

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**ABSTRACT:** Engineering is traditionally viewed as a male-dominated profession with a gender bias. The purpose of this study was to understand the motivations and reasons why women decide to take an engineering major, and the experiences and challenges faced by women in engineering. Guided by social cognitive career theory, this study addressed two research questions: why female university students decide to enrol in engineering programmes as their university major and degree-seeking programme, in regional Australian universities; and how female university students describe their career decision-making process(es) and experience(s) as women and gender minorities in the field of engineering, in regional Australian universities and communities. The results indicate that academic interests and goals, and gender-based social cognitive modelling and self-efficacy encouragement were key to their successful career development and behaviour. The study will allow policymakers and departmental heads to reform and improve current human resources planning.

### **INTRODUCTION**

Gender bias against female professionals in the engineering field is a significant problem. After more than a century of progress in women's rights, engineering is still considered a male-oriented profession, where women are under-represented. A study by Griffith has indicated that student enrolment in the fields of sciences, technology, engineering, and mathematics (STEM) are dominated by male students [1]. More than 70% of STEM university students are male. This reflects gender bias, personal interest, recommendations from counsellors and teachers, and learning preferences. However, although most majors in STEM subjects are male, there are no regulations or policies to encourage female students' enrolment.

The gendered stereotype is one of the barriers to women's involvement in STEM education and career development. However, statistics indicate that female professionals are working in scientific environments. According to the Australian Government Department of Industry, Science, Energy and Resources, 36% enrolled in university STEM fields of education (undergraduate and postgraduate) in 2019 were women. Twenty-eight percent working in the STEM industry in 2020 were women [2].

Another report indicated that although women are under-represented in STEM, in public health the female component is very high: women represent more than 75% of the public health workforce in the United States, the United Kingdom, Switzerland, the Russian Federation, the Netherlands, Hungary, Germany, Denmark, Canada and Austria [3]. However, within this 75%, most women work in nursing and midwifery roles. With the exception of the Russian Federation, where over 60% of women work as physicians, less than 40% of these women work as physicians in the United States, the United Kingdom, the Netherlands and Denmark.

It is worth noting that over 75% of professionals in public health globally are women. Although female professionals dominate the workforce in public health, women are under-represented, particularly in positions of medical engineering, medical equipment development, physicians, dentists, pharmacists and upper-level management. More importantly, women are expected to work in assisting roles due to their gender.

### **Purpose of the Study**

Previous studies have been conducted in countries and regions, such as Europe and North America, but there is a need for Australian communities to understand women's engineering education and development. This study aims to understand the motivations and reasons why women decide to take engineering as their university major, and the experiences and challenges of women in the field of engineering. Based on the guidelines of social cognitive career theory, this study addresses two research questions:

1. Why do female university students decide to enrol in engineering programmes as their university major and degree-seeking programme, particularly in regional Australian universities?
2. How do female university students describe their career decision-making process(es) and experience(s) as women and gender minorities in the field of engineering, particularly in regional Australian universities and communities.

### The Theoretical Framework

Social cognitive career theory served as the theoretical framework of this study on female engineering students. This investigates and explores individuals' career understanding and sense-making processes, particularly the internal and external elements of why individuals decide to follow their career pathways. The theory was originally developed by Lent et al [4], based on Bandura's self-efficacy approach and social cognitive theory to create a career-oriented theory to understand career development [5]. According to Lent et al, individuals tend to be concerned with their self-efficacy, outcome expectations, and personal goals to guide their career selection and development [4]. Although individuals may take various approaches to select their career direction(s), most identify the above three elements as their career motivations [4].

Due to social, financial and economic developments, career perspectives and behaviours have changed. The current study employed social cognitive career theory and the enhancements proposed by other scholars [6]. Based on a previous study, social cognitive career theory advocates that the following points may influence individuals' career perspectives and behaviours:

- Interest in career development.
- Personal considerations.
- Financial considerations.
- Academic interest.
- Achievement of educational and career goals.

Following social cognitive career theory, this study explores the career perspectives and behaviour of female engineering students at an Australian university.

