Female Engineering Students' Motivations, Career Decisions, and Decision-Making Processes: A Social Cognitive Career and Motivation Theory

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Abstract

Although women's rights and career developments have changed over the past decade, only a few updated studies have been conducted to understand the current backgrounds of women in engineering. This study aims to understand and investigate the motivations, career decisions, and decision-making processes of a group of women in the engineering industry, specifically, a group of electrical and electronic engineering students in Taiwan. Based on social cognitive career and motivation theory, the study was guided by two research questions: 1) Why do Taiwanese female electrical and electronic engineering students decide to study this major at university level? 2) Do the participants intend to join the electrical and electronic engineering industry after graduation? Why or why not? The general inductive approach research design with interview, focus group, and member checking interview were used. The results indicated that academic interests, interests in career development, and job security concerns played significant roles in the motivations, career decisions, and decision-making processes of a group of female engineering students in Taiwan. The results of this study filled the gaps in gender discrimination, social stigma, and stereotype toward women in engineering, particularly in Taiwan.

Keywords: career decision, engineering, engineering education, female engineer, motivation, social cognitive career and motivation theory, Taiwan, women in engineering

1. Introduction

1.1 Introduce the Problem

Engineering is a vocation within which there is reason to suspect the operation of significant gender bias and a social stigma against female engineers and engineering students (Dos Santos, 2021c; Sishchuk et al., 2020; Tao, 2018). While there are technically no limits on women joining the industry or enrolling in engineering programmes at university, this social stigma may yet arise through the attitudes of members of the general public, those working in the industry, and even fellow students. Gender bias is particularly in evidence in the field of electrical and electronic engineering. Traditionally, there is strong social stigma attached to women working in the fields of Science, Technology, Engineering, and Mathematics (STEM). According to several recent studies (Botella et al., 2019; Dos Santos, 2021b; McCullough, 2019), the number of women in engineering is significantly lower than men. Like many professional industries, such as nursing and early childhood education, engineering has an unbalanced gender diversity, which could significantly impact the motivations, career decisions, and decision-making processes of both pre-service and in-service professionals and talents.

A recent report from the Chinese Institute of Engineers (Williams, 2020) showed that, on average, only 13% of Taiwan's engineering population are women. The survey collected data from 1,307 valid samples with 531 female participants. The results indicated that while 44% of biomedical engineering professionals are women, the figure stands at only 3% for professionals in the mechanical engineering industry. Figure 1 shows the proportion of women in engineering according to industry. Previous studies (Kamphorst et al., 2015; McCullough, 2019) have argued that though female engineers may have positive working experiences, particularly when their own interests align with the projects they are working on, nevertheless, they can also experience social stigma and negative views of their place in the industry from members of the general public. This stigma imposes restrictions on women engineers, which can

have significant impacts on their self-efficacy and sense-making processes (Carnemolla & Galea, 2021; Swart, 2018).

