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The Motivations, Career Decisions, and Decision-Making Processes of Female Students Studying the Professional Doctorate in Engineering

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Women in engineering represent a significant group within the profession, across a range of fields, including oil, mechanical engineering, and biomedical engineering. However, only a few female engineers and engineering students decided to enter and stay in the engineering field due to social stigma and stereotypes toward women in engineering. The purpose of this study is to understand and investigate the motivations, career decisions, and decision-making processes of a group of female engineers and Doctorate in Engineering (DEng) engineering students in the American university environment. Based on the social cognitive career and motivation theory, the research study wants to understand the motivations, career decisions, and decision-making processes of a group of DEng female students in the United States. The case study design with semi-structured interviews, focus group activities, and member-checking interviews were employed to collect data from ten participants. The results indicated that career development, upgrade the current practice and management in engineering, and gender is not an issue for women in engineering were categorised as the themes. The results of this study outlined the qualitative comments about the learning motivations of female DEng and the reasons why DEng would be their selection instead of the traditional PhD in Engineering programme. The results also filled the gaps in the areas of female engineering students and professionals' motivations, career decisions, and decision-making processes after they completed the Professional Doctorate programme.

Keywords: doctorate in engineering, doctoral learner, professional doctorate, social cognitive career and motivation theory, social stigma theory

INTRODUCTION

Doctoral degree programmes are usually designed for learners and professionals who want to upgrade and expand their knowledge and practice in their professional industry. There are several different types of doctoral degree programmes for learners with different levels of achievement, goals, and career pathways (Newton et al., 2019). They include the traditional Doctor of Philosophy (PhD) degree and Professional Doctorates such as the Doctorate in Engineering (DEng) (Zemelka, 2017).

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Unlike traditional PhD degree programmes, DEng programmes are designed for learners who want to solve the current problems in the engineering industry, upgrade their practice and skills in the professional environments, and expand their research knowledge and skills in academia. More importantly, unlike traditional PhD in Engineering programmes (Zemelka, 2017), DEng programmes have dual goals, namely expanding theoretical knowledge in academia and upgrading current practice in the professional environment (Newton et al., 2019).

Another feature of DEng programmes is the orientation and scope of the outcomes and goals. The coursework of many DEng programmes focuses on both academic scholarship, engineering management, and the development of theoretical knowledge through the writing of a doctoral degree thesis. Although the coursework may include or indeed and focus on engineering management, the doctoral thesis must involve empirical and original findings which can expand current theoretical knowledge and practice in the engineering profession (Tao & McNeely, 2019).

The admission requirements and learners' backgrounds can differ between the traditional PhD and the DEng degree programmes (Newton et al., 2019). For example, the PhD usually attracts early career professionals who want to expand their theoretical knowledge of research skills and lab activities, whilst the DEng usually attracts mid-level professionals who want to upgrade both theoretical skills and managerial practice together to solve problems in the professional environment with empirical and original research as the contribution. Although both academic degree programmes may create new knowledge in the engineering industry, the DEng degree programmes should have dual achievements for their graduates (Loxley & Seery, 2012).

Based on the differences between the traditional PhD in Engineering and DEng programmes, these two programmes are designed for different groups of learners to achieve their goals and directions after university graduation. However, these two programmes could also allow different gender groups and learners to achieve their career achievements and goals for their career development and promotions. First, based on the United States Census Bureau, female workers and professionals are nearly half of the American workforce pool. However, only 27% of women work in the STEM industries and professions (Martinez & Christnacht, 2021). Although the population has increased from 8% in 1970 to 27% in 2019, male workers and professionals continue to be considered the majority in the STEM industry. In other words, the gender gaps, discrimination, and social stigma toward women in STEM exist, which significantly impact the motivations, career decisions, and decision-making processes of pre-service and in-service women in the STEM industries and professions, particularly women in engineering.

