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The Motivations, Career Decisions, and Decision-Making Processes of Female PhD Students in Engineering: Experiences and Challenges

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This study investigates the motivations, career decisions, and decision-making processes of a group of female engineers who decided to pursue their PhD degree in engineering and the understand women's experience challenges and difficulties during their career voyage in South Korea. Engineering is considered as a male-oriented profession. Although women may join the profession, no more than 16% of registered engineers are women in South Korea. Employing the phenomenological approach with semi-structured interview and focus group activity, 12 participants joined the study. Based on the social cognitive career and motivation theory, this study is guided by two research questions: 1) Why do female engineers decide to pursue their PhD degree in engineering in South Korea? What are the motivations and reasons? 2) How do female engineers describe their experiences and challenges in the engineering profession, particularly as female engineers in South Korea? The findings indicated that the relationship between gender and the engineering profession, we need to educate the new generation and conduct and exercise our academic goals and dreams were the main themes. The results of this study provided references to university leaders, department heads, government agencies, and policymakers to reform and upgrade the current regulations and policies to close the social stigma and bias gaps for women and minorities in engineering education and profession.

Keywords: engineering education, engineering student, female, PhD student, social cognitive career and motivation theory, women in engineering, workforce management

INTRODUCTION

Gender and social equality have become topics in vocational development, career decisions, and decision-making processes (El-Hout et al., 2021; Hand et al., 2017). Over the past few decades, although many people, researchers, organisational leaders, and policymakers continue to advocate the rights for gender equality, discrimination and social stigma continue to exist in some occupational professions. Traditionally, engineering, computer, information technology, and railroad management are considered as men's career pathways, whilst nursing, dancing, and kindergarten education usually attract women (Botella et al., 2019). Although colleges and universities do not have any restrictions on university admissions and programme

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requirements, it is not uncommon that individuals, groups, and general public members may exhibit social stigma and bias toward certain groups of students and researchers (Botella et al., 2019; McCullough, 2019).

Over the past few decades, university leaders, non-profit organizations, policymakers, and human resources planners have argued that the workforce, salary, management, position, and promotion gaps in the engineering profession are significant, particularly the gaps in gender diversity (Vidal et al., 2020). Many studies (Simon et al., 2017; Singh et al., 2020) have proven that both men and women can manage, handle, and practice engineering knowledge, skills, and vocational management at the professional and senior levels. General public members still believe that the engineering profession is exclusively designed for men due to stereotypes and social bias (Botella et al., 2019; Dos Santos, 2021a; McCullough, 2019). As a result, although many female students and learners have strong interests in engineering and the engineering career pathway, they decide not to pursue their dream (McGregor et al., 2017; Vidal et al., 2020).

According to a recent report (Yoon, 2022), the total number of technical engineers in South Korea has increased rapidly from 34,934 in 2011 to 52,753 in 2019. However, the total number of female technical engineers is significantly lower than that of their male counterparts. In 2019, 52,753 male technical engineers were registered, whilst only 8,253 female technical engineers were working in the professional field. The difference in the populations of men and women outline the unbalanced diversity and potential discrimination in the engineering profession. Also, other studies have further argued that female engineers and engineering managers face discrimination, social stigma, and bias due to their gender, particularly when female engineers seek career promotion and senior-level positions (Booy et al., 2012; McCullough, 2019; Stillmaker et al., 2020). Although many parties have tried to close the gender gap, problems and challenges for female professional engineers continue, particularly in South Korea.

Seeking career promotion and development is one of the goals of many professionals (Hanson et al., 2016). One of the effective directions for seeking career promotion is to pursue a postgraduate degree in order to acquire theoretical and practical skills and knowledge that can be applied to the professional environment after graduation. Studies (Botella et al., 2019; Dos Santos & Lo, 2018; Gibbs & Griffin, 2013; McCullough, 2019) have indicated that studying a postgraduate degree can improve the managerial styles, practical skills, and professional knowledge of engineers who want to upgrade their overall engineering background, particularly for mid-level and senior-level professionals.