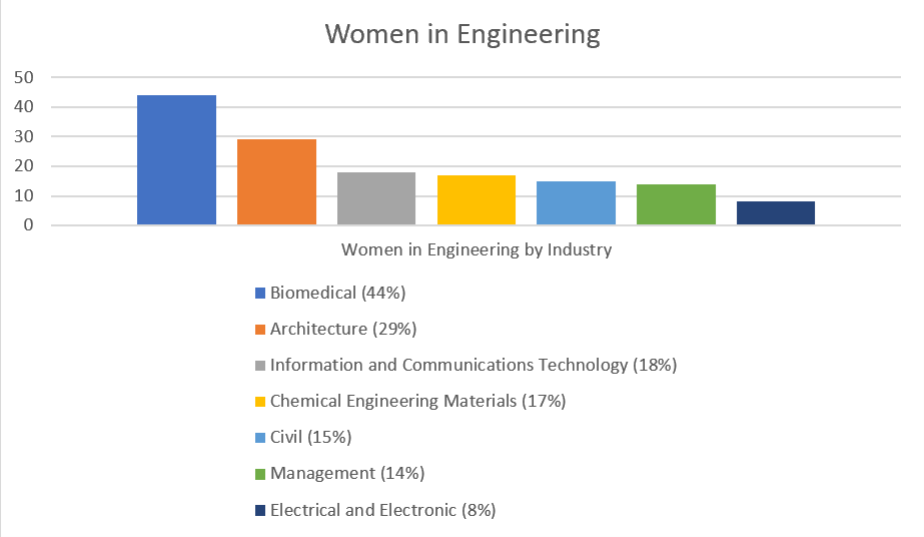

Figure 1. Women in Engineering in Taiwan (Williams, 2020)

Over the past several decades, Taiwanese government departments and non-profit organisations have introduced various measures that aim to promote gender equality and workplace justice for women, including for female STEM students. In 2018, the Cabinet's Department of Gender Equality released a publication outlining current issues and problems around gender equality in engineering in the Asia-Pacific region ("Taiwan Promotes Women in STEM with New Book of Success Stories," 2018). A previous study (Cheng, 2010) revealed how young women, particularly in the East Asian environment, are discouraged from pursuing careers in STEM subjects due to social stigma against women, challenges around balancing work and family life, and the need to overcome gender bias throughout their career development. Another study (Wang & Stocker, 2010) had similar findings, showing how gender bias in STEM-oriented industries and the social status of women had historically played significant roles in shaping the career decisions and decision-making processes of Taiwanese women in these industries.

1.2 Purpose of the Study

Although women's rights and career developments have changed over the past decade, only a few updated studies have been conducted to understand the current backgrounds of women in engineering. This study aims to understand and investigate the motivations, career decisions, and decision-making processes of a group of women in the engineering industry, specifically, a group of electrical and electronic engineering students in Taiwan. Based on social cognitive career and motivation theory (Dos Santos, 2021a, 2021d), the study was guided by two research questions:

1) Why do Taiwanese female electrical and electronic engineering students decide to study this major at university level?

2) Do the participants intend to join the electrical and electronic engineering industry after graduation? Why or why not?

2. Theoretical Framework and Relevant Literature

2.1 Social Cognitive Career and Motivation Theory

Social cognitive career and motivation theory (Dos Santos, 2021a, 2021d) was used as the theoretical framework to investigate the social problem under consideration. Social cognitive career and motivation theory was developed based on social cognitive career theory (Lent et al., 1994) and self-efficacy theory (Bandura, 1993). It argues that the motivations, career decisions, and decision-making processes of individuals and groups can be understood as arising out of a combination of internal factors and external environmental impacts. First, the internal factors, also known as the psychological and internal factors with self-efficacy, indicated that academic interests, personal considerations,

and achievements of education and career goals are the three directions which may influence individuals and groups' motivations, career decisions, and decision-making processes. Second, the external factors, also known as the social and external factors, indicated that interests in career development, financial consideration, and surrounding environments and individuals played significant roles in the individuals and groups' motivations, career decisions, and decision, making processes (Dos Santos & Kwee, 2021; Kwee, 2020, 2021a). Figure 2 outlines the social cognitive career and motivation theory.

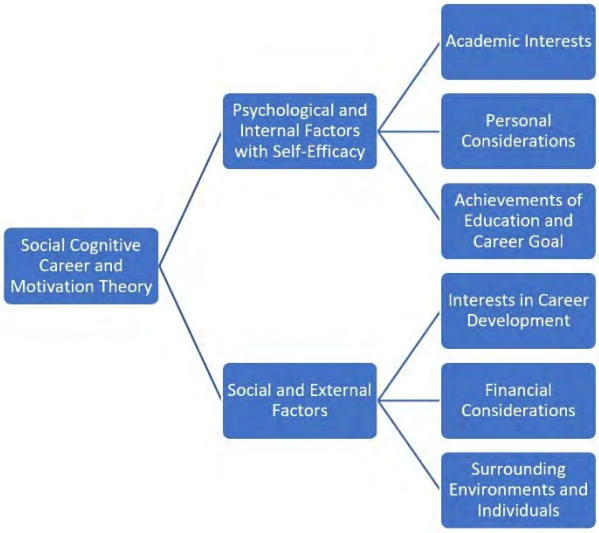

Figure 2. Social Cognitive Career and Motivation Theory (Dos Santos, 2021d; Kwee, 2021b)