Second, two recent studies (McGregor et al., 2017; Vidal et al., 2020) argued that although women in STEM, particularly in engineering, may enjoy the same positions, the salary and career opportunities can be limited due to the gender gaps and social stigma toward women in engineering. In other words, the gender, career, and salary gaps are significant, which change and impact the motivations, career decisions, and decision-making processes (Dos Santos, 2022) of many pre-service and in-service

women in engineering. Although the report from the United States Census Bureau (Martinez & Christnacht, 2021) argued that the overall gender diversity and population have increased and changed over the past few decades, the gaps in different factors are large. Therefore, the demands to fill such gaps are significantly needed.

Significance of the Study

In 2019, a study titled "Factors that influence the high percentage of women enrolled in engineering in the UAE and preparing for careers in the oil and gas industry" (Ainane et al., 2019) argued that Middle Eastern countries and states had established effective schemes to attract women into engineering programmes. The study outlined one of the special situations and backgrounds for the female engineers and engineering students due to the unique situations in the Middle East, particularly in the oil and gas industry. Although the oil and gas engineering and industry is one of the leading engineering professions, it is not as common as other engineering specialisations, such as civil, computer, and biochemistry engineering (Al-Junaid et al., 2019; El-Hout et al., 2021; Kocdar et al., 2020; Sattler et al., 2011). Therefore, based on the nature of this study, the researcher tended to understand the motivations, career decisions, and decision-making processes of a group of female DEng learners in the United States, regardless of their specialisations. Therefore, the results of this study would be useful for DEng and PhD in Engineering students internationally (Dos Santos & Lo, 2018).

There have been many previous studies (Frehill, 2020; McCullough, 2019) showing the predominantly male enrolment in engineering degree programmes as well as the dominance of men across the wider engineering industry. According to one report (Silbey, 2016), only 13% of those studying or working in engineering in the United States are women. Although many schools and universities have reformed their curricula and teaching strategies in a bid to increase the attractiveness of STEM (Science, Technology, Engineering, and Mathematics) subjects and professions to women, these efforts have been ineffective (Al-Junaid et al., 2019; Carnemolla & Galea, 2021; Mälkki & Paatero, 2015). Currently, 20% of those enrolled in engineering programmes are women. Forty percent of female graduates subsequently decide to leave the engineering profession after earning their degree. Although both government departments and non-profit organisations have established scholarships for women wanting to join STEM professions, the results of these efforts have been minimal in terms of university enrolment and have had no effect on the numbers of women working in the industry (Ainane et al., 2019; Botella et al., 2019; Tao, 2018). Therefore, the results of this study would be useful to investigate and understand the motivations, career decisions, and decision-making processes of DEng learners beyond the undergraduate and master's level curriculum and background. The study can also fill the gaps in the current areas of doctoral degree learners and higher education for engineering students (Frehill, 2020; Zemelka, 2017).

Purpose of the Study

Women in engineering represent a significant group within the profession, across a range of fields, including oil, mechanical engineering, and biomedical engineering.

However, social stigma and background issues mean that enrolment in many PhD and DEng programmes is over 80% male. Therefore, the motivations, career decisions, and decision-making processes of female learners currently studying DEng programmes are important.

Based on the abovementioned significance of this study, only a few studies were conducted to fill the research gaps in this area, particularly women in engineering, DEng learners' behaviours and motivations, and the career decision-making processes of women in engineering. Therefore, in short, the purpose of this study is to understand and investigate the motivations, career decisions, and decision-making processes of a group of female engineers and DEng engineering students in the American university environment. Based on social cognitive career and motivation theory (Dos Santos, 2021a, 2021c), the following two research questions guided this study:

1) Why do mid-level female engineering professionals decide to study the DEng programme?
2) Why do female engineering professionals decide to study the DEng programme instead of the PhD programme?

Theoretical Frameworks and Relevant Literature

Social Cognitive Career and Motivation Theory

This study employed social cognitive career and motivation theory (Dos Santos, 2021a, 2021c) and social stigma theory (Goffman, 1963). Social cognitive career and motivation theory argues that individuals' motivations and career decisions may be influenced by two sorts of factor, internal and external. Internal factors (i.e., psychological and internal factors with self-efficacy) that can impact the decision-making process include academic interests, personal considerations, academic achievements, and career goals. On the other hand, external factors (i.e., social and external factors) include interests in career development, financial considerations, and surrounding environments and individuals. Motivations, career decisions, and decision-making processes can be impacted by different factors and elements simultaneously. Furthermore, individuals and groups' behaviours should be impacted by at least one factor or element (Hidajat et al., 2020). Therefore, by employing the social cognitive career and motivation theory (Dos Santos, 2021a, 2021c), the researcher could categorise and figure out the behaviours and the intentions behind the behaviours (Hidajat et al., 2020). Figure 1 outlines the social cognitive career and motivation theory (Dos Santos, 2021a, 2021c).

