A PHENOMENOLOGICAL EXPLORATION OF WOMEN’S LIVED EXPERIENCES AND FACTORS THAT INFLUENCE THEIR CHOICE AND PERSISTENCE IN ENGINEERING

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Shawn Patrick Fagan
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Examing Committee Members:

Dr. Joseph DuCette, Advisory Chair, Department of Psychological Studies in Education
Dr. Wanda Brooks, Department of Teaching and Learning
Dr. Evelyn Walters, Department of Civil and Environmental Engineering
Dr. Carol Brandt, Department of Teaching and Learning
ABSTRACT

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).

The aim of this phenomenological study was to explore the lived experiences of women in an undergraduate engineering program at a large, comprehensive research university located in the Northeast region of the U.S. to gain a better understanding of factors that help shape and influence women’s choice and persistence in engineering. Lent, Brown, and Hackett’s (1994) social cognitive career theory (SCCT) provided a guiding framework to illustrate how the participants’ educational choice behaviors were influenced by a number of variables related to their personal characteristics, experiences, and environment. To strengthen the study’s credibility member checking procedures were used to authenticate the findings and the interpretation of the participants’ experiences and triangulation methods were used to validate the findings and illustrate convergence in evidence across female student and female faculty participants’ experiences. The findings revealed several recurrent themes across 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. Themes related to women’s choice of engineering were STEM or engineering exposure, self-efficacy in math and science, engineering outcome expectations, engineering agency beliefs, and pre-college environmental support. Themes related to women’s persistence in engineering were engineering barriers for women, women’s engineering barrier-coping strategies, and engineering environmental support.
DEDICATION

To my beautiful, intelligent, and amazing children, Lily and Owen. You are my source of inspiration, you have made me stronger, you fill my heart with joy.

I love you more than any words could ever describe.

Thank you for patiently waiting for “Daddy to finish his paper.”

To all the young girls and women interested in engineering:

Just do it…

Don't be intimidated by anyone…

Be patient…

Study hard, stay motivated…

Be confident in your ability…

Don't be afraid to put yourself out there…

Just do it…
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CHAPTER 1
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. In 2012, President Obama in concert with the Council on Jobs and Competitiveness made a pledge to increase the
number of engineering graduates over the next decade (American Society for Engineering Education, 2012). 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 freshmen 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.

Background to the Study

There have been myriad studies that have examined factors that contribute to student attrition in engineering programs. These studies have helped guide efforts in implementing effective strategies and interventions to increase student retention and degree completion. Two common themes that have emerged from the literature that explain engineering retention are internal and external factors. Internal factors can be summarized as aptitude, pre-college preparation, academic performance, affective and personality traits, and satisfaction; while external factors include academic engagement, academic and career advising, curriculum and instruction, environmental and social dynamics, and climate (Meyer & Marx, 2014). Despite modest progress, gaps still exist in engineering retention research as these studies are primarily quantitative, are saturated with male student data, and focus on institutional versus individual factors that contribute to persistence.

To understand student persistence, it is important to delineate the difference between retention and persistence as they are often used synonymously and are both
grounded in the measurement of student success. In general, retention is an institutional-level measurement of student success while persistence is an individual or student-level measurement of student success. Retention in engineering is the outcome of how many first-time students remained enrolled in the program measured over two points in time and is expressed as a percentage. Persistence in engineering can be described as the act of a student to remain in an engineering program and to continue steadily despite challenges, adversity, or difficulties (Tinto, 2012). Student persistence impacts the institutional indicator of student retention as the choice to persist or leave engineering directly impacts the institution’s retention rate.

While numerous quantitative studies in engineering education research have explored student attrition and informed the development of initiatives designed to improve student persistence, the national completion rates continue to remain fairly unchanged. Therefore, to add to the scope and rigor of engineering research and to gain a deeper understanding of the issue an extended use of qualitative methods is needed to contribute to the current engineering education literature. Koro-Ljungberg and Douglas (2008), articulated:

*We find that there are very few qualitative articles published...These issues may limit the rich, descriptive information that could be gained from qualitative inquiry, limiting the contributions qualitative studies could make to engineering education. We call on researchers to expand their use of qualitative methods and to design their studies with careful attention to epistemological consistency across the design.* (p. 163)

Statement of the Problem

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. According to Yoder (2016), female students represented roughly 23 percent of the total enrollment in undergraduate engineering programs; comparatively, male students represented 77 percent. Female students accounted for roughly 20 percent of the total degrees attained; comparatively, male students accounted for roughly 80 percent of the total degrees attained (Yoder, 2016).

Unfortunately, these percentages of bachelor’s degrees awarded to women have not significantly changed in the last three decades. If continued these trends could have severe economic consequences for individual workers and the nation as a whole. For
example, given the ongoing connection between an individual’s technical skillset and their economic opportunities, women’s economic independence may be hindered by missed opportunities in the technological industries in today’s job market (Shapiro & Sax, 2011). In light of the increased efforts and allocation of resources committed to enrich the United States’ position in scientific discovery and technological advancement, “women’s underrepresentation may lead to a loss of potential talent and innovation that may have an impact on the United States’ goal of remaining globally competitive in science and engineering” (Shapiro & Sax, 2011, p. 6). Additionally, studies have revealed the benefits – more creativity and innovation – that a diverse workforce can yield compared to a homogenous one (Chubin, May, & Babco, 2005; Corbet & Hill, 2015; Phillips, 2014) and how equal gender representation can help foster stronger, collaborative and cooperative work environments (Bear & Woolley, 2011).

The overall male-to-female undergraduate engineering enrollment at the current institution for this study is slightly lower than national averages. For example, at the current institution the overall male-to-female undergraduate engineering enrollment is roughly 81 percent male and 19 percent female compared to the overall national undergraduate engineering enrollment of 77 percent male and 23 percent female. In terms of degrees earned at the present institution, of the over 800 total undergraduate engineering degrees awarded between 2014 and 2017 male students accounted for 84 percent while female students accounted for 16 percent. This illustrates a slight difference between degrees attained among male and female students compared to the national data.

The data above illustrate that at the current institution the underrepresentation of women in its undergraduate engineering programs exists. If these trends continue at the present institution it could have a negative impact on the local economy and skilled
workforce as well as contribute to the widening occupational and gender pay gaps that still exist today. According to Hegewisch and Hartmann (2014), “women’s median annual earnings for full-time work are still only 76.5 percent of men’s, and marked differences in the occupational distribution of men and women continue to characterize the labor market” (p. 1).

To contribute to workforce demands and meet the goal of producing more engineering graduates, further examination of why women’s underrepresentation continues to persist at the current institution’s undergraduate engineering programs. Moreover, closely examining these issues will help provide the present institution with a better understanding of factors that influence a female undergraduate student’s decision to pursue engineering as a major and how their experiences influence their persistence within engineering.

