A Phenomenological Exploration of Women's Lived Experiences and Factors That Influence Their Choice and Persistence in Engineering

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Introduction

In recent years it has been suggested that the United States is losing its prominent global position in Science, Technology, Engineering, and Math (STEM) education, which has greatly influenced our country's global and economic competitiveness. According to the National Math and Science Initiative (NMSI, 2016), "American students are falling behind other countries in the critical subjects of math and science (STEM subjects) …challenges facing education today in the U.S. include staying competitive, closing minority gaps, closing gender gaps and improving teacher preparation" (para. 2). This decline has enabled many other developed nations to surpass the U.S. in degree attainment in STEM disciplines, especially in engineering, resulting in a significant growth in the science and engineering workforce in other countries (National Science Foundation, 2003). According to the National Science Foundation (2003), the U.S. currently ranks fourteenth in the world in the percentage of students earning a first degree in a science or engineering discipline compared to its rank of third in 1975. In addition, while the overall number of students enrolling in undergraduate engineering programs in the U.S. has continued to grow over the past decade, graduation rates remain stagnant (Yoder, 2016). If continued, these trends can have a damaging impact on our society's economy and skilled workforce.

As a result, deliberate efforts have been made by public policymakers, educators, and politicians to invest in STEM and engineering education to strengthen our nation's role as a world leader in scientific and technological advancement. Parallel to these efforts has been a call for the U.S. to produce more engineers. However, one of the major challenges with increasing the number of graduates from undergraduate engineering disciplines is the high rate of student attrition in these programs. It is estimated that approximately half of all first-time first-year students entering an engineering program will persist and earn an engineering degree, resulting in an attrition rate of roughly 50 percent (Ohland, Sheppard, Lichtenstein, Eris, Chachra, & Layton, 2008). High attrition is not only a concern to undergraduate engineering programs but also is a threat to industry, workforce demands, and public investment in engineering education.

To compound the urgent need to tackle the growing attrition concerns within engineering programs and increase engineering graduates, the need is even more critical among underrepresented populations such as women and underrepresented minorities. According to Fouad and Santana (2017), the United States Census Bureau of 2010 reported that "women were comprised of approximately 52 percent of the U.S. population, African Americans 12 percent, Latinos 16 percent, Asians 5 percent, and all other racial-ethnic groups 3 percent" (p. 25). However, women (11 percent) and African American, Latino, and Native American males (7.4 percent) only accounted for less than 20 percent of the engineering workforce in the U.S. in 2010 (Byars-Winston, Fouad, & Wen, 2015). If these trends continue as we approach the middle of the twenty-first century it could have a damaging impact on the United States' skilled workforce. This is especially true since it is projected that by the year 2050 approximately half of the total U.S. population will be comprised of people of color (Palmer, Maramba, & Dancy, 2011) and women will continue to make up half of the nation's current workforce and more than half of the nation's total college enrollment (National Center for Education Statistics, 2017).

Despite concerted efforts among the engineering community – educators, employers, research funders, policymakers, and engineering professionals – to increase women's enrollment and persistence in undergraduate engineering programs, women's underrepresentation in the engineering profession continues to persist into the twenty-first century. As a result of this trend, especially given women's proportion of the overall U.S. population and college enrollment, the need for further investigation of the issue has been well established. While numerous studies have examined this issue, many have done so quantitatively. Therefore, it has been recommended by the engineering community that an expanded use of qualitative methods be considered to address this research gap and add to the scope and rigor in understanding factors that influence women's choice and persistence in engineering (Koro-Ljungberg & Douglas, 2008).

Purpose of the Study

Various engineering studies have investigated factors that contribute to a student's choice of an undergraduate major using large datasets saturated in male student data, which may not provide a thorough examination of how women's lived experiences influence their choice of engineering. As a result, it is sometimes difficult to ascertain how the results from these large studies can be put into action at individual institutions, especially related to the development of interventions aimed at increasing women's engineering enrollment. Trauvetter (2018) posited that the use of qualitative methods in examining women's experiences prior to entry into an engineering program can provide researchers and practitioners with a deeper understanding beyond quantitative evidence.