In fact, pursuing a Doctor of Philosophy (PhD) in Engineering or a Professional Doctorate in Engineering may not be chosen by many professional engineers who want to continue their career pathways in practical environments, regardless of their gender, background, salary, and career pathway (McGregor et al., 2017). However, earning a postgraduate research degree may allow graduates to build up their career pathways to the leadership level, contribute new knowledge to engineering practice, upgrade their engineering management background, and teach students who want to learn engineering knowledge at the college and university level (Botella et al., 2019; Carnemolla & Galea,

2021; McGregor et al., 2017). As a result, a small population may decide to conduct original research in order to contribute their knowledge to engineering practice.

Purpose of the Study

Currently, many South Korean general public members still believe that the engineering profession is an exclusively male vocation. Although the female population of registered technical engineers has grown gradually over the past decade, gender diversity issues continue to challenge the motivations, career decisions, and decision-making processes of pre-service and in-service female engineers, particularly in-service female engineers who seek career promotion (Hidajat et al., 2020). There are two purposes of this study. First, this study investigates the motivations, career decisions, and decision-making processes of a group of female engineers who decided to pursue their PhD degree in engineering in South Korea. Second, as the engineering profession is a male-oriented industry, the study wanted to understand women's experience challenges and difficulties during their career voyage. Based on the social cognitive career and motivation theory, this study is guided by two research questions:

1) Why do female engineers decide to pursue their PhD degree in engineering in South Korea? What are the motivations and reasons?

2) How do female engineers describe their experiences and challenges in the engineering profession, particularly as female engineers in South Korea?

Theoretical Framework

The social cognitive career and motivation theory (Dos Santos, 2021c) was employed to understand and investigate the current study and social problem. The social cognitive career and motivation theory was developed based on social cognitive career theory (Lent et al., 1994) and self-efficacy theory (Bandura, 1995). The social cognitive career and motivation theory argues that both internal and external factors impact individuals' motivations, career decisions, and decision-making processes.

As for the psychological and internal factors of self-efficacy, the theory argues that 1) academic interests, 2) personal considerations, and 3) achievements of education and career goals play significant roles in changing and impacting individuals' motivations, career decisions, and decision-making processes. As for the social and external factors, the theory argues that 1) interests in career development, 2) financial considerations, and 3) surrounding environments and individuals could influence individuals' motivations, career decisions, and decision-making processes. The social cognitive career and motivation theory guided the researcher to collect and analyze qualitative data based on the participants' sharing and personal stories. Figure 1 outlines the social cognitive career and motivation theory.