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.

Moreover, there have been countless studies that have focused on developing student retention theory and informing researchers of the dynamics that shape a student’s
decision to persist. However, as Tinto (2012) noted “there has been little significant
development of a theory of action that would provide institutions of higher education
guidelines for the development of policies, programs, and practices to enhance student
persistence” (p. 251). 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.

Guiding Research Questions

The primary research question is:

1. How might choice and persistence take shape for women in an undergraduate
   engineering program?

The secondary research questions are:

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?

Significance of Study

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

Introduction

In the twenty-first century, engineering is one of the most sex-segregated academic and professional fields in the United States. Copious economic, capital, political, and technological resources have been apportioned to help improve this issue. Concurrently, many researchers and scholars across a variety of disciplines have spent a considerable amount of time and effort studying the underrepresentation of women in engineering (NAE, 2018). Through their work numerous theories and constructs have been used to gain a better understanding of the factors that influence women’s decisions to pursue and persist in engineering. These factors may be internal to the individual, such as interest or skills, or external, such as influences by families, the economy, or even certain policies. Understanding these factors can impact how we view and understand women’s attitudes and perceptions towards engineering and help us foster environments that interest them and encourage their persistence.

Two theories that have frequently been used in engineering career choice and persistence research are the expectancy-value theory (EVT) model (Eccles, et al., 1983; Wigfield & Eccles, 2000) and social cognitive career theory (SCCT) model (Lent, Brown, & Hackett, 1994). While the models may differ significantly in vernacular, they
deploy the use of similar constructs to predict choice behavior. A detailed overview of these theories is presented in the proceeding sections.

*Expectancy-Value Theory*

Wigfield and Eccles’ (2000) EVT model has been featured in numerous engineering retention and persistence studies and has provided a comprehensive framework for the study of student interest, motivation, and persistence in engineering based on aptitudes, expectancies, values, and goals. Expectancy-value theory intersects several theories of motivation including attribution theory, goal-setting theory, and self-efficacy theory. Expectancy-value theory illustrates “that individuals’ choice, persistence, and performance can be explained by their beliefs about how well they will do on an activity and the extent to which they value the activity” (Wigfield & Eccles, 2000, p. 68). In other words, these beliefs – defined as expectancies/competences and values – are expected to influence performance, persistence, and task choice. Expectancy/competence beliefs are identified as expectancies for success and are described as an individual’s beliefs as to how well he or she will perform on an upcoming task.

Value beliefs explain a student’s desire to engage in a task or activity and are comprised of four components: attainment value, intrinsic value, utility value, and cost value. Attainment value is described as an individual’s desire to do well on a given task and is related to identity or self. Matusovisch, Streveler, and Miller (2010) described attainment value as “a reason for pursuing an engineering degree that is related to being the type of person who is an engineer” (p. 294). Intrinsic value is the enjoyment one experiences from engaging in a task and is related to enjoyment or interest. The operationalized definition of intrinsic value is described as the enjoyment a student experiences in pursuing an engineering degree. Utility value refers to the perceived
usefulness of a given task and how it fits into an individual’s short-term and long-term goals. The operationalized definition for utility value in engineering is a student’s perceived usefulness of earning an engineering degree. Cost value refers to “how the decision to engage in one activity (e.g., doing schoolwork) limits access to other activities, assessments of how much effort will be taken to accomplish the activity (e.g., calling friends), and its emotional cost” (Wiggfield & Eccles, 2000, p. 72). The operationalized definition of cost is the price of success or failure in terms of effort, time, and/or psychological impacts of pursuing an engineering degree.

Although the EVT model provides a comprehensive framework for examining choice behavior it primarily focuses on the impact expectances and values have on choices made during early childhood. Consequently, SCCT is considered a more contemporary and widespread model for studying interest and career choice behavior. Additionally, SCCT “tends to be less concerned with the specifics of ages and stages, yet more concerned with theoretical elements that may promote or hinder career behavior across developmental tasks and periods” (Lent, 2013, p. 117). As a result, SCCT was used as the primary framework for this study and an overview of SCCT’s basic elements and its model are presented in the succeeding section.

Social Cognitive Career Theory

Building on the prior work of self-efficacy and its utility in career choice Lent, Brown, and Hackett (1994) introduced 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). In addition to these tenets of social cognitive theory the SCCT model:
…brings together common elements by earlier career theorists – especially Super, Holland, Krumboltz, and Lofquist and Dawis – and seeks to create a unifying framework for explaining three intricately linked aspects of career development: (a) the formation and elaboration of career-relevant interests, (b) selection of academic and career choice options, and (c) performance and persistence in educational and occupational pursuits. (Lent, 2013, p. 115)

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). An example of how the interaction of person inputs and background contextual affordances can influence one’s learning experiences can be illustrated in gender stereotypical expectations (e.g., “boys are good at math” and “girls are good at reading”). These gender-traditional attitudes may shape a girl’s beliefs
about gender roles and cause her to form a certain predisposition or attitude towards
math, which in turn may negatively impact her learning experience with that subject.

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. To continue with the example from the previous paragraph,
a female student’s negative learning experiences in math may lead to the belief that “I am
not good at math” and the outcome expectation of “if I take math courses, I will only
fail.”

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).

Since the purpose of this study was to gain a better understanding of the factors that influence women’s choice and persistence in engineering, the social cognitive career theory model was selected as the guiding theoretical framework for this study. In the ensuing section I will give a brief overview of two additional related theories and reasoning for why they were not selected for this study.

*Other Related Theories*

**Critical Engineering Agency**

Critical engineering agency (CEA) is a relatively new theoretical framework used to examine student career choice behavior in engineering that has been presented in the engineering education literature within the past few years (Goodwin, Potvin, Hazari, & Lock, 2016). Using subject-related identities and agency beliefs, which originated from critical agency frameworks in science and mathematics education, CEA strives to predict students’ engineering career choice. Subject-related identity is defined by Goodwin et al. (2016) as “how students see themselves as powerful thinkers and doers of a specific subject” and is framed with three constructs: interest, performance/competence, and recognition (p. 314). Goodwin et al. (2016) define agency beliefs as “how students view the world with a critical mindset to advance the world as a more equitable place” (p. 314). While CEA has contributed to the engineering education literature it only provides a snapshot of how domain specific identities can predict choice of engineering due to the
cross-sectional analysis of the research design and the examination of only one facet of diversity (gender).

Theory of Planned Behavior

The Theory of Planned Behavior (TPB) has been used to examine career choice in engineering as the theory suggests that interest and choice are a result of attitudes, subjective norms, and perceived behavioral control. TPB frames these variables as motivational factors and postulates that decision-making processes are informed and influenced by motivation to engage in or not to engage in choice behavior. While the TPB theoretical framework has added to the engineering choice literature I did not find TPB to be a good fit for the present study.