In regard to engineering retention, many studies have focused on understanding the reasons students fail to persist, especially among women and underrepresented populations, which have guided engineering programs in developing interventions and practices that can be implemented to support women's persistence in engineering. To expand on the current engineering education research the purpose of this qualitative study was to explore the lived experiences of eleven female engineering students to gain a deeper understanding of factors that have shaped and influenced women's choice and persistence in engineering.

The importance of this study is to explore the lived experiences of women in an undergraduate engineering program at a large, comprehensive research university during their pursuit of an engineering degree and to identify and understand factors that were influential in their choice to pursue engineering as a major and persistence within engineering. Additionally, the results from this study may be used to guide engineering educators and practitioners in developing effective strategies to improve woman's recruitment, retention, and graduation in engineering. According to Tinto (2012), "in the real world of action, what matters are not our theories, but how we can address pressing issues of retention and persistence" (p. 253).

Theoretical Framework

Building on the prior work of self-efficacy and its utility in career choice Lent, Brown, and Hackett (1994) introduced the Social Cognitive Career Theory (SCCT) to understand the complexities in one's decision to pursue certain academic and career interests. Drawing from Bandura's (1986) general social cognitive theory, SCCT underscores the reciprocal effects the person, their behavior, and environments have on one another, known as "triadic reciprocality" (Bandura, 1986).

SCCT has been widely used and recognized as one of the leading theoretical frameworks used to examine factors related to academic and career choice behavior of women and underrepresented minorities in STEM fields (Fouad & Santana, 2017). The SCCT model is used to explain "the factors that act on individuals as they make choices about their education and career in engineering and differences in the impacts of those factors based on an individual's background and characteristics" (National Academy of Engineering [NAE], 2018, p. 82).

In the SCCT model person inputs and background contextual affordances influence one's learning experiences, which has been shown to contribute to one's self-efficacy and outcome expectations in a given domain. The interaction of these variables in turn may foster development of interests, goals, and actions towards educational and occupational pursuits. Person inputs are defined as predispositions, gender, race/ethnicity, health/disability and personal traits. Background contextual affordances (or distal factors) refer to cultural and gender role socialization, socioeconomic status, role models, and skill development (Lent, 2013). Learning experiences are referred to as "personal performance accomplishments, vicarious learning, social persuasion, and physiological and affective states" (Lent, 2013, p. 118).

Self-efficacy beliefs/expectations refer to "people's subjective judgements of their capabilities to organize and execute courses of action required to attain designated types of performances or goals" (Bandura, 1986, p. 391). Self-efficacy beliefs are closely associated with one's confidence in their abilities and aptitudes (e.g., "can I do this?"). Self-efficacy beliefs are attained and adapted through one of the four learning experiences with personal performance accomplishments proven to have the greatest influence on self-efficacy. Students that perform extraordinary on math exams will tend to develop high levels of self-efficacy in relation to taking math courses. Outcome expectations refer to attitudes about what one presumes will happen from a particular behavior (e.g., "if I do this, what will happen?) and relate to self-evaluation, feedback, and physiological outcomes.

If one's self-efficacy and outcome expectations are high for the same performance domain or task, it is likely that the individual will develop interest in the domain, form goals to pursue the interest, and take actions necessary to achieve those goals. Interests refer to a person's individual development and arrangement of likes, dislikes, and indifferences in relation to career-relevant tasks. As interests develop, they encourage – along with self-efficacy and outcome expectations – the formation of goals for supporting or growing one's involvement in particular activities. Goals are defined as an individual's intention to participate in a particular activity or strive to reach a specific outcome. Goals help motivate an individual to take action toward achieving one's goals which results in subsequent performance expectations. Lastly, contextual influences proximal to choice behaviors – such as environmental supports and barriers – can affect the strength of the relationship between interests, goals, and actions on goal actions. (Lent, 2013).

Methodology

The purpose of the present phenomenological study was to explore women's lived experiences to gain a better understanding of factors that influence their choice and persistence in an undergraduate engineering program. According to Creswell and Poth (2018), "a phenomenological study describes the common meaning for several individuals of their lived experiences of a concept or a phenomenon" (p.75). Therefore, the study's intent was to explore women's experiences in engineering, understand how they made sense of these experiences,

interpret factors that were influential in their choice and persistence in engineering, identify common themes or elements that were recurrent across the participants, and inform future practices for enhancing women's recruitment, enrollment, and persistence in engineering.