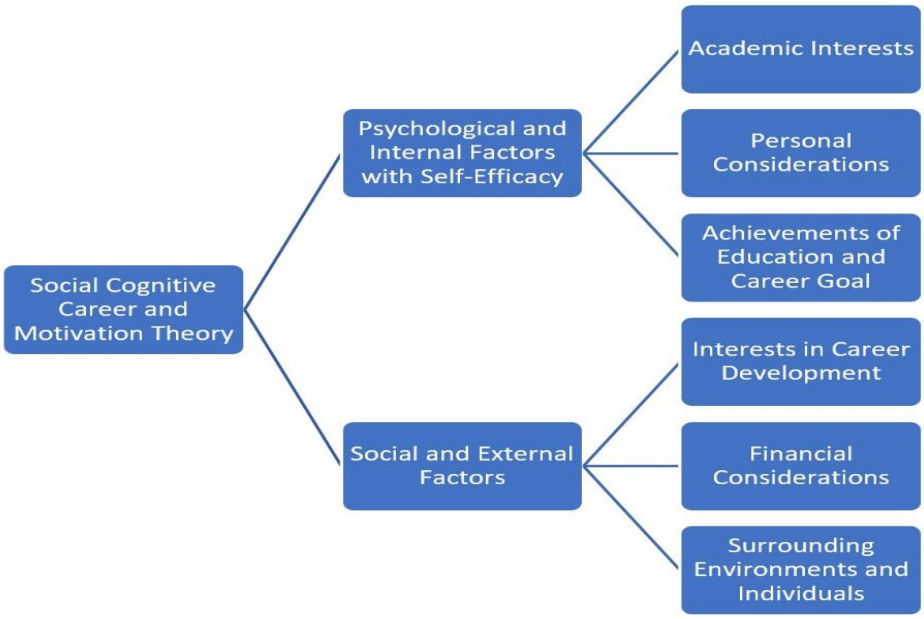

Figure 1
Social cognitive career and motivation theory (Dos Santos, 2021c).

Relevant Literature

Women in the engineering profession

Traditionally, the engineering profession is considered a male-oriented vocation that women are discouraged from joining for career and educational development (Dos Santos, 2021b; Vidal et al., 2020). Although the female population in the engineering profession has been increasing gradually, the gender gap is still large and significant, regardless of location or specialization (Male et al., 2018).

Currently, dozens of engineering specializations are categorized, such as civil engineering, computer engineering, biotechnological engineering, etc. Civil and construction engineering has become one of the hardest engineering specializations for female professionals. A recent study (Carnemolla & Galea, 2021) indicated that shortage of awareness, shortage of self-harmonization, the male orientation, esteem in the engineering profession, and influences from teachers, family members, and teaching curricula play significant roles in the motivations, career decisions, and decision-making processes of women in engineering (Hidajat et al., 2020). Although the government has established scholarships and plans for gender diversity in engineering, particularly in construction engineering, the gender gap could not be closed sooner (Dos Santos, 2021b).

Another study (McGregor et al., 2017) expressed that the gender pay gap between men and women is significant, particularly in male-dominated sectors, such as engineering.

Regardless of country or location, both male and female professionals perform work of the same or similar nature. However, male professionals tend to receive a higher salary and greater admiration due to their gender. Another study (Serrano & Groh, 2016) also argued that the travel grants given to men and women could be different, although both belong to the same sectors and departments. This unfairness significantly impacts female engineering professionals' self-efficacy, motivations, career decisions, and decision-making processes. The gender gaps and differences are less likely to be closed as the engineering profession is significantly controlled by a group of male leaders, workers, and professionals who protect their gender-oriented rights. As a result, female engineering professionals may continue to suffer from stereotypes, social stigma, and discrimination due to their gender (Simmons et al., 2018).

Women in the engineering education

Selecting university academic programmes and career pathways is not easy for secondary school graduates who do not have significant working experience in the industry. Some studies indicated that the influences from both internal and external factors could impact students' motivations, career decisions, and decision-making processes (Dos Santos & Lo, 2018; Flores et al., 2008). A recent study (Berge et al., 2019) argued that gender, age, and social class could impact the performance and enrolment management of engineering education. Unlike other academic programmes which may have open-enrolment management, engineering programmes usually have advanced-level mathematic skills as a prerequisite. Samuelson & Litzler (2016) argued that due to racial and financial differences, minority students might face challenges in engineering education due to social expectations and social inequality. Another recent study (Dos Santos, 2021b) also argued that gender played a significant role in the motivations, career decisions, and decision-making processes of potential female engineering students, particularly in mechanical engineering.

In fact, social stereotypes and social stigma are some of the restrictions and limitations facing many female engineering students and engineers (Dos Santos, 2021b). However, a recent study (Gero & Friesel, 2020) investigated and conducted a case study of Danish and Israeli universities, particularly the ideas of electrical engineering students. The participants argued that intrinsic motivation, such as interest in studying engineering, and identified regulation, such as recognition of the value inherent to these studies, drove their motivations, career decisions, and decision-making processes. Another study (Dos Santos, 2019) also investigated a group of females practising engineering who decided to switch their career pathways from the engineering industry to engineering education. The participants indicated that stable employment and having a meaningful and inspiring career were the same motivations and reasons. In this case, the study tended to understand the motivations, career decisions, and decision-making processes (Hidajat et al., 2020), as well as the experiences and challenges, of a group of female engineers who decided to pursue their PhD degree in engineering in South Korea.