2.2 Female Engineers in Education and Industry

Some levels of gender orientation and bias have traditionally played a part across a range of different industries, including early childhood education, nursing, and STEM-oriented industries (Cottingham, 2019; Stillmaker et al., 2020). Traditionally, engineering is considered as a male-oriented profession. Although there are technically no limitations on the number of women joining the engineering profession, the existing gender gap and the social stigma attached to women joining the industry significantly impact the motivations, career decisions, and decision-making processes of both pre-service and in-service women in engineering. A recent study (Vidal et al., 2020) argued that gender roles have a significant impact on engineering students during their educational formation. Despite working hard to complete assigned coursework, female engineering students still encounter significant gender bias among those who believe the subject they are studying to be unsuitable for female learners. An earlier study (Griffith, 2010) also argued that women were considered minorities in the STEM industry, particularly in engineering. Although universities, embracing ideas of gender diversity, continue to offer special arrangements and designated spaces for female engineering students, many women decide to leave the engineering industry after graduation. One potential solution to mitigate this trend would be to encourage peer-to-peer relationships among students and mentorship from faculty members. This could exert a positive influence on female engineering students' motivations, career decisions, and decision-making processes (Dennehy & Dasgupta, 2017) as individuals may be encouraged by hearing about the experiences and ideas of experts, seniors, and peers in their field (Dos Santos, 2021e; Kwee, 2020). A recent study (McGregor et al., 2017) argued that the salary scale between men and women is different, despite both groups being equally capable of producing high-quality work. Currently, in the United States, the government and the engineering industry continue to offer help and encouragement for female engineers and engineering managers. However, the gender gap and social stigma continue as many of the upper-level positions are occupied by men (McCullough, 2019). Although the past decade has seen a closing of the gender gap and an increase in gender diversity, particularly in Middle Eastern countries (Ainane et al., 2019), female engineers and engineering students nevertheless continue to suffer the adverse effects of gender bias and social stigma.

3. Methodology

3.1 The General Inductive Approach

In order to investigate the motivations, career decisions, and decision-making processes of a group of Taiwanese female students studying electrical and electronic engineering majors and planning to join the engineering industry after graduation, a general inductive approach (Thomas, 2006) was adopted. This approach is appropriate, first, because, though the researcher initially planned to collect qualitative data from only one university in Taiwan, it is in fact very hard to find at least 15 female electrical and electronic engineering students at a single Taiwanese university. Therefore, the researcher decided to collect data from multiple Taiwanese universities. Second, collecting the qualitative data from a single university could result in a narrow and less representative impression. Therefore, the general inductive approach was useful as a way of collecting rich and diverse information from a wider population (Dos Santos, 2020, 2021f).

3.2 The Participants

It is important to invite at least 15 participants in order to collect a wider perspective from the community. Therefore, the researcher decided to employ the snowball sampling strategy and purposive sampling strategy (Merriam, 2009) for the invitation. First, the researcher employed the purposive sampling strategy to invite three participants. The participants were encouraged to refer at least one participant with a similar background for the study. As a result, 16 participants joined the study. The participants needed to meet all of the following criteria in order to join the study:

1) Currently enrolled on an electrical and electronic engineering programme in Taiwan

2) Female student

3) At least 18 years old

4) Non-vulnerable person

3.3 Data Collection

Three qualitative data collection tools were used, including one interview session (Merriam, 2009), two focus group activities (Dos Santos, 2021f, 2022a; Morgan, 1998), and one member checking interview (Birt et al., 2016; Dos Santos, 2022b). First, interview session was used to collect in-depth, private, one-on-one, and individual qualitative data from the participants. During the interview session, the researcher asked questions about personal stories, motivations, career decisions, and decision-making processes about their university major selection and career decisions after university graduation. The interview sessions lasted from 63 to 99 minutes without breaks (Seidman, 2006).