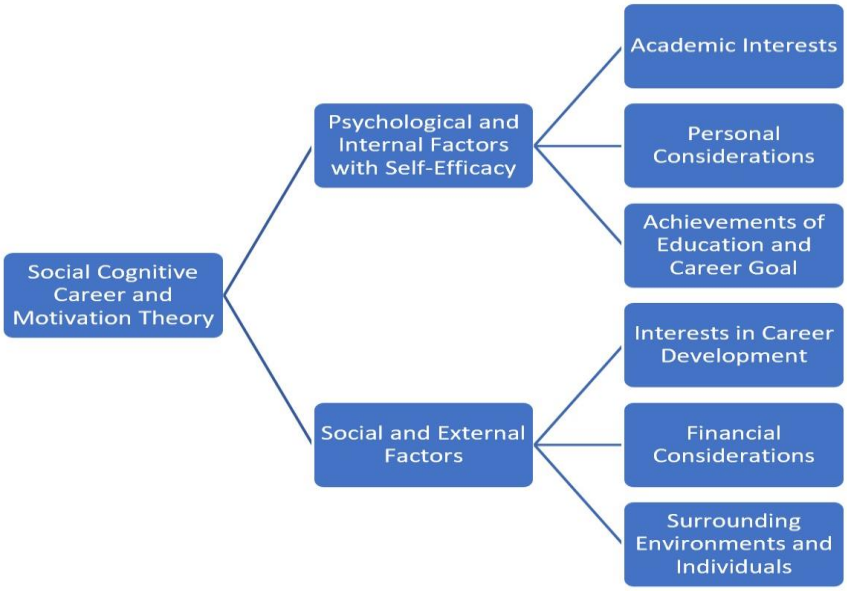

Figure 1
Social cognitive career and motivation theory (Dos Santos, 2021a, 2021c)

Social Stigma Theory and Women in Engineering

Social stigma theory (Goffman, 1963) argues that individuals' characteristics, such as gender, occupation, qualifications, skin colour, and any illness, may cause emotions of confusion, anxiety, and fear among others. In this case, vocational-oriented social stigma and discrimination may be found in the STEM industry, particularly for female engineers, engineering students, and female doctoral degree learners in the engineering school (Botella et al., 2019; Dos Santos, 2021b; McCullough, 2019). The gender gap is one of the social stigma and discrimination toward women. Over the past decades, although many women joined the STEM industry, particularly in engineering, the gender gaps and gender social stigma continued to exist, which created negative impacts and experiences for women in engineering (McCullough, 2019).

Another factor is the promotion of women in engineering. Unlike men in engineering, women and the female population are considered as the minority in the STEM industry, particularly in engineering (Booy et al., 2012). Although the government departments and the engineering industry tried to fill the gender gaps and create opportunities for women in engineering, many of the mid-level, senior-level, and leaders' positions are occupied by men. Under the current circumstances, many women in engineering feel disappointed and concerned as their work and jobs are not admired by the industry. Therefore, the negative impacts and experiences could significantly create the turnover and low level of engineering enrolment in the female population (McCullough, 2019; Stillmaker et al., 2020; Vidal et al., 2020).

Selecting and Studying Doctoral Degree Programme

Selecting the doctorate programme most appropriate for professional development is a difficult decision. A recent study (Gibbs, 2021) indicated that while many are able to differentiate between the relative advantages of traditional PhD and Professional Doctorate programmes in light of their own goals and achievements after graduation, there are also many people who find it difficult to select the most appropriate programme. A significant proportion of those who choose to enrol in Professional Doctorate programmes are senior-level managers who want to improve and develop their managerial skills and are interested in solving problems in the workplace (Loxley & Seery, 2012). Although mid-and senior-level managers and professionals are encouraged to select the traditional PhD programmes for academic and professional development, the Professional Doctorate programmes usually meet their professional achievements and needs as not many senior leaders want to switch their career pathways from the industry to academia.