Learning motivations of women in engineering: the south korean perspective

Although the female population has become half of the human resources in the South Korean environment, many professions, occupations, and sectors are still occupied by

men counterparts, particularly in engineering (Joo, 2019). A previous study (Youn & Choi, 2015) indicated that some universities might include the terms women and/or female in their academic programs and courses in order to separate the differences. Although some argued that the applications might increase gender diversity, many believed the term might increase the social stigma and biases toward women in engineering (Kang & Rowley, 2005). Therefore, women with professional and academic interests in engineering may stop their desire due to the social stigma. Another previous study (Kang & Rowley, 2005) argued that there would be human resources gaps in engineering due to the retirement of professional engineering within the next few decades. In fact, offering training to frontline engineering and women in engineering is one of the most important steps as they are the vocational workers and staff in the profession. However, the faculty of engineering and engineering schools also need to have instructors and professors for long-term training and research activities. Women in engineering may fill the gaps in this area due to the gender diversity and female workforce population in South Korea. However, many studies indicated that women in engineering continue to experience discrimination and social stigma due to their gender roles (Joo, 2019). The discrimination and biases may further prohibit the desires and interests of women in engineering who want to join the frontline profession or engineering education, particularly in South Korea. However, there are only a few studies that focus on this area. Therefore, it is important to conduct studies and fill the gaps in this area (Takenoshita, 2020).

METHOD

Phenomenological Approach

The phenomenological approach (Moustakas, 1994) was employed to collect qualitative data from a group of 12 female engineering PhD students in the South Korean environment. The phenomenological approach allowed the researcher to collect sharing and personal stories from a wider environment with a similar background and experience. In this case, although female engineering PhD students may be found in South Korean universities, no universities have enrolled more than five female engineering PhD students in their engineering programs. Therefore, the phenomenological approach allowed the researchers to collect useful information from different participants within the targeted community.

Participants and Recruitment

12 participants were invited to the current study. The purposive and snowball sampling strategies (Merriam, 2009) were employed to recruit the participants. First, the researcher contacted three participants based on the personal network. After the first interview sessions, the participants were encouraged to invite other female engineering PhD students in South Korea. After several rounds of referral, 12 participants agreed to join the study. Due to the background of the study, the participants must meet the following criteria:

1) Have completed professional service in the engineering profession for at least one decade;

2) Currently enrolled as a female engineering PhD student in South Korea;

3) Non-vulnerable person.

Data Collection

Semi-structured interview sessions (Merriam, 2009), focus group activity (Morgan, 1998), and member checking interview sessions were employed to collect qualitative data from this group of participants (Kwee, 2021). First, the researcher contacted three participants via semi-structured interview session. After the semi-structured interview sessions were completed, the participants were encouraged to refer at least one participant who met the criteria. Eventually, 12 participants joined the study. Second, after all participants completed their semi-structured interview sessions, the focus group activities were conducted. The researcher arranged one focus group activity with 12 participants. The researcher served as the coordinator of the focus group activity. The participants in the focus group activity might share their personal stories and understanding with other participants who share similar backgrounds. After all the participants completed the semi-structured interview sessions and the focus group activity, the researcher categorized the qualitative data based on each participant's personal file. Third, the researcher sent the individual data to the participants for the member checking interview and confirmation. During the member checking interview, the participants confirmed their personal data. All participants agreed with their data for further study.

Please note, due to the COVID-19 pandemic and social distancing recommendation, the data collection procedure needed to be completed online via online-based communication tools. Also, during the data collection procedure, the researcher used the digital recorder to record the voiced messages. No visual information and data were recorded.