Definitions of Key Terms

For purposes of this study, the following terms were defined.

Attrition refers to a student who fails to remain enrolled at an institution in consecutive semesters.

Engineering refers to the profession in which knowledge of mathematical and/or natural sciences gained by study, experience, and practice is “employed in research, development, design, manufacturing, systems engineering, or technical operations with the objective of creating and/or delivering systems, products, processes, and/or services that lead directly or indirectly to an improvement in our quality of life” (Committee on the Education and Utilization of the Engineer, 1985).

Persistence refers to the act of a student to continue steadily despite challenges, adversity, or difficulties (Tinto, 1993). As an operational definition, persistence was defined as a student having completed a minimum of three years of study in engineering
and enrolled in one of the two contiguous Senior Design Project Capstone courses (i.e., ENGR 4172-4177 - Senior Design Project I or ENGR 4296 - Senior Design Project II).

Retention is an institutional measure of student success and refers to the ability of an institution to retain a student over two points in time.

Self-efficacy refers 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).
CHAPTER 2
REVIEW OF LITERATURE

Introduction

A review of literature was conducted to provide a general framework of the background information relevant to the study including an introduction to student college choice, career development theories, the history of student retention, history of engineering education, and choice and persistence in undergraduate engineering programs. The chapter is divided into five sections. The first section presents a brief overview of the student college choice process. The second section presents an overview and history of career development theories. The third section presents an overview of student retention. The fourth section presents an overview of the history of engineering education. The last section of the chapter presents an overview of choice and persistence in undergraduate engineering programs.

Student College Choice

Since the turn of the twentieth century the topic of student college choice began to attract significant attention. The need to examine student college choice was driven at the state and federal levels as public concerns began to surface regarding college affordability and access and equity as well as the declining pool of traditional-aged students across the U.S in the latter portion of this period. Several commonalities that emerged from these studies were how an individual’s background characteristics, academic and career goals, and experiences corresponded with one’s perception of attending college and the opportunities it afforded them. The examination of these variables helped explain factors that contributed to an individual’s decision to enroll in college.
During this time several of the emerging student college choice models described college selection as a developmental process that transpired over a series of phases. Litten (1982) and Jackson (1982) conceptualized the college choice process as a three-phase model. Litten’s (1982) model conceptualized this process as: 1) desire to attend college phase, 2) research and information gathering phase, and 3) application, admission, and enrollment phase and Jackson’s (1982) model illustrated this process as: 1) preference phase, 2) narrowing phase, and 3) evaluation phase (Hossler & Gallagher, 1987).

Using these models as a framework, Hossler and Gallagher (1987) developed a three-stage developmental model of college choice that illustrated the interplay of individual and organizational factors throughout the three phases and how they influenced the college choice decision. The first phase of the model was defined as predisposition and entailed the development of one’s interest in attending college. In the first phase Hossler and Gallager (1987) posited that the interaction between socioeconomic status, family influences, educational experiences and college characteristics (e.g. proximity to campus) played an important role in stimulating a student’s interest in pursuing a college education. The second phase involved researching and gathering of information about various universities and colleges. In this phase the combination of student search activities, student college values, and institutional customer relationship management guided the student in narrowing down their college choices and initiating the application process. The third phase was defined as choice of institution to attend and illustrated the interaction of the student’s college choices and the college or universities recruitment activities.

Though the three-phase student college choice model was introduced over thirty years ago, it is still widely used and referenced in today’s literature and research.
However, despite its utility in explaining the various stages of the student college choice process, the model does not inform institutional, state, and federal stakeholders of the factors that influence a student’s selection of an academic major. To better understand a student’s process in selecting a major, an overview of career development and popular career development theories are presented in the subsequent section.

Overview of Career Development and Relevant Theories

The term “career” is defined as “the totality of work – paid or unpaid – one does in his/her lifetime” (National Career Development Association, 2003, p. 2). Career development is “the total constellation of psychological, sociological, educational, physical, economic, and chance factors that combine to influence the nature and significance of work in the total lifespan of any given individual” (National Career Development Association, 2003, p. 2). Career development can be described as the process that spans from childhood to adulthood by which a person’s career identity is formed and is constructed of both the career choice phase and the career adjustment phase of work life. To better understand and predict how individuals navigate this process numerous career development theories have emerged dating back to the beginning of the twentieth century. Career development theories have been advanced and conceptualized from four disciplines – differential psychology, personality psychology, development psychology and sociology and are situated in one of four perspectives – sociological, psychological, vocational, or developmental. These theories were used “to provide systems for explaining how many factors operate together to determine occupational choice and development over the life course” (Lent, 2013, p. 115).
Career Development Theory

Frank Parsons has been credited as the “founder of the vocational guidance movement” with his seminal work and development of the talent-matching approach in 1909 (Osipow, 1989). He believed that individuals and occupations each have unique characteristics and traits and that maximizing production and satisfaction occurs when these attributes are closely aligned between the individual and the occupation. The talent-matching approach led to a focused effort toward the task of identifying one’s major and its most essential attributes and matching them with the appropriate occupational traits. Many of today’s aptitude and interest inventory approaches have been influenced by Parsons’ groundbreaking work (Osipow, 1989).

During the middle of the twentieth century scholars began expanding upon Parsons’ work by constructing career development theories that incorporated the process of career decision making, career entry, and career adjustment (Osipow, 1989). John Holland began developing his career typology theory (1985) in the 1950s and he held the belief that career choice was not random but an expression of one’s personality. Holland’s theory advanced that work environments can be described as either realistic, investigative, artistic, social, enterprising, or conventional and that individuals possess a combination of two or more of these traits (Osipow, 1989). He theorized that people in similar jobs have similar personality traits and the highest career satisfaction occurs when there is a parallel between the individual’s personality trait and that of the occupation. Holland also used career typology theory to predict educational behaviors as he stated that the “choice of, stability in, and satisfaction with a field of study is determined by a person’s personality type” (Holland, 1985, p. 30).
Donald Super’s career developmental theory (1980) emerged from his twenty-five-year longitudinal study that followed a group of high school boys beginning in the early 1950s (Osipow, 1989). Super’s career developmental theory is one of the most recognized lifespan views on career development and it posited that individuals choose careers that allow them to express their self-concept and that career choices evolve throughout one’s lifespan – growth, exploration, establishment, maintenance, and disengagement (Walker-Donnelly, Scott, & Cawthon, 2019). Additionally, Super believed that satisfaction in one’s career was possible only when both the nature of work and the way of life complemented an individual’s aptitudes, interests, and values. (Super, 1980).