Another study (Newton et al., 2019) has also highlighted how Professional Doctorates usually include both taught coursework and empirical thesis components as requirements for graduation. In this way, they enable mid-and senior-level managers to effectively refresh their understanding of research procedures, data collection and analysis, and thesis completion procedures. A recent study (Dos Santos & Lo, 2018) investigated the motivations and reasons why a group of managers and leaders decided to study the Professional Doctorate instead of the traditional PhD programmes in the United Kingdom. The participants argued that the taught and research coursework significantly increased their understanding and capacities for research-practitioner's perspectives and goals. In fact, many mid-and senior-level managers and professionals are out of school for decades. Therefore, many do not have solid research skills and background as their counterparts, particularly fresh university graduates who have recently completed their master's thesis. In this case, the Professional Doctorate programmes with coursework requirements significantly meet their expectations and background.

Furthermore, the research-practitioners who emerge from these programmes, it has been argued (Dyrenfurth et al., 2016), tend to use their degree and the knowledge they acquire to increase competitiveness and sustainability within their profession and to champion socially-responsible endeavours. Unlike fresh university graduates and young PhD degree graduates, Professional Doctorate learners are mid-and senior-level managers and professionals with at least five years of working experience in their targeted industry. As mentioned by a recent study (Dos Santos & Lo, 2018), Professional Doctorate programmes usually require professional experience as one of the admission requirements. Therefore, many Professional Doctorate learners are here to upgrade their managerial skills with research capacities which can upgrade their professional practices and environments in the industry. Therefore, the aims and outcome expectations between the traditional PhD and Professional Doctorate can be different due to the background of the learners and the expectations after university graduation.

METHOD

Research Design: Case Study

The present study employed a qualitative case study design (Yin, 2012). Currently, most American universities offer traditional PhD in Engineering degree programmes rather than DEng or Professional Doctorate programmes. While many universities continue to establish DEng or Professional Doctorate programmes to meet the industry's needs, the PhD is still the popular option among learners. In this case study, the researcher aims to investigate the phenomenon as it manifests at an American university where both PhD and DEng programmes are offered.

The case study design is useful in this study. First, scholar (Yin, 2012) indicated that case study is an appropriate design to investigate a problem of a site, a group of people, a situation, an event, or a belief in a given situation. In this case, the case study design was employed to investigate the career, motivations, and decision-making processes of women in engineering and DEng degrees.

Second, although DEng and female engineering doctoral degree learners are not uncommon internationally, the researcher wanted to understand the qualitative data and personal experiences in an American university in order to categorise and study the in-depth data.

Third, the Doctorate in Engineering is the common offered doctoral degree in the United States. Many doctoral degree learners usually study and enrol in this programme in order to achieve their career achievements and goals. However, the DEng degree is one of the Professional Doctorates which may not be very attractive to many potential learners. Therefore, it is important to understand the backgrounds and perspectives of a group of Professional Doctorate learners, particularly in the field of engineering. Female engineers and engineering learners in the doctoral degree programme are uncommon. Therefore, using the case study research design is useful to collect data from a group of participants who share similar backgrounds and understanding.

Participants and Recruitment

Ten participants joined this study based on the purposive sampling strategy. The researcher contacted the school administrator for the study, particularly the agreement between the school and the potential participants. The administrators forwarded the protocol, statement, risk statement, interview questions, and unsigned agreement form to the potential participants. Ten participants agreed to join the study. The participants should meet all the following criteria:

1) female DEng student who are currently enrolled at the targeted university

2) decided to pursue the DEng instead of the PhD programme during the application period

3) non-vulnerable person

4) willing to share personal stories and decision-making processes to the researcher.

Data Collection

Two interview sessions (Merriam, 2009), one focus group activity (Morgan, 1998), and one member checking interview session (Creswell, 2012) were employed to collect data from ten participants. First, the researcher contacted each participant for the individual, private, and one-on-one interview. After two interview sessions (per participant) were completed, the participants were invited to join a focus group activity in order to share their ideas and stories in the group format.