The study was conducted using an Interpretative Phenomenological Analysis (IPA) methodological approach grounded in an epistemological assumption and orientated in a constructivist worldview. The use of IPA allowed for an in-depth exploration of women's lived experiences and its inductive procedures focused on the interpretation of their experiences and factors that were influential in their choice and persistence in engineering.

Research Questions

The research questions below were designed to guide the study in the exploration of the lived experiences of eleven female students in an undergraduate engineering program. These questions provided a foundation for gaining a detailed understanding of how the participants made sense of their experiences and factors that were influential in their choice and persistence in engineering.

1. How might choice and persistence take shape for women in an undergraduate engineering program?
    a. What roles do pre-college engineering-related learning experiences play in women's choice of engineering as a major?
    b. How do women overcome social and cultural barriers in their persistence in an engineering program?

Participants

The recommended sample size for qualitative studies can vary based on the research design and approach. In phenomenological studies the recommended sample size is approximately three to fifteen participants that have a common or shared experience related to the phenomenon under investigation (Smith, Flowers, & Larkin, 2009). The participants for this study were selected through the utilization of a multiple purposeful sampling strategy which included a two-step criterion sampling method and a maximum variation sampling method. This approach was used to minimize sampling errors, such as sampling bias, and to increase the credibility of the study. Additionally, five female faculty members, who majored in engineering as undergraduates, were selected to participate in the study as a method of triangulation and to strengthen the trustworthiness of the findings.

Procedures

Approval for access to the research site was granted by the Dean of the College in September 2018. Permission to conduct the study was requested through the university's Institutional Review Board (IRB). An IRB Protocol for Minimum Risk Studies was submitted in October 2018 and approval was granted in November 2018. Two consent forms, consistent with the institution's IRB standards, were developed for the study: a general informed consent and permission to audiotape. The consent forms were sent to each participant who agreed to participate in the study ahead of their scheduled interview. The consent forms were also reviewed at the time of each interview to ensure the participants were informed of the conditions, risks, and safeguards of the project.

Additional steps were taken to ensure the study was conducted ethically and avoided any ethical dilemmas such as protecting the anonymity and confidentiality of the participants. Steps to

ensure anonymity included assigning codes to mask any personal identifiable information that could be traced back to each participant. Steps to safeguard confidentiality in addition to assigning codes to each participant included the storage of any personal identifiable information in a separate file (e.g., demographic information, student identification number, etc.) and securely discarded once the data collection had been completed. NVivo – a qualitative data analysis computer software package developed by QSR International – was used as the primary data management, transcription, and analysis tool for the study.

Data Collection

In-depth interviews were the primary source of data for the study and consisted of two semi-structured individual interviews lasting approximately thirty to sixty minutes with each participant. Thirty-two total interviews were conducted for the study which consisted of twenty-two student participant interviews and ten faculty participant interviews. The focus of the first interview explored the choice phenomenon and the focus of the second interview explored the persistence phenomenon. An interview protocol was developed using a semi-structured interview format. This format provided flexibility during the interviews and for the use of prompting and probing, which encouraged the participants to elaborate on their experiences and ensured that topics, issues, and questions relevant to the study were covered. Interview questions consisted of a mix of general open-ended, descriptive, narrative, evaluative, and non-directive questions which were used to help guide the interview. Additionally, each interview was recorded using the "Voice Memos" application on an Apple device and were uploaded into a secure filing system in NVivo.

Data Analysis

IPA follows a similar analytical approach commonly found in qualitative research, which entails preparing and organizing the data, reduction of the data, and interpreting the data through discussion or visual formats (Creswell & Poth, 2018). One of the challenges in qualitative research is to convince the reader that the analytical process is focused, clear, and defined. To demonstrate this, the data analysis spiral was utilized as a guiding framework in the analysis process. This structured format guided the analytic process and allowed for a high level of focus and attention towards the participants' account and reflection of their experiences.