Krumboltz’s social learning theory of career selection (1976) is a comprehensive theory that examined how an individual’s educational and occupational interests and selection are influenced by a variety of internal and external factors. The theory identifies the “interactions of genetic factors, environmental conditions, learning experiences, cognitive and emotional responses and performance skills that produce movement along one career path or another” (Krumboltz, 1976, p. 71). Individuals are exposed to numerous learning experiences throughout their lifetime and based on these learning experiences help prepare individuals for making rational and logical career decisions. Furthermore, Krumboltz (1976) theorized that “at each decision point the decider has one or more response or decision options…internal (personal) and external (environmental) influencers (constraints or facilitators) shape the nature and number of those options and the way in which individuals respond to them” (p. 71).

Dawis and Lofquist’s theory of work adjustment (1984) describes the relationship of the individual and his or her work environment. Theory of work adjustment is deeply
rooted in the vocational perspective, similar to Parsons’ and Holland’s theories, as it suggests that career choice is predicated on the fit of the individual and the environment. It is also viewed as a model of person and environment interaction as it reflects the reciprocal relationship between a person and their environment. The work environment requires that certain tasks be performed, and that the individual possesses certain skills to perform these tasks. In exchange, the individual requires compensation for work performance and certain preferred conditions, such as a safe and comfortable place to work.

In the early 1980s, Betz and Hackett laid the groundwork for the development of the social cognitive career theory when they began investigating the significant differences in the career development patterns of men and women with the goal of developing a theory that could be applied to understanding women’s career choice behavior (Betz & Hackett, 1981). Building on Krumboltz’s social learning theory of career selection (1979) and the tenets of Bandura’s social cognitive theory (1986), they offered a model that focused on the utility of self-efficacy beliefs and how these beliefs influence a woman’s decision to pursue particular careers. They accomplished this by examining self-efficacy expectations within a sample of twenty traditional and nontraditional occupations based on the percentage of women and men represented in these professions (Betz & Hackett, 1981). A key finding from the study demonstrated that self-efficacy expectations were closely related to career choice and that “low self-efficacy expectations may have been a major factor in the restriction of women's career options, particularly in women's failure to consider occupations traditionally viewed as more appropriate for males” (Betz & Hackett, 1981, p 400).
Overview of Student Retention

Similar to student college choice and career development research, student retention has become a major focus of theory, research, policy, and practice throughout American higher education. But why is college student retention so important? Student retention is posited as one of the most important measures of student success at a university or college by various governing bodies, ranking agencies, and special interest groups. It illustrates how well an institution supports a student’s progress to degree and, more importantly, a student’s ability to reach their academic and personal goals.

Additionally, retention in college is essential in the development of a one’s ability to think critically, become a lifelong learning, and contribute to society (Seidman, 2012). The acquisition of these skills has become increasingly important for success in today’s knowledge-based and technology-driven society. The value of a college education is well-documented both for the individual and society (Seidman, 2012). Individual benefits include increased earnings and better quality of life. Social benefits include public economic benefits, lower unemployment, reduced crimes rates, and increased civic involvement.

History of Student Retention

Student college retention has a long history in American higher education. It can be traced back to the late 1800s and early 1900s during the massive expansion of institutions of higher education due to the signing of the Morrill Land Grand Act. This expansion led to an increased awareness and desire to attend college, which resulted in a significant increase in enrollment throughout the country. According to Berger, Ramirez, and Lyons (2012) “antecedents of retention began to emerge out of this growth in the undergraduate population and the increasing numbers of diverse types of college and
universities” (p.18). As a result, the shifting societal expectation that to be competitive in the workforce obtaining a college degree was essential.

As the desire to attend college increased, institutions “began to view a certain amount of attrition as a hallmark of institutional success; that competition for academic success would inevitably lead to failure for some students” (Berger, Ramirez, & Lyons, 2012, p.18). As a result, institutions began paying closer attention to student attrition, which led to an interest in examining student retention. The first published study on retention occurred in 1938 by John McNeely entitled “College Student Mortality” (Berger et al., 2012). This study, which laid the foundation for future studies in student retention, was the first to document student attrition rates, graduation rates, and factors that contributed to student departure.

During the 1950s the U.S. experienced another spike in college enrollment as over two million students across 1,800 institutions were attending college. This development stemmed from government policy that “encouraged college attendance and promoted education as necessary for the stability of the United States” (Berger et al., 2012, p.19). As enrollment grew across all types of universities and colleges, institutions of higher education began to shift their focus on understanding why some students were not successful in completing their college degrees.

This continued in the 1960s and 1970s as institutions were interested in learning what factors caused academic failure and student departure, which led to multiple approaches being used to examine the problem. Spady (1971) was one of the first scholars to classify these approaches when he identified six types of studies, which were “census, autopsy, case, philosophical and theoretical, descriptive, and predictive” (p. 65). Census studies were focused on reporting attrition, transfer, and retention rates among
and across institutions. Autopsy studies identified reasons students departed using self-reported data. Case studies tracked the success or failure of students identified as at-risk at the point of admission. Philosophical and theoretical studies claimed that action was needed to remedy student departure and provided recommendations to address the problem. Descriptive studies described the experiences and characteristics of students that failed to persist.

The 1970s can be described as the time in American higher education history when retention became a widespread topic among universities and colleges as institutions became increasingly concerned with student attrition. Throughout this period scholars continued to build upon studies from the previous decade through the development of empirically based retention theory. One of the earliest theories to emerge was Spady’s sociological model of student departure which introduced the interaction that occurs between the student and the social and academic environment (Berger et al., 2012). Spady posited that when the student and the environment were compatible the probability of persistence increased. Following Spady’s sociological model of student departure was Tinto’s interactionalist theory of student departure, one of the most cited retention theories in history. Other retention theories that emerged during this period included Kamens’ (1975) sociological and organizational behavior theory, Meyer’s (1970) institutional socialization theory, and Astin’s (1977) student involvement theory. By the conclusion of the 1970s, retention theory was well established leading to a more thorough and methodical investigation of retention in the decades to come.

The 1980s was a springboard for retention research, theory, and practice as college enrollment began to stagnant encouraging higher education professionals to explore new ways to attract and retain students. During this period, the concept of
enrollment management was conceived as schools and colleges started implementing a more holistic approach to student retention by connecting student recruitment and choice to student attrition and persistence. “While the emergence of enrollment management dominated the practice of retention at this time, advances in the study of retention were being built on the successful contributions of the previous decade” (Berger et al., 2012, p. 25). An example was Bean’s (1983) theoretical approach that applied findings from employment turnover studies to explain student attrition. This continued expansion provided higher education professionals with the necessary tools and knowledge to develop and implement intentional initiatives and interventions to increase student retention and persistence.