Data Analysis

First, after the researcher collected the voiced messages from the participants after the member checking interview, the researcher transcribed the voiced messages to the written transcripts in order to process the data to meaningful themes and subthemes of the study.

Second, the researcher re-read and re-visited the written transcripts multiple times in order to figure out the relationships and connections. Based on the general inductive approach (Thomas, 2006) and the grounded theory approach (Strauss & Corbin, 1990), the researcher employed the open-coding technique (Strauss & Corbin, 1990) to categorize the large-size and massive information into themes and groups. From this stage, 20 themes and 25 subthemes were categorized as the first-level themes and subthemes.

However, researcher (Thomas, 2006) believed that first-level themes and subthemes should be further studied in order to outline the effective results for the finding chapter. Therefore, based on the first-level themes and subthemes, the researcher employed the

axial-coding technique (Strauss & Corbin, 1990) to narrow down the themes and subthemes. As a result, three themes and two subthemes were yielded.

Validity and Triangulation

Semi-structured interview sessions (Merriam, 2009), focus group activity (Morgan, 1998), and member checking interview sessions were employed. Qualitative data may include subjective findings, personal stories, sharing, and ideas based on the participants' backgrounds and previous experiences. In order to reduce the subjective, researchers suggested triangulation (Creswell, 2012; Merriam, 2009) to reduce the concerns. In this case, three data collection tools were employed, particularly the employment of member checking interview was used to confirm the validity of the data. As a result, all data and ideas were confirmed by the participants.

Human Subject Protections

Privacy is the most important factor for this study. Therefore, the researcher locked the signed consent forms, voiced messages, written transcripts, personal data, contact information, and related information in a password-protected cabinet. Only the researcher could read the data. After the study was completed, the researcher destroyed the materials to protect privacy. The study was supported by the Woosong University Academic Research Funding 2022.

FINDINGS AND DISCUSSIONS

Although the participants worked in different engineering organizations and studied at different universities, the participants shared many similar ideas and stories based on their previous experiences and backgrounds. Table 1 outlines the themes and subthemes of the participants.

Table 1
Themes and subthemes

Themes and Subthemes
1. Relationship between Gender and Engineering Profession
1.1. We do not have Enough Female Engineers
2. We Need to Educate the New Generation
2.1. We will become the Models for all Women in Engineering
3. Conduct and Exercise our Academic Goals and Dreams: Regardless of the Views of the Public

Relationship between Gender and Engineering Profession

> *…engineering and engineering education are not only for boys and men…this profession and this major are open to all students and people who love this industry…many South Korean people believe…engineering is only for boys and men…it is wrong…our roles and positions…should show all the people in South Korea…female people and women can also work…based on their wants and needs…not just follow the trend in the community…*(Participants #4)

Based on some recent studies (Dos Santos, 2019; Shi, 2018; Yoon, 2022), gender inequality is not uncommon in the fields of STEM, particularly in engineering. General

public members strongly believe that engineering is a vocational development for men due to the stereotypes and social expectations of this career development and pathway. Not only South Korea, but other westernized countries, such as Australia, also face similar social problems due to gender-oriented social stigma (Botella et al., 2019; Dos Santos, 2021a; McCullough, 2019). One interesting story was captured based on a participant who had previously worked in Australia, who said:

> *…I used to work in Australia for a decade…the same problem…because of the gender bias and understanding of engineering…the gender issue between men and women…it is not about the location, country or region…it is about the general public members…it is important to change this unhealthy understanding…female engineering models and leaders should be here to promote the gender diversity…*(Participant #3)

In line with the social cognitive career and motivation theory (Dos Santos, 2021c), the surrounding environments and individuals played significant roles in mapping and impacting the motivations, career decisions, and decision-making processes of women wanting to join the engineering profession, particularly in South Korea (Dos Santos, 2022). Although the participants argued that the demand for female engineers is significant, general public members continue to exhibit bias regarding this profession due to stereotypes and social bias, regardless of location or region (Botella et al., 2019; Carnemolla & Galea, 2021; McCullough, 2019; Serrano & Groh, 2016). As a result, many female students and potential female engineers decided not to pursue their engineering degrees and select other career pathways.