After both interview sessions and focus group activity was finished, the researcher categorised the voiced messages and transcribed to written transcripts. The written transcripts were sent to the participants. The researcher invited each participant for the member checking interview in order to confirm their own materials. All participants agreed and confirmed their materials. Due to the COVID-19 pandemic, the data collection procedures were completed online.

Data Analysis

The general inductive approach (Thomas, 2006) was employed to narrow down the massive qualitative stories and data from raw materials to meaningful themes and subthemes. Two-step procedures were employed. First, as the qualitative data and information were rich and large, the researcher needed to re-read the materials multiple times in order to categorise the connections. Based on the grounded theory approach, the open-coding technique (Strauss & Corbin, 1990) was used to narrow down the large-size information to meaningful themes and groups. In this case, the researcher merged 12 themes and 15 subthemes.

However, many qualitative researchers argued that further studies should be conducted. Second, based on the abovementioned themes, the researcher further narrowed down the themes and groups based on the axial-coding technique (Strauss & Corbin, 1990). As a result, three themes and two subthemes were merged for this study.

Triangulation

Qualitative researchers tend to ensure the triangulation of the qualitative studies. Therefore, in this case, the researcher employed three data collection tools, including two semi-structured interview sessions, one focus group activity, and one member checking interview session for each participant. Based on three different tools, the qualitative data were confirmed by the participants based on three channels (Merriam, 2009).

Human Subject Protection

Privacy is the most important part of this study. Therefore, the researcher stored all the related materials in a password-protected cabinet, including the signed agreements, voiced messages, written transcripts, personal contacts, university information, and computer. Only the researcher could read the materials and information. After the researcher completed the study, the researcher deleted and destroyed the related materials immediately in order to protect the privacy of all parties. The research received support and approval from the Woosong University Academic Research Funding 2022.

FINDINGS AND DISCUSSIONS

Ten participants joined the study and shared the motivations, career decisions, and decision-making processes that led to them enrolling in a DEng programme at a research-based university in the United States. Although the students came from different backgrounds and professions, many shared similar stories, particularly regarding their decision to enrol in the DEng programme. The researcher decided to combine the findings and discussion chapters together as a comprehensive chapter for immediate comparison. It is not uncommon for many qualitative studies to have combined chapters for comparison.The following chart outlines the themes and subthemes that emerged in the findings.

Table 1
Themes and subthemes

Themes and subthemes
Career Development: Time to Upgrade my Qualification
Professional Interests in the DEng: The PhD is not my Goal
I Want to Upgrade the Current Practice and Management in Engineering
Engineering Management and Practical Development
Gender is not an Issue for Women in Engineering: Women can be Smart Too

Career Development: Time to Upgrade my Qualification

For mid-level managers and professionals, pursuing a postgraduate qualification is one pathway to achieving higher salaries and promotions, since the degree boosts graduates skillsets and knowledge (Loxley & Seery, 2012). Ten participants in the present case study indicated that they were motivated to enrol in doctoral study by a perceived need to upgrade their qualifications in order to achieve their professional goals, particularly as women senior-level leaders in a male-dominated industry. As one participant said:

> *…in the engineering industry…I can see a lot of good and clever female engineers…but many cannot climb up…and cannot break the ceiling…I don't believe this is the fact…I want to seek a doctorate and be one of the senior leaders…because of this excellent doctorate…I want to see the relationship between education and senior positions…*(Participant #3)

Many argued that although women may display competence and managerial skills equal to their male counterparts, nevertheless, gender bias continues to impact on their career development (Frehill, 2020). Therefore, in order to help them stand out, many see achieving a higher level of degree as a means to boost their CV relative to other candidates. As one participant said:

> *…for the senior male leaders and the board members…these people do not want to join any female counterparts to the game [the senior management]…many excuses…such as gender, family, education, working capacity…for those physical restrictions…I could not change…but I can achieve a doctoral degree in engineering…I can use a terminal degree…and tell people women in engineering can be very useful…*(Participant #5)