The 1990s and 2000s were periods which saw a continued expansion of the knowledge and breadth of student college retention. It was also a time when retention was fully embedded in U.S. higher education policy and practice and used as an important institutional measure of student success. However, despite the wide array of research, theory, and practice national retention rates were lower than many across the higher education landscape had anticipated. As noted by Berger et al. (2012) during this period the average first-year freshmen retention across all four-year colleges was 25.9 percent; however, these rates varied considerably depending on the institution’s admissions standards (i.e., highly competitive versus non-competitive or open admissions). Student counseling and advising programs emerged and were introduced as an integral part of the student experience and development.

Retention rates also varied across different student populations and were sizably lower among students from underrepresented populations, first-generation, and lower socioeconomic backgrounds. This realization shifted the focus to the examination of
diverse student populations and required that unique intervention strategies be implemented compared to previously established retention models. This trend has persisted to present-day as many institutions of higher education continue to struggle in retaining underrepresented minority students.

The study and practice of retention continues to become more and more important as earning a college degree is the key to a successful life, stronger economy, and more productive society. However, some may argue that the value of a bachelor’s degree has lost its worth but in the field of engineering the bachelor’s degree is the key to a becoming a professional engineer. Therefore, continued advancement of retention theory and practice is critical for the future of engineering education and its profession.

**Pillars of Student Retention**

Over the past 30 years, scholars have contributed to the field of student retention research by discovering many variables that influence student retention and persistence. Several of the most cited variables are summarized below.

*Academic preparation.* It has been theorized that a student’s academic preparation is a significant predictor of student success which directly and indirectly impacts a student’s decision to persist or depart. Unfortunately, a substantial number of students matriculating today are underprepared for college-level coursework, especially in the STEM fields, which often requires them to start in remedial coursework (Swail, 2004). Exposure to a challenging and rigorous high school curriculum is a strong predictor of college success and persistence.

*Involvement/engagement.* Involvement, described as academic and social integration, has been related to student success. According to Tinto (2012), “the more students are academically and socially involved, the more likely they are to persist and
graduate” (p. 257). Academic involvement includes a student’s connection to the institution, engagement in academic learning, positive faculty-student interactions, and utilizing academic resources. Social involvement includes establishment of peer networks, participation in extracurricular activities, and engagement in campus social traditions.

**Financing college.** As the costs of attending college have skyrocketed over the past several decades variables related to how students will finance their education have been related to undergraduate retention.

**Demographic characteristics.** Demographic characteristics have been found to be related to student retention and degree attainment. These variables include gender, ethnicity, age, parental income and education, and distance of home town from the institution.

**History of Engineering Education in the United States**

The history of engineering education in the U.S. dates to the early 1800s “for the purpose of promoting the application of science to the common purpose of life” (Grayson, 1980, p. 373). While the structure and curricula of many American institutions in higher education can be traced backed to England, the structure and curricula of U.S. engineering education originated from the French professional school of engineering model. However, despite similarities across existing U.S. professional schools one of the key differences in the origination of engineering education in the U.S. was its integration into the collegiate education model. “As a result, engineering education did not evolve from apprenticeship training and only slowly replaced it, gaining the support of practitioners with considerable struggle” (Grayson, 1980, p. 373).
This was a stark contrast compared to professional schools such as law, medical, and dental schools, which were developed for practical and technical preparation in the respective professions compared to the traditions of a collegiate education. For example, many of the colleges founded in the U.S. between the 1750s and 1850s built their curricula around the promotion of the Christian religion and the classical subjects of Latin, Greek, history, philosophy and religion. As a result, the higher education landscape presented significant challenges during the introduction of engineering education as existing institutions held firmly to their strong traditions and sense of elitism. However, this would eventually change as engineering education gradually grew throughout the U.S. during the second half of the nineteenth century.

Despite the slow growth of engineering schools throughout the U.S., three major events took place in 1862 that were central to the major change in the development of engineering education. The first was the passing of the Homestead Act of 1862, which provided free land located in the Western United States to eligible citizens to work on and improve for five years. This resulted in a large contingent of U.S. citizens migrating to the Western region of the country and the eventual passage of the Pacific Railroad Act of 1862. The Pacific Railroad Act of 1862 sponsored the construction of a transcontinental railroad between Nebraska and California. Accomplishing this required the innovation and creativity from the field of engineering to create a passage across the challenging terrain to the West. “The railroad created a demand for engineers with greater mastery of scientific resources, and so engineering schools arose out of simple necessity (Grayson, 1980, p. 378). The third major event was the passing of the Morrill Land Grant Act of 1862, which granted States an apportionment of public land to be used to establish a college that would “teach such branches of learning as are related to agriculture and
mechanic arts…to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life” (Agricultural & Mechanical College, 1862). The impact of these three major events resulted in the historic expansion of engineering schools from 12 to 70 in the span of ten years (Grayson, 1980).

With the expansion of engineering education throughout the late 1880s it was important that engineering schools strived to meet quality standards and produced graduates prepared to enter the profession. The first organization that began monitoring the educational quality of engineering programs was founded in 1893 and was known as the Society for the Promotion of Engineering Education (SPEE) – known today as the American Society of Engineering Education (ASEE). The role of SPEE was to advise and assess engineering programs and serve as a quality assurance in the advancement of engineering education. However, as engineering programs and the profession continued to grow additional oversight was needed to ensure all engineering programs were adhering to the standards of the profession.

In 1918, the Carnegie Foundation in partnership with several professional engineering societies commissioned Charles R. Mann to conduct the first formal study of the state of engineering education. Mann (1918) examined the conditions of engineering education, identified problems within engineering education, and provided several recommendations for improvement. The conditions of engineering education were defined as curricula, struggle of resources and recognition, methods of administration, attrition and graduation rates, and pedagogy (Mann, 1918). The problems within engineering education were identified as inconsistencies in admissions standards, course content and curricula, transferability of courses, grading systems, and hands-on technical training across various institutions as well as an overwhelming course-load (Mann,
Several recommendations for improvement and advancement of engineering education included selective admissions standards, alignment of curricula with the profession, implementation of a core curriculum, and the recognition of teaching as a profession (Mann, 1918).

Although the results of Mann’s study provided a framework for continuous improvement and assessment in engineering programs, many programs were slow to implement formalized evaluation processes. This lack of standardized assessment and evaluation left many uneasy with the state of engineering education. According to Reynolds (2005), “some engineering educators had become concerned that engineering education had fallen relatively behind other fields of professional education…and it was very doubtful if engineering colleges should be called professional colleges at all” (pp. 60-61). To address these concerns the president of the SPEE secured funding from the Carnegie Foundation to examine how to advance and improve engineering education (Reynolds, 2005).