### METHODOLOGY

A qualitative research methodology with a case study was employed [7]. Information was collected about personal experiences, descriptions, feelings, thoughts, and understanding from individuals and groups including the *how* and *why* research questions. The case study concerned in-depth information about a group of female engineering students at one of the regional Australian universities. Hence, this study concerned the career decisions, perspectives and behaviours of a group of participants in a targeted location. Based on the Department of Home Affairs, regional areas in Australia are grouped into categories. One of them refers to areas outside Sydney, Melbourne and Brisbane. The current study recruited participants from a site outside those three major cities. The researcher also notes that there is an association called the Regional Universities Network (RUN) with seven universities, however, it was not in the scope of this study.

#### Participant Population

A purposive sampling strategy was employed to recruit 15 participants [8]. The author contacted the relevant department head of a regional university to co-ordinate this study of female engineering students. The study rationale, interview protocol, agreement and related materials was sent to the department head. The department head agreed with the study and forwarded the materials to all students who met the criteria. After several rounds of discussions, a total of 15 participants met the requirements and agreed to participate in this study. The participants met the following criteria:

- Currently enrolled as an undergraduate engineering student;
- Female student;
- At least 18 years old and a non-vulnerable person;
- Willing to use technologically-assisted interview software.

#### Data Collection

Due to location restrictions (i.e. participants and researcher lived in different locations), the interview sessions were conducted via Whatsapp. According to Seidman, qualitative sharing and personal stories are rich and engaging material for understanding the research questions [9]. However, the researcher needed to establish the relationships between the participants to gather meaningful information. Therefore, the researcher conducted three one-on-one interview sessions (for each participant) and three focus group activities. Each participant needed to join three interview sessions. Each interview session lasted from 45 to 68 minutes. Three focus group activities were hosted (i.e. five participants in a group). Each focus group activity lasted from 58 to 71 minutes. During the data collection, a digital recorder was used for voice messages. No visual materials were recorded. After the researcher transcribed the voice messages to written transcripts, the researcher sent the targeted materials to each participant for checking. All participants agreed with the material.

## Data Analysis

The author read the material to categorise potential directions and groups. Open-coding technique were employed as the tool to group materials to different meaningful themes and subthemes. There were nine themes and 12 subthemes. The axial-coding technique was employed for further development. As a result, two themes and three subthemes were identified.

## Human Subject Protection

Privacy was an important element in this study. Therefore, the researcher tried to protect the information of the university and participants. The signed agreements, any information about the university and department, the background of the participants, personal contacts and information, email addresses, voiced messages, written transcripts, information of the university, computer and related materials were locked in a password-protected cabinet. Only the researcher had the right to read the material. After completing the study, the researcher deleted and destroyed the materials immediately to protect the personal information of all parties. The current study was supported by the Woosong University Academic Research Funding 2021.

## RESULTS AND DISCUSSION

After completing 45 one-on-one interview sessions and three focus group activities, the data and materials collected were merged. The personal comments and opinions of the participants of this study answered the research questions and described the experiences of female engineering students from an holistic perspective. The following section outlines the themes and subthemes (Table 1).

Table 1: Themes and subthemes.

Academic interests and academic goals
Becoming useful engineers in regional communities, regardless of gender
Gender-based social cognitive and self-efficacy encouragement
Modelling from parents: women in regional areas
Bias from the general public, but not in university environments and engineering organisations

### Academic Interests and Academic Goals

According to social cognitive career theory, academic interests and educational goals and achievements always play an important role in career development and perspectives [6]. Individuals always keep in mind their academic interests when considering potential graduate career pathways [10]. Unlike liberal arts programmes, such as English, engineering is a professional programme that requires extensive training, mentorship from university professors, and internships with supervisors [11]. All 15 participants expressed opinions on professional training and further development after university. One significant comment was captured:

*...I want to become an engineer ...so I study engineering as my degree programme ...this is my academic goal ...although some people and the public society may not agree with my goal ...but this is my own life ...I should exercise it regardless of other people's mind... (Participant #3, interview, 2nd year).*

### Becoming Useful Engineers in Regional Communities, Regardless of Gender

For more than a decade, the Australian government has sought to develop regional communities with fresh graduates and immigrants from other countries [12]. Although the government established policies and plans for the workforce and human resources, only a few university students and new immigrants have decided to move to or stay in regional areas. For this study, the researcher collected data from female engineering students at a regional Australian university. It is important to understand why the choice of a regional community. First of all, many believed that regional communities and organisations had the potential to offer career development. One participant commented:

*...the regional areas need a lot of engineers and scientists ...from hospital, aerospace skills, knowledge of astronomy ...the competition in the urban cities and areas are hard and strong ...but there are still a big demand in the regional areas ...if I have the backgrounds and experiences in the regional areas ...I believe my backgrounds will increase my competition... (Participant #13, interview, 4th year).*

With the reflection of a previous study [13], the researcher further asked how gender might influence their status and role as engineering students or potential engineers after graduation in a regional area [13]. All 15 stated that the Australian government and regional areas are open-minded about female engineering students, as are engineers in most areas. Two shared their internship experiences in regional sites:

*...although there is no absolute fairness ...regardless of gender, nationality, or visa status ...I think the regional areas ...and the Australian government ...some of the engineering organisations ...are doing their*

*best for career developments ...and gender-free opportunities ...my interned site always encouraged us to share ...regardless of our student's status and gender ...I can see how the regional areas ...may offer us the chances for career development... (Participant #14, focus group, 4th year).*

*...most of the urban engineering firms are packed with male engineers ...as they can find enough workforce ...but the regional firms ...are opened to all of the applicants and workers ...of course they do not have enough applicants ...but it is a good chance for people with different backgrounds to start their engineering jobs and positions ...in the regional area... (Participant #9, focus group, 4th year).*

In conclusion, echoing a previous study, female engineering students always select their degree programmes and consider career perspectives based on their personal interests and goals for career development [13]. They all said that organisations in regional areas provide help and opportunities for people with different backgrounds. With the reflection of social cognitive career theory [6], the participants were positive about their prospects in regional areas after graduation.

#### Gender-based Social Cognitive and Self-efficacy Encouragement

Another significant finding of this study is the gender-based social cognitive modelling and self-efficacy encouragement from the participants' parents, teachers, counsellors, and relatives. According to some previous studies, people's behaviours are highly influenced by social and external agencies, such as other people and environmental factors [6][8]. In this case, all the participants stated that the selection of their university degree programme in engineering was influenced by other people during their secondary school. Some previous studies indicated that the general public believes that engineering programmes are for male students and professionals, whilst women should study liberal arts programmes [1][14]. However, the participants stated that, based on their own previous experience, encouragements and the positive self-efficacy of their personal beliefs, their gender should not be a restriction. As for their previous experiences, the researcher captured a significant comment:

*...my science teacher ...studied her undergraduate degree in engineering and completed her teachers' qualification programme ...she was my teacher and I believe her teaching skills and professional knowledge are excellent ...I do not see why women ...cannot become engineering teacher in high school or university ... (Participant #3, interview, 2nd year).*

Besides the influence of their teachers, 11 participants attended or listened to conference presentations by key female engineers in Australia, such as Dr Mehreen Faruqi (civil engineering), Dr Marlene Kanga (chemical engineering), and Ms Flavia Tata Nardini (space engineering). These female engineers in Australia influenced their social cognitive career decisions and self-efficacy as female engineering students. One key comment was captured:

*...I want to become a civil engineer ...just like Dr Faruqi ...I watched her lessons and I attended one of the conferences with her research studies ...I even talked to her and shared my dream as a civil engineer in the future ...her words are so encouraging ...I have a very strong mind about my jobs and future ways... (Participant #4, focus group, 3rd year).*

In short, in line with social cognitive career theory [6], the participants' career perspectives and behaviours were highly influenced by some key models and self-efficacy encouragement. Although some mentioned hardships and difficulties, the self-efficacy and beliefs of these participants were high.

#### Modelling from Parents: Women in the Regional Areas

One of the interesting findings of this study was the influence of parents. Twelve of the participants' mothers are active STEM professionals working in regional areas of Australia. Australia welcomes skilled professionals from different parts of the world. Many of the participants' parents are skilled professionals. Beyond that, all participants stated that their parents encouraged them to achieve their dreams regardless of gender and location. Some previous studies indicated that women face unfairness and hardships due to their gender in STEM fields [15][16]. However, their mothers, encouraged the participants to overcome the bias and discrimination deriving from their gender and locations. Two interesting comments were captured:

*...my mother is an active engineer in the regional area ...in New South Wales ...I want to become an engineer because of her encouragement ...I did not have any ideas about what should I achieve in the future ...but my mother always encourages me ...think about the sciences, and enjoy sciences ...as she told me that the regional Australian regions have the potential vacancies ...I want to study engineering in the regional areas... (Participant #6, focus group, 3rd year).*

*...some people told me that women should work as housewives and take care of their children and families ...I do not want to do that as I want to become a scientist ...my mother is an engineer for the park department in the regional area ...I want to become a successful person ...just like her ...her behaviours and positions encourage me ...to overcome some problems ...as a girl ...who grew up in the remote areas... (Participant #7, focus group, 4th year).*

In short, parental influences, particularly from mothers, played an important role for these participants. A previous study indicated that family members' and relatives' suggestions might impact young adults' career decisions and perspectives [17]. The finding of this study matches those of this previous study and are in line with social cognitive career theory [6].