We Do Not Have Enough Female Engineers

> *…the gender diversity in engineering is very bad…only less than 20% of the registered engineers are women…in Europe, the number is going up…to 30% to 40%...it is a very good start…we can see…that the government and society showed the admire to female professionals in engineering…but this is not going to happen in South Korea…*(Participant #1)

The participants expressed that the gender inequality and unbalanced gender diversity (Dos Santos, 2021b; Hackett et al., 1992; Vidal et al., 2020) in the engineering profession is disappointing for many female engineers and engineering students in South Korea. Many (Berge et al., 2019; El-Hout et al., 2021)argued that gender diversity is getting better in Europe. However, the changes are less likely to happen in South Korea soon due to stereotypes and social biases (M. S. Kim & Seo, 2014). Another significant message was about the salary differences between men and women. Two stories were captured:

> *…the salary for female engineers is not the same as male engineers…we worked the same…the same responsibilities and jobs…but the unfairness…and the salary differences…are very disappointed...this is a big problem in South Korea…not just in engineering…other science professions, such as biotechnology, medical, and computer technology…female professionals always receive lower salary…*(Participant #2)

> *…the salary differences between men and women are very unfair in South Korea…students and engineers read the news and reports…many decide to leave the engineering profession or join other industries…for lower workload and better salaries…both men and women hold the same positions…but we have different contacts and payments…*(Participant #10)

In line with the social cognitive career and motivation theory (Dos Santos, 2021c), gender inequality and unbalanced gender diversity (Dos Santos, 2021b; Hackett et al., 1992; Vidal et al., 2020) have become some of the arguing points and disappointments for many female engineering professionals. Also, the salary and payment differences between men and women have also impacted their motivations, career decisions, and decision-making processes (McGregor et al., 2017). In line with these findings, the participants argued that their personal considerations, such as a desire for balanced gender equality and social justice for female engineers and engineering students, have become their goals for their PhD studies and practising engineering in the profession (Dos Santos, 2022). However, all expressed their concerns due to, and experiences of, gender inequality in the engineering profession, which could impact their self-efficacy and motivations (Bandura, 1995; Dos Santos, 2021d).

We Need to Educate the New Generation

> *…when I was a student in my undergraduate degree programme…I was the only girl in my school year…in the college of engineering…no girls wanted to study engineering decades ago…I can see some changes…but the changes are not big at all…step by step…but the steps are very small…*(Participant #6)

All participants argued that the female student population was not large in the college of engineering and other STEM programmes. Although university leaders and school administrators have tried to close the gender gaps for all programmes, particularly in STEM areas, the solutions are not effective. For example, the participants indicated that although government departments, non-profit organizations, and universities offer different scholarships for women in the STEM departments and programmes, the enrolment would not change significantly:

> *…many engineering companies in Korea…offer scholarships and special internship opportunities for women and female students…the opportunities could not change the situations…it is about the public image from the Korean people…it is not about money or career opportunities…*(Participant #5)

All participants indicated that the current strategies, such as minority scholarship and internship opportunities, could not help the gender gaps. As one said, *"changing the public view and understanding are the keys to this problem. The scholarship is not the point"* (Participant #2). In line with some previous studies (McGregor et al., 2017; Stillmaker et al., 2020; Vidal et al., 2020), if the views of general public members do not change, the social stigma, bias, and gaps will continue.