William Wickenden was commissioned to lead the project and at the time was considered “the most extensive ever undertaking of engineering education, making every effort to involve every American engineering school, representatives of American industry, and the major professional engineering societies in all stages from data gathering to analysis to implementation of recommendations” (Reynolds, 2015, p. 61). This seminal study called for the standardization of engineering curricula, the need for formalized accreditation of engineering education, and greater involvement from professional engineering societies. These recommendations led to the creation of the Engineers’ Council for Professional Development (ECPD) in 1932. The ECPD was tasked to serve “as an engineering professional body dedicated to the education,
accreditation, regulation, and professional development of engineering professionals in the United States” (ABET, 2018, para. 1). In 1936, ECPD, which presently is known as the Accreditation Board for Engineering and Technology (ABET), began evaluating and accrediting its first engineering programs, which marked a significant advancement in engineering education.

Nearly eighty years later ABET accredits more than 3,200 programs across 670 institutions and 24 countries, continues to strengthen and advance engineering education, and is the most respected accrediting body in the United States and abroad for applied science, computing, engineering and engineering technology programs. The organization is one of the first accrediting agencies to introduce an outcomes-based system to measure student learning. ABET accreditation legitimizes and adds value to an academic program and verifies that the program is committed to best practices in education, self-assessment, continuous improvement, and learning outcomes.

ABET requires that all programs seeking accreditation or re-accreditation must demonstrate that the program meets several criteria as outlined in its “Criteria for Accrediting Engineering Program” guidelines. Of the eight items listed a program must demonstrate that it has a documented process for meeting student outcomes – identified as student outcomes one through seven – that align with the educational objectives of the program. Among the seven student outcomes there are a number of key terms referenced – global, social, cultural, diversity, collaborative, inclusive – that connote the organization’s commitment to ensuring that engineering graduates are trained to work in a global and diverse workforce, meet societal needs, and build a better world. However, to accomplish these goals it is paramount to tackle the diversity and gender challenges that face the engineering workforce. In the following section a brief overview of the
history of women in engineering is presented to shed light on the historical underrepresentation of women in engineering programs and the profession.

Women in Engineering

“Engineering education in the U.S. has had a gendered history, one that until relatively recently prevented women from finding a place in the predominantly male technical world” (Bix, 2004, p. 27). While the first woman to earn an engineering degree in the U.S. occurred in 1876, during this period and until the twentieth century “women studying or working in engineering were popularly perceived as oddities at best, outcasts at worst, defying traditional gender norms” (Bix, 2004, p. 27). However, during World War II the U.S. experienced a severe shortage of workers in industry and manufacturing which led companies to begin recruiting and training women to fill the void. At the close of World War II and upon the return of male veterans the need of women in engineering diminished. According to Bix (2004), “conservative gender modes of the postwar decades brought a prevailing expectation that women’s career ambitions must give way to the goal of marrying and raising children” (p. 29). Further, during this time young girls received very little social support in pursuing technical fields and were often deliberately ridiculed by those in their family and social circles (Bix, 2000).

Despite the lack of support, increased opportunities for women to participate in the technical workforce grew in the middle of the twentieth century. To meet these labor force changes, numerous engineering schools in the U.S. transitioned from offering a male-only education to coeducational offerings. One of the first schools to regularly admit women in engineering was the Georgia Institute of Technology in the early 1950s. Around the same period, a group of women engineers and students officially established an organization – the Society for Women Engineers (SWE) – as a platform to cultivate
and support women’s interests in pursuing engineering as a vocation. Correspondingly, engineering opportunities continued to increase during the Cold War and the competition between the U.S. and Soviet Union to achieve spaceflight. These historical events began fragmenting preexisting gendered barriers to an engineering degree and helped provide women entry and access to engineering career paths during the second half the twentieth century.

While these were significant movements that helped spark an increase in enrollment and degrees earned by women in engineering, by the end of the twentieth century women were still disproportionally represented in the engineering profession. For example, women accounted for 12 percent of the total enrollment in undergraduate engineering programs across the U.S. in 1979 and accounted for 19 percent in 1998 (Bix, 2004). In terms of degrees earned, in 1966 women earned less than one percent of the degrees awarded compared to 19 percent in 1996 (Bix, 2004; Hill, Corbett, & St Rose, 2010). Further, women represented nine percent of all engineers in the profession in 1998. These increases illustrated the modest progress that has been made in women’s recruitment, retention, and graduation in engineering during second half of the twentieth century. Since the turn of the century less progress has been achieved as the percentage of women’s enrollment (23 percent), degrees earned (20 percent), representation in the profession (11 percent) in the U.S. has markedly remained stagnant.

Overview of Choice and Persistence in Engineering

Choice of Engineering

This section presents factors that have been found to be influential in a student’s selection of engineering as an academic major. It is important to note that many studies categorize these factors in a manner that aligns with the SCCT theoretical framework that
was utilized for this study. These factors have been arranged into three categories to help organize this section, which are individual factors, learning experiences, and environmental factors. As previously mentioned, these factors do not arise in a vacuum; rather they interact and coalesce together during the decision-making process in selecting a college major.

Individual factors have been found to play a pivotal role in a student’s decision to pursue engineering as a major. These factors have been described as interest in engineering, self-efficacy in math, science, or related engineering subjects, self-concept and identity, and outcome expectations. A student’s interest in engineering or engineering-related subjects has been shown to be an influential factor in the decision-making process in selecting engineering as a major (Carnasciali, Thompson, & Thomas, 2013; Godwin et al., 2016; Lent et al., 2005; NAE, 2018; Schaefers, Epperson, & Nauta, 1997; Seymour & Hewitt, 1997;). Seymour and Hewitt (1997) posited that “feeling free to choose on the basis of personal interest was important because it encouraged bonding to the major…” (p. 67). Student interests in engineering can stem from a number of other factors and experiences, which will be presented in the subsequent sections.

Having a strong self-efficacy in math or science has been found to be a reliable predictor of a student’s desire to pursue engineering. Seymour and Hewitt’s (1997) found that confidence in one’s math and science ability was identified as one of the top motives for why students selected engineering as a major. Additionally, a number of studies reported that self-efficacy in subjects closely related to engineering was the principal reason students indicated why they selected engineering as their major (Carnasciali et al., 2013; Mau, 2003; Painter, Snyder, & Ralston, 2017). Having the confidence in one’s ability to perform in rigorous subjects correlates with a student’s ability to set challenging
goals and to commit to achieving those goals in that domain. Higher self-efficacy in math and science provides a fertile ground for the development of confidence in one’s ability and interest in pursuing engineering as math and science are key subjects across all engineering disciplines.