Second, after all participants finished their interview sessions, the researcher arranged the focus group activities in order to collect focus sharing and stories. Eight participants formed a single focus group activity. Therefore, two focus group activities were formed. The researcher served as the coordinator for the questions and movements during the focus group activities. No active participation were involved. Each focus group activity lasted from 119 to 132 minutes with one ten-minute break. After the participants completed their interview sessions and focus group activities, the researcher categorised the data based on each participant's personal file. The researcher sent the qualitative data to the participants for confirmation. The member checking interview sessions were hosted individually in order to receive confirmation from each participant. All participants agreed and confirmed their data during the member checking interview sessions (Merriam, 2009).

Due to the COVID-19 pandemic, social distance requirements, and travel restrictions, the data collection procedure could only be hosted online. All participants agreed with the online data collection procedure and arrangement. During the data collection procedure, the researcher used a digital recorder to record the qualitative data. However, no visual data and materials could be collected.

3.4 Data Analysis

The researcher used the general inductive approach (Thomas, 2006) as the means to categorise the qualitative data into meaningful themes and subthemes. A two-step data analysis procedure was employed, including the first-level and second-level data analysis procedures. First, the researcher re-read and re-visited the data multiple times to find out the connections and ideas between the stories (Strauss & Corbin, 1990). As for the first-level themes and subthemes, the researcher categorised 25 themes and 21 subthemes based on the qualitative data. However, further data analysis should be conducted as it would be impossible to report many themes and subthemes. Therefore, the researcher further studied and narrowed down the data as the second-level themes and subthemes. As a result, three

themes and two subthemes were yielded.

3.5 Human Subject Protection

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki. The study was supported by the Woosong University Academic Research Funding 2022.

4. Findings and Discussions

Over the course of 16 interview sessions and two focus group activities, the researcher gathered useful stories and information from the participants. Although the participants were from different backgrounds, cities, and universities, many shared similar stories about their motivations for pursuing electrical and electronic engineering at university and their plans to enter the industry after graduation.

Table 1. Themes and Subthemes

Themes and Subthemes
Academic Interests: I Love STEM and Lab Activities
I Want to Acquire In-Depth Knowledge and Engineering Skillsets
Interests in Career Development: I Want to Become a Female Electrical and Electronic Engineer
Women in Engineering: Influences from Female Electrical and Electronic Engineering Professionals
Job Security Concerns: Gender Gap is Closing in Taiwan

4.1 Academic Interests: I Love STEM and Lab Activities

Many studies (Darchy-Koechlin & Draelants, 2010; Dos Santos, 2020a, 2020b, 2020c; Grubb et al., 2017) have argued that individuals select their career and university major based on personal and academic interests in the subject matters, regardless of gender or background issues. In this case, the participants indicated that their choice of electrical and electronic engineering as university major was a result of their own academic interests in STEM subjects, and was not impacted by gender bias or social stigma toward female learners and professionals. Two stories about participants' high school experiences were captured:

> *…I love engineering and science…my high school is one of the schools where students and graduates receive good science grades and university admission exam scores over the past decades…many students love studying science and becoming scientists in the university…I am one of the students who want to pursue a science career because we all love science…*(Participant #13)

> *…science and mathematics are very interesting…I want to study these subjects in high school and university…but I think I should combine these two subjects together…engineering is a very good match…so I want to study engineering at university…and this major can satisfy my needs and wants…*(Participant #2)

Second, many participants indicated their desire to study for a degree that involved lab-based activities. Despite evidence of a significant gender imbalance in STEM labs (Griffith, 2010; Stillmaker et al., 2020; Vidal et al., 2020), particularly in Asian countries, many have confidence in their capacity to leverage their academic interests to overcome barriers arising from gender bias and social stigma toward women doing lab work. Two participants shared similar stories:

> *…I am a lab person…my chemistry teacher in high school received his PhD degree in chemistry with lab work…I joined his lab and after school club for the chemistry activities…I enjoyed the lab jobs, and I want to continue my lab job after high school…many people told me that girls should not study STEM subjects…but I don't see why?* (Participant #1)

> *…I grew up in a lab during high school…although many of my female classmates did not like STEM and lab jobs…I like that and I was the only female lab teammate in my high school…I want to study as a university major with lab jobs and continue my academic interests in STEM and lab…I decided to learn to engineering as my major…so I can study lab and stay in the lab…*(Participant #11)

4.1.1 I Want to Acquire In-Depth Knowledge and Engineering Skillsets

Academic interests played a significant role in the motivations, career decisions, and decision-making processes

of the participants. Almost all participants indicated that their high school experiences and coursework changed their understanding of engineering, particularly the issue of gender bias and the social stigma toward female engineering and STEM learners (Balta et al., 2017; Firdaus et al., 2020). The participants argued that engineering skills and knowledge could be applied to many real-life practices and experiences, which encouraged them to continue to study this subject as their university major. One participant said:

> *…I studied an elective course in engineering in high school…I love this subject, and I want to study more about engineering…engineering is very interesting because…we can see how mathematics and physics in our real-life…from our school buildings to our food…we can see engineering sciences in the place…therefore, I want to study more about engineering skills and knowledge…if possible, I want to use engineering skills in my career pathways…*(Participant #4)

Another group of participants argued that they wanted to engage in in-depth study of engineering knowledge and skillsets in order to upgrade outdated infrastructure in towns and communities with large numbers of elderly residents. Many expressed an opinion that the practical knowledge acquired through engineering study is particularly applicable to real-life situations and could be used to re-new their communities and country. One participant said:

> *…engineering is an applied subject which allows people, researchers, and general public members…to use and apply engineering and mathematics in their life experiences…and I want to understand how can we use engineering in our life matters…my sisters and my friends in high school did not understand the magic of engineering…they called me engineering geek…but I want to study more about engineering…and I want to practice engineering in our community...and I want to study the in-depth knowledge and reform our community…the old community with old people and senior residents…*(Participant #14)

In line with social cognitive career and motivation theory (Dos Santos, 2021a, 2021d), academic interests played a significant role in the motivations, career decisions, and decision-making processes of the participants. As demonstrated in a number of previous studies (Chew et al., 2020; Falco & Summers, 2019; Fuesting et al., 2017), it is the academic interests of high school students and adult learners that motivate them when selecting their university major and career pathways. Although the gender gap, discrimination, and social stigma might limit their career decisions and decision-making processes, the participants in this study continued to follow their academic interests when making decisions about what university major to study and what career path to pursue. While some participants mentioned that gender bias might impact their decisions in these areas, all either went on to further study in engineering or took up roles within the engineering industry after university (Dennehy & Dasgupta, 2017; Stillmaker et al., 2020).

4.2 Interests in Career Development: I Want to Become a Female Electrical and Electronic Engineer

Despite some recent studies (Botella et al., 2019; Dos Santos, 2021b; McCullough, 2019; McGregor et al., 2017; Shi, 2018) revealing ongoing bias toward and discrimination against female STEM professional and students, including from members of the general public, within communities, and even in academia, the participants in the present study overcame these obstacles, such that their motivations, career decisions, and decision-making processes were informed by and products of their own interests, career development goals, and personal aims. Furthermore, participants indicated that their desire to become female electrical and electronic engineers was driven in part by a determination to use their image as professional engineers to encourage other female high school students and adult learners to join the engineering profession, regardless of their specialisation or level of expertise (Botella et al., 2019; Li et al., 2021). As one participant put it:

> *…my high school counsellors and teachers asked me to go back to my high school for a peer-to-peer presentation for students who wanted to apply to engineering school…I was the only girl who attended engineering school for my academic year…so I want to use my image to encourage my peers to do something that they want…don't limit ourselves because of our gender…the views of general public members are not important…this is our life…this is not their life…*(Participant #3)

4.2.1 Women in Engineering: Influences from Female Electrical and Electronic Engineering Professionals

Traditionally, engineering is a male-oriented profession, and female engineers and professionals are considered minorities in this industry. Although many government departments, non-profit organisations, universities, and the engineering industries themselves want to balance the gender gaps and eliminate social stigma, these efforts have not been effective (Vidal et al., 2020). Participants in the present study agreed that members of the general public, university staff, and government bodies all encourage female students and potential female engineers to join the engineering industry. Many participants had also attended engineering conferences and workshops, which

significantly opened their minds and expanded their horizons about female engineers in Taiwan. One participant who was marked by her experiences at a conference said:

> *…a female engineer shared her experience with women in engineering…she told us that the industry always welcomes female engineers and professionals to join the industry…she also argued that the gender discrimination is not very significant…because the gender discrimination and bias are closing… female professionals fill many senior positions and frontline positions…I think it is a good time for women to join the industry…*(Participant #8)

Another group of participants shared their experiences of academic inspiration from and internships with female faculty members and supervisors. First, participants indicated that they had attended lectures given by female engineering faculty members who had acquired professional experiences in the engineering industry before joining academia. These shared professional experiences and stories significantly changed participants' understanding of engineering and impacted their career decisions. One said:

> *…I was not planning to join the engineering industry…but I like engineering…so I studied engineering as my university major…but I received some positive stories and encouragement from my professor…she encouraged me to pursue something that I want…and I should follow my mind…do not listen to the social stigma and bias about the gender discrimination…therefore, I am sure…that I am going to join the engineering industry as a female engineer in the electrical and electronic engineering industry…*(Participant #7)

Second, participants also argued that their internship experiences, during which they were mentored by female supervisors in the industry, significantly changed their career decisions and decision-making processes. Their female supervisors shared many positive stories with them, particularly relating to their experiences as female engineers and engineering supervisors.

> *…students can do two internships for the bachelor's degree programme…I completed my first one, and my supervisor was a female engineer…I was very happy because my supervisor taught me a lot and shared many stories about women in engineering…she told me that the industry is changing…30 years ago…women in engineering…was not common…but many women joined over the decades…it is a good time for us to join the engineering industry…*(Participant #6)

> *…may be in other specialisations, such as civil engineering…women are still the minorities…due to the rapid development of the Taiwanese technology and electrical and electronic engineering knowledge…many women enter the industry…and many foreigners and international graduates joined this industry too…the female engineers and senior leaders…are packed with the cultural diversity…we can see female professionals and foreigners in the industry…the positive sharing and experiences significantly changed my career decisions…*(Participant #15)

In line with social cognitive career and motivation theory (Dos Santos, 2021a, 2021d), interests in career development also played a significant role in the motivations, career decisions, and decision-making processes of the participants. Traditionally, engineering is considered as a male-oriented profession where female professionals are the minority. However, a recent study (Ainane et al., 2019) argued that women continue to join the engineering profession. The proportion of women in the profession has been increasing over recent decades due to demands for gender diversity. Participants in the present study argued that the gender gap is closing due to increasing gender diversity and social development. This has encouraged and facilitated many women to continue to follow their goals and enter the engineering profession (Williams, 2020).