#### *Bias from the General Public, but not University Environments or Engineering Organisations*

Many previous studies indicated that female STEM professionals face hardships and challenges due to their gender and social biases [18][19]. However, the participants suggested that the gender biases and misunderstanding come mostly from the public and the media. A recent study found that social media tend to promote men as STEM professionals and women as librarians [19]. Although gender bias is not relevant in contemporary Australian communities, gender roles and misunderstanding continue to influence some groups. However, most of the participants in this study stated that they did not face significant discrimination or biases due to their gender in university environments and internship sites. As for this social phenomenon, the researcher captured one significant comment:

*...although my university and interned organisations are all located in regional communities ...I do not believe my gender will influence how my professors, classmates, and peers read and work with me ...my supervisors in the engineering organisation treat me professionally without any problems ...my gender ...the regional locations ...do not make any differences... (Participant #9, focus group, 4th year).*

According to previous studies, gender is one of the challenges faced by many female engineering students due to social stereotypes [13][19]. However, based on social cognitive career theory, the participants overcame such biases through their strong belief in their academic interests, academic goals and self-efficacy as engineers [6]. One of the important findings is that parental influences played an important role in their career perspectives, behaviours and career decision-making process. Although social and cultural communities may present different types of gender-oriented bias and discrimination, many women may overcome the hardships and difficulties with their focus on career development, academic interests, and the achievement of educational and career goals.

The experiences of female engineering students suggest that Australian communities (in engineering education and engineering organisations) are relatively open to people with different backgrounds, particularly female professionals. According to the participants, many of their parents also work in regional engineering organisations as engineers. The positive modelling from their parents encouraged their career decision-making process and influenced their experiences as female engineering students [5]. Also, the positive images projected by some key female engineers in the Australian engineering field encouraged their career development.

#### LIMITATIONS AND FUTURE DEVELOPMENTS

The current study captured the comments and opinions of female students at a regional university in Australia. Its findings cannot be considered representative of the overall situation in Australian engineering communities. However, the researcher conducted three one-on-one interview sessions with each participant and three focus group activities. Although the study only collected information from 15 female engineering students, the findings may improve understanding of the current situation in Australia. Future research could extend the population and sites to different locations, such as urban and other regional universities. Moreover, although the female student population is one of the most important in engineering, active female engineers' professional and career development and behaviours could be studied. For example, why female engineers decide to work in this male-dominated industry. Therefore, future research studies could extend the investigation into these areas.

#### CONTRIBUTION TO THE PRACTICE

Although this study only collected data from the female engineering students in a regional university in Australia, the results will serve as a blueprint for improvements and developments in STEM curricula, female students' experiences and regional universities' advancement. For STEM curricula and development, school leaders, faculty members, and department heads may think about merging liberal arts and general education curricula and teaching plans into the STEM courses and lessons. Also, students' experiences should be considered and improved regardless of their gender roles. As female students are the gender-minority groups in the engineering department, the school leaders may establish plans and schemes to increase their university experiences based on sharing this study. Last, but not least, the Australian government is actively developing the regional areas, particularly the student enrolment for the regional universities. Therefore, establishing plans and programmes for students with different backgrounds is essential, particularly for female students in engineering programmes.

#### CONCLUSIONS

Female engineering students and engineering professionals are some of the most important assets of Australian communities. School professionals, university departments, industry experts, government departments, policymakers, and researchers should continue to pay attention to engineering education and professional development for the active skilled workers in the field. The results of this study will allow leaders and departmental heads to reform and enhance

the current human resources planning and labour markets. For example, how can the interested parties create encouragements, engagements and inclusive environments for people with different backgrounds. Because the demands of engineering professionals are increasing, long-term schemes for human resources development will be important.

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