Professional Interests in the DEng: The PhD is not my Goal

> *…PhD degree training and…nature…is designed for people who want to enter the academia…but the Professional Doctorate or the DEng…are for people who want to work in academia and the industry…DEng is more flexible…because DEng training and background are well-designed for both aspects…PhD is too narrowed…why not give myself…a dual skill and opportunity…*(Participant #4)

As pointed out in previous studies (Frehill, 2020; Zemelka, 2017), while PhD and DEng degrees are both doctoral-level programmes that allow learners to create original contributions and expand their current knowledge within their fields, the overall goals of the two types of programme are not the same. In particular, the dual goals of DEng programmes aim to produce graduates who are both researchers and practitioners. Participants in the present study all indicated that they wanted to become researcher-practitioners capable of conducting original research while at the same time upgrading their professional practice as female engineers. As one participant put it:

> *…I want to upgrade my managerial skills in the engineering industry…because I want to become a senior leader…the DEng degree is the right option…because it trains leaders the appropriate managerial skills and how we can apply the current knowledge to the practice…also, we need to complete original research for the engineering industry…the researcher-practitioner approach is excellent…*(Participant #1)

All participants argued that they might eventually join academia, where they hoped to make contributions that took advantage of their combined backgrounds in doctoral research and professional industrial environments. In fact, unlike the traditional PhD degree programmes with solid training for future researchers and faculty members in colleges and universities, the DEng and Professional Doctorate programmes are designed the meet the needs of both future researchers and research-practitioners in the professional environment. As One said:

> *…at this point, I want to become a senior leader…but decades later…I want to go to academia…and become a university professor…because I can transfer my skills and practical knowledge to our students and next-generation engineers…many of our current university professors are pure researchers without industry experiences…*(Participant #8)

In line with social cognitive career and motivation theory (Dos Santos, 2021a, 2021c), interests in career development played significant roles in the motivations, career decisions, and decision-making processes of the participants. Participants argued that enrolling in the DEng degree programmes could significantly increase their opportunities for promotion to senior leadership positions (Dyrenfurth et al., 2016; Newton et al., 2019), especially given the programme's combined focus on research, practice, and managerial skills. More importantly, the participants argued that the PhD degree training is exclusively for people who want to enter academia. However, the DEng or the Professional Doctorate degrees are designed to learners for both academia and industry (Gibbs, 2021). Therefore, all participants indicated that the motivations of joining the DEng program and training met their expectation.

In line with social stigma theory (Goffman, 1963), participants also argued that gender bias limited the career development opportunities of female professionals in the fields of engineering. Therefore, many saw the DEng degree programme, and the upgraded skillsets this would equip them with, as a pathway to breaking the male-dominated industry's glass ceiling (Dicke et al., 2019; Moss-Racusin et al., 2018).

I Want to Upgrade the Current Practice and Management in Engineering

Like many STEM industries, the engineering industry needs its members to regularly upgrade their skills and practices in order to meet the needs of current technologies (Dos Santos, 2021d; Park et al., 2018). Participants argued that although many mid and senior-level engineers and professionals continue to complete Continual Professional Development (CPD) hours and training, many of the skills and practices taught during this training are outdated, particularly the engineering management practices. Participants, therefore, expressed a desire to use the knowledge gained through the DEng programme to reform and upgrade current managerial styles and practices, particularly for women in the engineering industry (Chookaew & Howimanporn, 2022). In the words of one participant:

> *…the CPD hours and training are not useful…we need to have the right people to teach the right things for the organisations…many of the CPD training are for general development…and the training are outdated without any good applications…I want to learn something new and apply this new knowledge to the current engineering industry…the leaders in the field would understand the needs of the people…*(Participant #10)

Engineering Management and Practical Development

Professional frontline staff may not be the best candidates for leadership and senior manager's position. In engineering, all participants also argued that good practising engineers might not be the most appropriate choice to fill senior administrative positions. A recent study (Chookaew & Howimanporn, 2022) argued that engineers should receive appropriate levels of training across practical skills, theoretical knowledge, and managerial ideas over the course of their careers. However, not all managers or leaders are appropriately skilled management professionals, and participants believed that the DEng degree would therefore be helpful in allowing them to upgrade both managerial and practical skillsets through a single programme (Dos Santos & Lo, 2018; Gibbs, 2021; Newton et al., 2019), including under the part-time completion option. One participant said:

> *…I can learn managerial skills, engineering applications…and more importantly, expand the current engineering knowledge as a researcher-practitioner…at the same time as a female engineer and professional…many senior leaders do not understand…because they were all great engineers…but some human resources…people to people management…and government policies…we need to have some right people with the excellent background…I will be the right one…and the right woman…*(Participant #9)

In line with social cognitive career and motivation theory (Dos Santos, 2021a, 2021c), the participants argued that those employed in today's engineering industry need to be equipped with the contemporary, practical, and applicable techniques and training that can enable them to promote the upgrading of current practice across the industry (Ahern et al., 2012; Mälkki & Paatero, 2015). Although CPD training may be useful, many believe that hands-on training from frontline, practising engineers, including from peers and co-workers, would help fill the gaps in this area. More importantly, many mid- and senior-level managers and professionals have already left university and engineering schools for decades. Many of the theoretical theories, knowledge, and skills were outdated. Therefore, the contemporary and updated training and practical skills from their counterparts would be helpful (Ismail & Jarrah, 2019). In this case, the participants wanted to become one of the trainers and leaders in engineering in order to provide the contemporary training and knowledge to their peers and professionals in engineering, particularly as women in engineering (Ainane et al., 2019; Botella et al., 2019).

In line with social stigma theory (Goffman, 1963), the participants argued that male engineering industry professionals might look down on their female peers, regardless of their competence and skills. Participants therefore expressed the desire to use their DEng degree to expose to their peers the stereotypes of female professionals and the social stigma directed towards them. In other words, gender bias should not have any connection to female engineers' professional skills and techniques (Frehill, 2020; Gibbs, 2021; McCullough, 2019; Newton et al., 2019). More importantly, the participants wanted to use their gender role and status as the means to overcome the social stigma and discrimination toward women in engineering, particularly women in engineering with professional practices and higher qualification (Booy et al., 2012; Vidal et al., 2020).

Gender is not an Issue for Women in Engineering: Women can be Smart Too

Gender is one of the greatest barriers preventing the advancement of women in engineering, particularly to senior leadership positions, which are largely dominated by their male counterparts. Many previous studies (Ainane et al., 2019; Frehill, 2020; McCullough, 2019) have argued that the differences between male and female engineers and professionals are not significant and can be explained as resulting from differences in professional development and training. However, only 20% of those in the engineering industry are women (Silbey, 2016). This gender imbalance is something that participants cite as motivating them to reform current management and practice in engineering and to advocate for the rights of minorities in the industry (Booy et al., 2012; Griffith, 2010; Wu et al., 2020). As two participants said:

> *…many studies and people argue that women in engineering…can be very smart…and have excellent capacity…the gender issue…is an excuse and stereotype…we are working on the rights that women were doing six decades ago…people do not believe in women…and I am here to tell you women can be the leader and greatest professionals in the STEM industry…with a doctoral degree and good practice…*(Participant #7)

> *…gender stereotypes and stigma are our restrictions…I can see women…women can be very useful and smart in the engineering industry…but many people do not recognise our work and brain…I want to use my professional background and my qualification…as the means to tell people that…women in engineering can be very helpful…can be smart leader in the STEM industry…*(Participant # 1)

Many participants wanted to use their gender status, qualification, and professional skills to demonstrate to members of the general public, and, more broadly, to those in STEM-based industries, the competence, skillsets, and management abilities of women in engineering (Griffith, 2010; Vidal et al., 2020; Wu et al., 2020). All offered contemporary examples of how women can be leaders on the international stage and in the political arena. As one participant put it:

> *…Kamala Harris and Angela Merkel would be the greatest female leaders in human history…we are not in politics…but we all believe women can become the greatest leaders in the engineering industry…I am in the DEng programme and this programme will equip me to become one of the skilled professionals…not only in the field of engineering…but also excellent and smart people in our community…*(Participant #6)