4.3 Job Security Concerns: Gender Gap Is Closing in Taiwan

Postgraduate career pathway and development is one of the biggest concerns for many university graduates (Dennehy & Dasgupta, 2017). Due to the development of technology and opportunities in the Taiwanese environment, many technology organisations seek to hire engineering graduates with professional practice and knowledge, regardless of their gender and background. Two groups of participants were identified. First, a number of participants expressed a desire to leverage the professional knowledge and skills they acquire to join the industry after graduation. As two participants put it:

> *…I want to join the industry directly after my internship…my interned organisation called me to stay in their department after I received my bachelor's degree because there are many opportunities and vacancies in the industry…I am willing to accept this offer because I can see my future in this organisation…*(Participant #12)

> *…mid-size and large organsations need graduates with excellent electrical and electronic engineers…my*

> *classmates, both boys and girls…are well-trained engineers…we are ready to join the industry and exercise our professional skills for the organisation…the electrical and electronic engineering industry is very large and is one of the best opportunities in Taiwan…many international companies need the technology from Taiwan…*(Participant #16)

A second group of participants said that they intend to study for a postgraduate degree in order to upgrade and build up their professional knowledge and skills at the postgraduate level. These participants argued that undergraduate knowledge and training is not sufficient to the demands of electrical and electronic engineering practice in the industry. Therefore, they argued that postgraduate-level training is essential. One said:

> *…I am applying for a master's degree in the same specialisation…I received one offer from one of the top universities in Taiwan and two offers from the United Kingdom…I am sure that I will attend a master's degree programme because it is my goal…I want to learn the professional knowledge and practice…not only at the bachelor's degree level…*(Participant #10)

In line with social cognitive career and motivation theory (Dos Santos, 2021a, 2021d), job security and financial consideration played significant roles in the motivations, career decisions, and decision-making processes of the participants. Due to the rapid development in the sciences and technology industry, many Taiwanese organisations are thirsty for engineering professionals with specialised skills and expertise. Many participants in the present study argued that their professional skills would help them secure potential engineering career opportunities following undergraduate and postgraduate study (McGregor et al., 2017; Vidal et al., 2020). Also, many believed that they should take advantage of current technological trends in order to maximise their career progression and professional development. Although the gender gap and social stigma may impact their career opportunities to a certain degree, many argue that their professional skills and qualifications will be enough to overcome these challenges (Botella et al., 2019; Maskey, 2018; McCullough, 2019).

5. Limitations and Future Developments

First, the current study collected qualitative data from the Taiwanese environment. Although the Taiwanese results may reflect the overall situations and backgrounds in the East Asian region, the Taiwanese data could be limited. Future research studies may use this study as a reference to collect data from their own regions and countries. In this case, the social issues for female engineering students may be answered and outlined.

Second, gender gaps and social stigma significantly impact the motivations, career decisions, and decision-making processes of women. However, gender gaps also impact male counterparts and professionals, such as male nursing professionals and male kindergarten teachers. Therefore, future research studies may use the research design and protocol of this study to collect data in order to answer the gender gaps and gender diversity in their own regions and countries.

Third, besides the STEM environments and industries, other environments and backgrounds, such as teaching, nursing, medicine, construction etc., also have gender gaps and social stigma toward men and women. However, due to the limited resources, only female engineering students and professionals were invited. Future research studies may further collect data from other individuals and groups in order to answer and fill the gaps in the industries.

6. Contribution to the Practice

First, female engineering students and engineers face gender gaps and social stigma challenges. The results of this study outlined the current social problems based on a group of female engineering students in Taiwan. Government departments, non-profit organisations, and policymakers can use this study as a reference to advocate and reform the current gender policies and issues. Second, the results of this study filled the gaps in the current problems about gender gaps, gender-oriented discrimination, and social stigma. Based on the qualitative data from a group of female engineering students, the results offer the readers and researchers the social background and gender issues in Taiwan. Third, unlike other projects and studies with quantitative data, qualitative data with stories and personal comments would be useful to understand the in-depth understanding of the experiences of gender gaps, social stigma, and discrimination.

7. Conclusion

Gender and women in engineering have become a topic in the current academia and educational environment. The results indicated that academic interests, interests in career development, and job security concerns played significant

roles in the motivations, career decisions, and decision-making processes of a group of female engineering students in Taiwan. The results of this study filled the gaps in gender discrimination, social stigma, and stereotype toward women in engineering, particularly in Taiwan.

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