Self-concept along with self-esteem, self-knowledge, and social self are part of an individual’s self-schema, which forms one’s self-perception. Self-concept represents one’s ideas about who they are and who they aspire to be and can function as a motivator for certain choice behavior. Self-concept has been found to be key factor that informs a student’s interest in engineering and serves as a strong predictor in a student’s decision to pursue engineering as their major. Matusovich, Streveler, and Miller (2010) found that in a student’s decision to pursue engineering to the extent to which they identified with the engineering profession or had a strong sense of self as an engineer was posited as a better predictor than having interest alone in engineering in one’s major choice process. Related to self-concept, altruism or agency beliefs have also been linked to a student’s decision to pursue engineering as they have exhibited a strong desire to use engineering for a greater social purpose. This is particularly true among women pursuing engineering (Godwin et al., 2016; NAE, 2018; Seymour & Hewitt, 1997). Understanding one’s self and who they aspire to become is an important cognitive component of one’s self-schema and can serve as a powerful incentive in choice behavior.

Outcome expectations have been shown to be a modest determinant in a student’s decision-making process for selecting engineering as a major. Outcome expectations can range from seeking approval from family and friends to the anticipation of a positive career outlook in an engineering field. Financial outcome expectations or materialism – as coined by Seymour and Hewitt (1997) – albeit a common attitude is a fairly weak
predictor compared to one’s perceived satisfaction and expectancy for success in engineering. Male students are more likely to cite financial outcome expectations when selecting engineering while female students are more likely to cite outcome expectations regarding how satisfying they perceive engineering coursework will be for them (NAE, 2018; Seymour & Hewitt, 1997; Zafar, 2013).

Learning experiences prior to entering college are considered a significant factor in a student’s decision process to study engineering (NAE, 2018; Painter et al., 2017; Shapiro & Sax, 2011). Learning experiences that contribute to the decision to pursue engineering can be summarized as exposure to rigorous math and science courses, especially advanced placement courses, in-school STEM-related activities, problem-solving, and summer camps or out-of-school extracurricular activities. These learning experiences provide students with an opportunity to develop cognitive and non-cognitive skills that are necessary for success in engineering. Exposure to stimulating coursework and problem-solving activities provide students with valuable developmental experiences to help grow their confidence, resiliency, and interest in engineering.

Environmental factors play a valuable role in a student’s decision to pursue engineering and are categorized as supports and barriers. Supports can be further described as supportive family members, mentors, or teachers. Family support and influence can play a pivotal role in a student’s choice of engineering (Godwin, Potvin, & Hazari, 2014; NAE, 2018; Painter et al., 2017). An example of family support or influence can be described as having a parent or family member that is an engineer, which involves occupational inheritance or serves as a vicarious learning experience. Occupational inheritance involves the acquisition or development of specific beliefs or values about a career through the lived experiences of one’s parents or family members.
Vicarious learning experiences result in the belief that one can succeed in engineering when they self-identify with an engineering family member. Godwin et al. (2014), found that parental support of a student’s interest to pursue engineering was the strongest familial influence compared to other familial support experiences. Specific to female students, it has been found that fathers have the greatest positive influence on engineering career choice (Godwin et al., 2014) and egalitarian families tend to provide important support that are integral in choice and success in engineering (Assessing Women in Engineering, 2015). Mentors and teachers play an important role in helping develop or validate a student’s interests in engineering. They also serve as important role models that help strengthen a student’s self-efficacy and self-concept towards engineering, which is especially true for female students (NAE, 2018; Shapiro & Sax, 2011).

There have been numerous factors found and supported by research that can impact a student’s decision to pursue an engineering major. However, it is important to understand how these factors operate in a dynamic fashion and vary based on the individual student and their unique experiences. It is also important to note that these factors not only will help shape a student’s decision to pursue engineering but will also play a critical role in their persistence within engineering. In the following section, factors that influence persistence in engineering and what prior research has taught us will be presented.

_Persistence in Engineering_

Research on student persistence in engineering is a segment of the larger body of research on student outcomes in engineering education. Its purpose is to gain a better understanding of the issues surrounding degree completion and the unmet demand of engineers in the United States. Despite its importance in the advancement of engineering
education, research on student persistence is complicated and “is uncommon because of the costly nature of longitudinal tracking at the individual level” (Litzler & Young, 2012, p. 320). Hagedorn (2012) noted that “persistence and retention are often used interchangeably which is a source of confusion… but to clarify institutions retain and students persist” (p. 85). Persistence is defined as the act of a student continuing in college steadily despite challenges, adversity, or difficulties (Tinto, 1993). A student is considered a persister if he or she enrolls in college and remains enrolled until completion (Hagedorn, 2012).

Students’ decisions to persist or leave engineering are influenced by a number of factors, which have been broadly categorized as internal and external factors. Internal factors are described as nonacademic (Marra, Rodgers, Shen, & Bogue, 2012), individual (Meyer & Marx, 2014), or characteristics and perceptions (Litzler & Young, 2012) and external factors are described as academic and peer engagement, faculty, mentor, and familial support, environmental and structural dynamics, academic and career advising, and curriculum and instruction (Eris et al., 2007; Seymour & Hewett, 1997).

One of the most widely known and referenced longitudinal studies that examined student persistence in science, math, and engineering (S.M.E.) was conducted by Seymour and Hewitt (1997) over a three-year period between 1990-1993. The study examined factors such as choice of major, learning experience, persistence, and career prospects. Seymour and Hewitt (1997) labeled persisting students as “non-switchers” and non-persisting students as “switchers.” The study found that key differences between switchers and non-switchers were that non-switchers reported that they had chosen their major because of individual interests while switchers acknowledged their major selection was an “unformed choice.” Additionally, Seymour and Hewitt (1997) posited that non-
switchers were motivated to study and persist in engineering because of intrinsic interest and altruism (commitment to a wider social purpose); whereas, switchers were motivated by the influence of others, pragmatism, and materialism. Additionally, Honken and Ralston (2013) found that persisting students more frequently cited reasons linked to interest for selecting engineering than non-persisting students. “The most interesting observation was that students who remained enrolled in engineering on average had indicated more interest-related reasons for choosing engineering (4), compared to students who switched majors (2.7) or who left the university (2.3)” (Honken & Ralston, 2013, p. 33).

Another critical factor in a student’s decision to persist is the development of one’s identity and self-concept in engineering. Engineering identity was summed up by Stevens et al. (2008) as “the primary compass that guides a student through engineering” (p. 366). Gaining an understanding of the engineering profession and what it means to be an engineer combined with a propensity towards engineering related-tasks is critical for persistence. If a student does not identify with engineering or cannot see themselves performing the work of engineers, then their interest may dissipate and decrease the likelihood of persistence. This is one example of the interaction between multiple factors and how they can converge to influence a student’s decision to persistence.