Results

The IPA approach provided an in-depth and interpretative investigation into the personal experiences of the participants and allowed the participants to reflect on the significance of their experiences during their choice and persistence in engineering. The study's in-depth analysis revealed several recurrent themes from the participants' experiences that aligned with the SCCT framework, offering a unique perspective of how choice and persistence in engineering took shape for the participants in the study. To deepen the study's credibility member checking techniques were used to authenticate the analysis and interpretation of the participants' experiences and triangulation methods were used to validate the findings and illustrate convergence in evidence across the student and faculty participants' experiences.

Emergent Themes Related to Women's Choice of Engineering

While there were many differences – socioeconomic status and demographics, parental education, upbringing, and educational experiences – among the eleven student participants (and five faculty participants) several similarities and connections related to *Women's Choice of*

Engineering emerged from their lived experiences during the analysis. Emergent themes were classified as recurrent if they were present in at least half of the student participant interviews. The emergent themes were triangulated with the faculty participant data to validate the findings and illustrate convergence in evidence across the student and faculty participants' experiences. The findings were closely linked to several variables within the SCCT framework such as person inputs, environmental influences, learning experiences, self-efficacy expectations, and outcome expectations. Furthermore, the findings illustrated how the interaction and interplay of these variables amplified the participants' interests and choice goals resulting in their decision to pursue engineering as a major. The *Women's Choice of Engineering* findings are revealed within five themes identified as (I) STEM or Engineering Exposure, (II) Self-Efficacy in Math and Science, (III) Engineering Expectations, (IV) Engineering Agency Beliefs, and (V) Pre-College Environmental Support.

Choice Theme I: STEM or Engineering Exposure

All eleven student participants had reported participating in direct or vicarious STEM or engineering learning experiences prior to college. These positive learning experiences proved to be extremely influential in bolstering their self-efficacy and outcome expectations related to engineering. This helped mold their engineering interests and served as a stabilizing force in their decision to pursue engineering as an undergraduate major. The triangulation of the faculty participants' data supported the student participant findings as all five faculty participants reported direct or vicarious STEM or engineering learning experiences prior to college. The findings were consistent with the SCCT framework and existing engineering education literature as the development of initial educational interests have been shown to be closely related to positive learning experiences (Lent, 2013) and exposure to STEM or engineering learning experiences prior to college has been found to be influential in the development of an individual's interests in engineering (NAE, 2018; Painter et al., 2017; Shapiro & Sax, 2011).

Choice Theme II: Self-Efficacy in Math and Science

Of the eleven student participants ten reported possessing strong self-efficacy beliefs in mathematics and science prior to college, which has been well documented as an important determinant in developing one's interest in engineering (Carnasciali et al., 2013; Mau, 2003; Painter et al., 2017; Seymour & Hewitt, 1997). This was also consistent with the SCCT framework as it suggests that interests in an academic and career path are likely to grow and persist when individuals perceive themselves as capable within a given subject or performance domain. As a result, this demonstrated how the student participants' confidence in their ability to succeed in subjects associated with engineering helped guide their engineering interests and decision to pursue engineering as a major. The triangulation of the faculty participants' data supported these findings as all five faculty participants reported strong self-efficacy beliefs in mathematics and science prior to college.

Choice Theme III: Engineering Expectations

The eleven student participants reflected on similar beliefs regarding their outcome expectations related to obtaining an engineering degree. The common thread among their beliefs was how an engineering degree could provide them with career opportunities that would allow them to achieve their personal, social, and career goals. This illustrated the central role outcome expectations play in regulating and influencing an individual's career choice behavior as outcome expectations, along with self-efficacy expectations, directly influence one's academic and career interests. This was consistent with the SCCT framework as it posits that outcome

expectations are derived from the interactions between one's learning experiences and self-efficacy expectations (Lent, 2013). Furthermore, outcome expectations are also directly linked to an individual's choice goals, performance goals, and choice actions. The triangulation of the faculty participants' data supported these findings as all five faculty participants reported similar perceptions of the consequences or outcomes pursuing an engineering degree would yield.

Choice Theme IV: Engineering Agency Beliefs

Nearly all of the student participants described how they viewed engineering as a profession that makes a difference in the world and how this aligned with their goal of entering a profession that is committed to a greater social purpose. The findings were consistent with the existing literature as engineering agency beliefs have been linked to a student's decision to pursue engineering and is especially true for women as they tend to concentrate their interests in fields that help people and make a difference in the world (Godwin et al., 2016; NAE, 2018; Seymour & Hewitt, 1997). The findings were also consistent with the SCCT model as engineering agency beliefs intersect several of the variables in one's career-related choice behavior. The triangulation of the faculty participants' data moderately supported these findings as three faculty participants tied their interests in engineering to helping others.