We Will Become the Models for All Women in Engineering

> *…I went to different conference meetings and high schools for discussions and sharing…it is important to tell people that we [women] can do*

> *engineering…and sciences…engineering is not only for men…all women and girls are great professionals…*(Participant #8)

All participants had hosted different types of academic and professional conferences due to their professional interests and skills in engineering, regardless of their gender. The participants argued that men and women should have the same rights to select their career pathways and professional developments (Dos Santos, 2020; S.-Y. Kim et al., 2020). Although gender can be one of the restrictions and social stigmas facing women in engineering, all believed their professional images, roles, and skills would become models for girls and female students in engineering (Dos Santos, 2022).

Another important message was about professional counselling and suggestions that industry leaders could become inspirations for secondary school graduates who want to join the engineering profession, particularly for female students and pre-service engineers. Some interesting stories were captured:

> *…sometimes, I received emails and messages from high school students who wanted to study engineering…some female students wanted me to provide suggestions about females in engineering…I honestly tell them the truth about the gender diversity and social equality for female professionals in engineering…but I always encourage them…please join the industry because of your interests and goals…social stigmas and biases played no roles…*(Participant #7)

Another participant also indicated that during the school conference meetings and workshops, some female high school students also asked questions about the engineering profession, female individuals in engineering, and the overall career development for female engineers domestically and internationally. Many believed their professionalism and modelling as female engineers could positively change and impact female students and how the South Korean community understands female engineers in the region:

> *…there are many opportunities for hardworking engineers…although the female engineer population is not large in Asia…a huge demand for female engineers is here…I hope the conference with female engineers and female engineering PhD learners could become the model for our pre-service engineers in South Korea and other Asian countries…*(Participant #9)

In line with the social cognitive career and motivation theory (Dos Santos, 2021c), educating the next generation, particularly female engineers and engineering students, has become their career goal, which matches the theoretical framework (i.e. interests in career development). Although the engineering profession is considered as a male-oriented vocation, female engineers and engineering professionals are in demand (Hackett et al., 1992; Robinson et al., 2016; Strachan et al., 2018). Based on the findings, the participants wanted to apply their theoretical knowledge and skills to the practice and engineering education, particularly for female engineers and engineering students in the industry and universities. Reflecting the results of a recent study (Dos Santos, 2019), this study has confirmed how female engineering professionals want to

switch their career pathways from practising engineers to engineering educators (Dos Santos, 2022).

Conduct and Exercise our Academic Goals and Dreams: Regardless of the Views of the Public

> *…I decided to learn engineering because of my dream…when I was a high school student…many of my female classmates studied teaching, nursing, language, fine arts, and psychology…male classmates joined the engineering, business, and sports…the gender-oriented stereotypes strongly controlled our decisions…but I loved engineering…I joined it…I did not care about the views of other people…I do what I want…girls should do things that they want to do…*(Participant #11)

All participants were experienced engineering professionals with decades of working experience. In other words, they had completed their high school diploma and undergraduate degree at least two decades previously. In this case, in line with the social cognitive career and motivation theory (Dos Santos, 2021c), many argued that during their undergraduate degree selection period, their motivations, career decisions, and decision-making processes were significantly impacted by the surrounding environments and individuals. Many of their female counterparts decided to select other academic programmes, such as teaching and nursing, due to the views of other people and general public members. The participants argued that academic goals and dreams should be prioritized.

The researcher further captured the motivations, career decisions, and decision-making processes about joining a PhD in engineering programme after decades in the industry. All participants indicated that their academic goals and professional interests played significant roles as many would like to contribute their knowledge and skills to the knowledge, practice, and next generation. Two stories were captured:

> *…PhD is not for all people…in the PhD engineering programmes in South Korea…it looks like only male students are being accepted…this is the social expectation…but I want to upgrade my skills…so I contacted the professors, and I followed my mind…I always recommend my female counterparts…please do not mind…any comments from the general public…they could not control our life…we should control our career pathways and dreams…*(Participant #12)