> *…women can be leaders and governors of many countries and cities…we are just working in the engineering industry…we are not here to change the world or change the overall development in the third-world countries…we need to use our gender role…for the development…for women in STEM and engineering…we need to help our future and fresh graduates in engineering…the gender gaps must be filled…*(Participant #2)

In line with social cognitive career and motivation theory (Dos Santos, 2021a, 2021c) and social stigma theory (Goffman, 1963), the participants believed that personal considerations and surrounding environments and individuals all played significant roles in their motivations, career decisions, and decision-making processes (Dos Santos & Lo, 2018). First, the participants saw enrolment in the DEng degree programme as a means to upgrade the status and role of female engineers, particularly by boosting the percentage of female professionals in engineering, both on the frontline and in senior positions (Frehill, 2020; Gibbs, 2021; McCullough, 2019; Newton et al., 2019). Currently, many PhD in Engineering and DEng enrolment are male learners. Although the population and enrolment of female learners in STEM, particularly in engineering, has increased, gender gaps exist. Many argued that the gender gaps are created due to the social stigma and discrimination toward women in engineering (Dos Santos, 2021b; Goffman, 1963). In this case, the participants argued that they are here to overcome the social stigma and fill the gender gaps between people, general public members, industry leaders, and engineering professionals (Booy et al., 2012; Stillmaker et al., 2020; Vidal et al., 2020). Second, the participants further argued that just as female politicians play important roles in the public arena, so too female engineers should promote the representation of women in the engineering industry, particularly in the current political environment.

CONCLUSION

Engineers and DEng learners' motivations, career decisions, and decision-making processes are underestimated, particularly those of female mid- and senior-level engineers and professionals. The results of this study outlined qualitative data from these groups of people and filled some of the gaps in current understanding of this area, particularly there are only a few studies employed the qualitative design to understand the motivations and decision-making processes of doctoral degree learners in engineering.

Although the PhD in Engineering and DEng degree programmes may result in similar outcomes, such as original and empirical contributions to the fields, the outcomes and achievements for learners can be different. The results of this study further clarified the distinguishing characteristics of the DEng programme and the particular advantages it confers on its graduates, particularly there are only a few studies focused on the differences between these two dotoral degrees and qualifications in the current database.

The present study also served to highlight issues around workforce and human resources shortages, gender biases, and the social stigma experienced by female engineers and professionals in a male-dominated industry. Although a recent study (Ainane et al., 2019) argued that gender bias is diminishing and the representation of women within the industry is increasing, it remains important to understand the current situation in the North American environment and compare differences between different regions and countries. Therefore, based on the voices and results of this study, the results of this study will fill the research gaps in this area, particualry in the areas of discrimination and bias.

Women in engineering and female doctoral degree learners are important assets to their industries. However, due to gender bias and stereotypes, women in engineering may not receive equal numbers of opportunities compared to their male counterparts. Professionals, leaders, government departments, non-profit organisations, and policymakers may use this study as a reference point in reforming efforts aimed at combatting the current situation of gender bias and social stigma within STEM-oriented fields.

LIMITATIONS

The present study investigated the motivations, career decisions, and decision-making processes of a group of female leaders enrolled in a DEng degree programme in the United States. There is much scope, however, for further study of gender and learning issues around the PhD and DEng degree programmes, particularly through analysis of data on women enrolled in PhD in Engineering programmes and their views on these issues (Hughes et al., 2017). Therefore, future research might profitably proceed by expanding the population of PhD in Engineering learners interviewed, whether those at the same university or at other universities, in order to create a holistic picture of the current industry.

As highlighted in a previous study (Ainane et al., 2019), the proportions of female engineers and engineering students in Middle Eastern countries are significantly higher

than in the United States. Therefore, a comparison study between the two regions would be useful. Future research might collect data from multiple groups of participants in order to outline the ways in which the motivations, career decisions, and decision-making processes of female engineers are affected by sociocultural and geographic differences.

The present study employed the case study approach, which only allowed participants at one university and on one targeted DEng degree programme to share their motivations, career decisions, and decision-making processes. However, female learners from other universities and degree programmes may have different understandings of and answers to the issues examined in this paper. Therefore, future researchers might profitably replicate the protocol and design of the present study to conduct new investigations specific to other universities and cities.

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