Choice Theme V: Pre-College Environmental Support

The eleven student participants detailed the positive environmental support they received during their adolescent years from parents, family members, role models, teachers, and mentors. As the student participants reflected on these sources of support, they described them as highly influential in the development of their academic and career interests, goals, and choice actions. The findings aligned with the SCCT framework as it suggests that "career interests are more likely to blossom into goals and goals are more likely to be implemented when people experience strong environmental supports" (Lent, 2013, p. 125). Additionally, the impact positive environmental support had on the student participants' interest in engineering supports the existing engineering education literature as environmental support has been shown to play a significant role in a student's decision to pursue engineering, especially for women (Fouad & Santana, 2017; Godwin et al., 2014; NAE, 2018; Painter et al., 2017; Shapiro & Sax, 2011). Furthermore, the triangulation of the faculty participants' data supported these findings as four of the five faculty participants provided examples of significant support from either their families, teachers, or role models. Finally, the findings support the notion that strong environmental support plays an instrumental role in aiding one's development and sustenance of career interests, goal-setting, and choice actions in engineering.

Emergent Themes Related to Women's Persistence in Engineering

The aim of the second in-depth interview was to explore the participants' experiences once they matriculated as an engineering student to gain a better understanding of factors and influences related to their decision to persist in engineering. Among the eleven student participants several similarities and connections related to *Women's Persistence in Engineering* emerged from their experiences during the analysis. Emergent themes were classified as recurrent if they were present in at least half of the student participant interviews. The emergent themes were triangulated with the faculty participant interview results to validate the findings and illustrate convergence in evidence across the student and faculty participants' experiences. The findings in the second part of the study were closely linked to several variables in the SCCT framework such as self-efficacy expectations, outcome expectations, interests, choice goals, choice actions, and proximal environmental influences. Furthermore, the findings illustrate the dynamic relationship

among these variables and how they influenced the participants' goal transformation process and their decision to persist in engineering. The *Women's Persistence in Engineering* findings are revealed within three themes identified as (I) Engineering Barriers for Women, (II) Women's Engineering Barrier-Coping Strategies, and (III) Engineering Environmental Support.

Persistence Theme I: Engineering Barriers for Women

Nearly all of the student participants reflected on how noticeable it was that they were disproportionately represented in their program and more than half of the student participants recalled instances when they experienced explicit or implicit biases regarding their intelligence or capabilities as a woman studying engineering. These findings confirm prior research as, in addition to the academic rigor, women must also overcome significant social barriers in their persistence in engineering (Chubin et al., 2005; Lichtenstein et al., 2014; Seymour & Hewitt, 1997). These results were also consistent with the SCCT framework as it suggests that "nonsupportive or hostile conditions can impede the process of transforming interests into goals and goals into actions" (Lent, 2013, p. 125). Despite a lack of triangulation between the student and faculty findings, the student participants' experiences regarding their disproportionate representation and women's perceived intelligence or capabilities in engineering are significant as they present how the student participants made sense of socio-structural barriers and challenges that exist for women in engineering.

Persistence Theme II: Women's Engineering Barrier-Coping Strategies

Despite the presence of engineering barriers, the student participants described how they responded to and overcame these challenging encounters through the utilization of engineering barrier-coping strategies. Nearly all of the student participants reflected on how they developed barrier-coping strategies in response to their disproportionate representation and/or negative perceptions of women in engineering. This demonstrated how persisting women were able to neutralize environmental barriers through the use of effective barrier-coping strategies. It also confirmed the existing engineering literature as it has been shown that barrier-coping strategies play a critical role in strengthening and reinforcing women's interests, goals, and choice actions in engineering (Litzler & Young, 2012).Furthermore, these findings add to the existing engineering literature as they provide a unique perspective from the student participants' point of view and demonstrate how women make sense of these intimidating conditions, and the significant role barrier-coping strategies play in neutralizing these conditions. Lastly, the findings fit with the SCCT model as it suggests "that contextual supports and barriers can moderate the goal transformation process" (Lent, 2013, p. 125). Therefore, in order to achieve one's career goals in the face of challenging conditions one's ability to adapt to their environment is paramount. While triangulation between the student and faculty participants' experiences were only moderately applicable the students' data provided a rich, in-depth understanding of how women respond to and overcome barriers in engineering.