> *…I have worked in the engineering industry for two years already…I want to study for my PhD degree because I want to upgrade the current practice in engineering…some of the technologies and practices in engineering are very outdated…I want to bring new ideas and skills to the field…gender cannot change and limit my dream…I want to do something I want…as a female engineer…*(Participant #5)

Unlike bachelor's and master's degrees, a PhD degree usually requires years of time commitment, sacrifice, and effective time management before graduation. In line with several previous studies (Botella et al., 2019; Dos Santos & Lo, 2018; Larson, 2011), doctoral degree learners usually require strong personal, academic, and vocational

interests in the subject matter. In this case, the female engineers advocated that their academic goals and interests included contributing their knowledge and skills as female professionals to the practice and knowledge of engineering. In line with the social cognitive career and motivation theory (Dos Santos, 2021c), the interests of academic goals and achievements played a significant role in the motivations, decisions, and decision-making processes (Dos Santos, 2022).

In conclusion, based on the findings, relationship between gender and engineering profession, we need to educate the new generation, and we will become the models for all women in engineering play significant roles in the motivations, career decisions, and sense-making processes of the participants, particularly female PhD students in engineering in South Korea. In line with the social cognitive career and motivation theory (Dos Santos, 2021c), the findings with the connection of the theoretical framework connected and discovered how women in engineering and how potential engineering educators describe the current situations and educational sectors in engineering and university in South Korea (M. S. Kim & Seo, 2014). As modelling plays significant role in education and the decision-making processes (Bandura, 1991), it is important to create positive image and role for women in engineering in order to further expand the gender diversity in engineering.

LIMITATIONS

First, female students face challenges and difficulties because of their gender roles, particularly in the fields of STEM education and industry. However, this study only focused on the problems of female engineering PhD students. Other female professionals and students in other STEM directions may face some similar problems too. Therefore, future research studies may expand the directions and subject matters to other female professionals and students in order to understand this social problem.

Second, this study focused on the social problems of PhD students. Although there are only a few studies focused on the problems of PhD students, undergraduate and master's degree students may face some similar problems too, particularly female students. Therefore, future research studies may further study the social problems for undergraduate and master's degree students' understanding and career decision-making processes.

Third, the researcher investigated the social problems in South Korea. However, gender roles and social stigma for STEM female professionals and students could impact the motivations, career decisions, and decision-making processes for women internationally. Although the results from South Korea could reflect the social problems in other countries, particularly in the East Asian region, women from other parts of the global communities may have different voices and understanding. Therefore, future research studies may use this study as the blueprint to collect qualitative data from other women in their countries and region.

CONTRIBUTIONS

Three contributions to the practice and literature were categorized. First, PhD students and graduates are one of the most important groups of professionals in academia and

industry, particularly their contribution can upgrade the current theoretical frameworks and practices in the targeted field. It is important to encourage potential PhD students and candidates to the research programs. The results of this study outlined the motivations, career decisions, and decision-making processes of a group of industry professionals in the research PhD programs. The outcomes will further fill the gaps in the PhD students' motivations, career decisions, and decision-making processes in South Korea, particularly for engineering students and professionals.

Second, PhD programs and research outcomes could positively upgrade and expand the current knowledge in the fields, particularly in the engineering profession. However, only a few industry professionals decided to give up their career developments and mid-level positions in academia. University leaders and department heads may use this study as a reference to reform and promote their postgraduate programs to both full-time and part-time students. In short, the outcomes of this study will fill the gaps in the areas of university management and policy for university leaders and department heads, particularly in the faculty of engineering and office of gender diversity.

Third, women in engineering is one of the strongest groups in the profession. In fact, both men and women must have the same abilities and talents for practice, management, and theoretical knowledge. However, due to the social stigma and bias, many women face challenges and difficulties from the general public members and industry workers. The current study may use as a reference and fill the gaps to close the discrimination and social stigma gaps in the community and industry. Non-profit organizations, organizational leaders, government leaders, and policymakers may reform and develop regulations and policies for minorities in the STEM profession.

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