Persistence Theme III: Engineering Environmental Support

Each of the student participants provided examples of support they received as matriculated engineering students and the positive impact it had on their persistence. For example, nearly all of the student participants reflected on the support they received from their professors, while a number of the student participants reported support they received from their family. Lastly, the majority of the student participants commented on peer support they received in engineering through their involvement in student professional organizations and peer groups. Overall, the student participants reflected on how these sources of support aided in the strengthening of their

self-efficacy, interests, sense of community, and sense of belonging in engineering. As a result, the presence of engineering environmental support for these eleven women played a valuable role in their persistence in engineering. The findings support the existing engineering literature as it has been demonstrated that strong environmental supports in engineering are influential in a student's persistence (Chubin et al., 2005; Eris et al., 2010; NAE, 2018; Seymour & Hewitt, 1997; Tate & Linn, 2005). This is especially true for women given the social and cultural barriers they are faced with in engineering. The findings were also linked to the SCCT framework as it suggests "that certain conditions may directly affect people's choice goals and actions and contextual variables may affect people's ability or willingness to translate their interests into goals and their goals into actions" (Lent, 2013, p. 125). The findings demonstrated how the student participants were able to locate and obtain support within engineering, which helped guide their choice goals and actions and ultimately contributed to their persistence in engineering. The triangulation of the faculty participants' data supported these findings as the faculty participants reported similar sources of support during their undergraduate engineering careers, the impact they had on their engineering experience, and how these forms of support contributed to their persistence in engineering.

Discussion

Despite concerted efforts throughout the U.S. to produce more women engineers, their underrepresentation in engineering programs and the profession continues to persist. If unchanged these trends can have a damaging effect on our society's skilled workforce and economy as well as our nation's role as a world leader in scientific and technological advancement. "The inability of engineering to attract and retain more women denies employers and the nation access to a large and, given demographic trends, growing share of the engineering-capable talent pool" (NAE, 2018, p. 82). While numerous studies have explored women's choice and persistence in engineering, many have been designed quantitatively and resulted in a limited view of the complex issue.

The current study sought to address these research gaps as well as respond to the engineering community's call for an expanded use of qualitative methods in the investigation of women's underrepresentation in engineering. The benefits of utilizing qualitative methods, especially in relation to this issue, are that inductive and inferential procedures strive to answer questions related to what, why, and how, as opposed to, for example, "how much" and "how many" in quantitative studies (Tuffour, 2017).

Future Research

Further research in examining women's choice and persistence in engineering is essential in addressing workforce needs and public concerns regarding women's underrepresentation in the engineering profession. Future research could benefit from expanding this qualitative study to include multiple institutions. This could help provide additional insights and evidence of factors that contribute to women's choice and persistence in engineering across various institutions and could be comprised of private and public, small and large engineering programs across the United States.

Secondly, a longitudinal design could help enrich the findings as it could provide a real-time examination of women's lived experiences as they progress in an engineering program from a year-on-year prospective. This could provide a more accurate depiction of factors that contribute

to women's choice and persistence in engineering. Longitudinal research across institutions and programs might also aid in observing trends and potential barriers related to women's choice and persistence at certain institutions or academic programs or majors within engineering.

Lastly, a comparative mixed-methods or qualitative study exploring the lived experiences of women persisters and non-persisters in engineering would be useful in learning if any significant differences exist across the two populations and how these may have influenced their decision to persist in engineering or switch from engineering.

Conclusion

The results from this study illustrate the many factors and variables that affect women's choice and persistence in engineering. The utilization of the SCCT model provided a guiding framework in understanding how these factors and variables interact over time and the complex ways in which they influence women's academic and career choice behavior in engineering. Although the findings from this study should contribute to the existing engineering education literature and will serve the current institution well, efforts to investigate the issue further are needed to continue to improve our understanding of women's underrepresentation in engineering.

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