Student characteristics and perceptions have been presented as factors associated with persistence in engineering. For example, Ohland et al. (2008) reported that “engineering students rated themselves lowest compared to all other majors in gains in personal and social development, gains in general education, reflective learning, and integrative learning” (p. 274). Further, Litzler and Young (2012) found that persisting students in engineering reported higher levels of stress from the heavy engineering course
load compared to non-persisting students. However, through these challenging experiences persisting students learned to develop coping strategies to help them manage and persevere during these difficult encounters. It is these personal traits and characteristics that play a critical role in a student’s persistence as they help strengthen and reinforce a student’s commitment to engineering and completion of their degree (Litzler & Young, 2012). Additionally, the development of effective coping strategies helps persisting students weigh the costs, benefits, and utility in their decision to make sacrifices and invest the necessary time and effort required to become a successful engineering student.

As mentioned above, students in engineering programs are faced with a rigorous and demanding course load, especially compared to their non-STEM and non-engineering peers, and outcome expectations have been shown to play a pivotal role in helping students persevere and remain motivated to persist. Seymour and Hewitt (1997) illustrated that switchers and non-switchers differed in their perception of career prospects. Non-switchers in engineering cited less anxiety about career options; comparatively, switchers cited that career prospects and material rewards did not justify the time and effort of persisting in engineering. Duncan and Zeng (2005) found that “job opportunity in engineering was identified as an important motivator for persisting in engineering” (p. 14). These findings support that persistence in engineering is related to students’ outcome expectations regarding the utility of an engineering degree and the importance of a career in engineering.

External factors can be influential in students’ decisions to continue in engineering and are often seen working in concert with internal factors. Relatedly, external factors may help a student overcome negative internal factors in persistence. In a
longitudinal study by Eris et al. (2010) parental and mentor encouragement while pursuing an engineering degree were found to be influential in a student’s decision to persist in engineering. Positive experiences with “faculty also play a significant role in undergraduates’ persistence in engineering…by enhancing confidence in problem-solving, engineering design, and interpersonal skills” (NAE, 2018, p. 98). Interaction with faculty has been found to be important, especially among female students, as attending office hours, seeking help, and participating in mentoring all are related to increased persistence. Moreover, mentors are a valuable resource for engineering students as they provide support, vicarious learning experiences, and help students develop effective strategies to mediate the challenges that engineering students commonly face. Seymour and Hewitt (1997) found that switchers and non-switchers experienced the same set of issues throughout their learning experience such as poor teaching, rigorous curriculum, poor advising, and increased time to degree but non-switchers reported developing coping strategies through peer networks and mentoring that helped them overcome these negative factors.

Peer networking and support groups are positively associated with persistence. Tate and Linn (2005) found that women who routinely engaged in help-seeking practices such as tutoring and peer study groups were more likely to persist in engineering. Peer networking and support groups provide students with a sense of togetherness through encouragement and collaboration. The members of these groups hold each other accountable while providing timely support during challenges but more importantly they build camaraderie and cohesiveness as they struggle together through the rigors of an engineering program.
Extracurricular and experiential experiences have been found to positively influence engineering student persistence. Involvement in student professional organizations provides similar support experiences for students as found in peer networks and study groups but it also involves opportunities for students to apply theoretical concepts in real world applications. For example, the Society for Automotive Engineers (SAE) and Engineers Without Borders (EWB) participate in various engineering design competitions that provide valuable hands-on experiences through the application of concepts learned in the classroom. These experiences have been found to be excellent opportunities for students to strengthen their engineering identity and engineering self-concept, which has been shown to increase the likelihood of persistence.

Furthermore, many students are attracted to engineering because of the hands-on nature of the profession yet in many engineering programs students are not afforded these opportunities until later in the curriculum; therefore, experiential and extracurricular experiences can help bridge this gap for students and influence their decision to persist.

**Gender Differences in Persistence in Engineering**

Another key finding from Seymour and Hewitt (1997) was the similarity in persistence among male and female students in engineering as male students persisted at 52 percent and female students persisted at 51 percent. Among non-switcher female students, a key finding that was not present in non-switcher male students was the importance of peer support groups and mentoring. Since the Seymour and Hewitt study significant attention and research has been focused on women’s persistence in engineering.

Schaefers, Epperson, and Nauta (1997) explored factors relating to persistence in men and women in engineering and, like Seymour and Hewitt, did not find gender as an
important variable for explaining persistence in engineering. Schaefer et al. (1997) posited that these findings “suggest that women who attempt engineering…are very similar to their male peers but because the number of women enrolled is still small, the loss of one-third of them heavily impacts their representation” (p. 165). Honken and Ralston (2013) also found few differences between men’s and women’s persistence in engineering. In a study conducted by Zhang, Anderson, Ohland, and Thorndyke (2004) that tracked and examined over 87,000 engineering students the results revealed that there were no differences in graduation rates that could be contributed to gender.

Conversely, Sax (1992) found that men were higher in persistence rates than women in the biological, physical, and engineering sciences. Ellis, Fosdick, and Rasmussen (2016) found that for students starting in entry level Calculus courses women persisted at lower rates compared to men. Additionally, Levin and Wyckoff (1995) hypothesized that men persisted at higher rates than women due more to non-cognitive factors, such as motivation and attitude, than academic factors. Ellis et al. (2016) confirmed these findings as they found that “women’s mathematical confidence, rather than a lack in mathematical ability, may be responsible for the high departure rate of women” (p. 1). Classroom experiences and climate have also shown considerable differences in persistence among female students compared to male students as the perceived unwelcoming environment can result in feelings of isolation and a lack of sense of belonging in engineering resulting in female students’ decision to leave engineering (Chubin et al., 2005; Seymour & Hewitt, 1997).
Summary

This chapter provided a summary of the literature relevant to the study by presenting an overview of student college choice, relevant career development theories, student retention, history of engineering education, and choice and persistence in undergraduate engineering programs. The mixed findings in the literature demonstrate the need to explore women’s choice and persistence in engineering further to gain a better understanding of women’s experiences prior to and during matriculation in an engineering program.
CHAPTER 3

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 while combining certain aspects of reflective lifeworld research. According to Vagle (2018), “…it is equally possible to choose aspects of various approaches and combine them in unique ways” (p. 70). The use of IPA allowed for an in-depth exploration of women’s lived experiences and its inductive procedures focused on the interpretation of factors that were influential in their choice and persistence in engineering. As the underrepresentation of women in engineering programs and the workforce continues it is important to understand how women make sense of their experiences as they navigate and persist in engineering. Researcher reflexivity and bridling, from Reflective Lifework Research, were incorporated in this study instead of the phenomenological reduction and bracketing, which will be discussed further in the analysis and trustworthiness section. The goal of the study, through its
findings, was to gain a better understanding of factors that are influential in women’s choice of engineering and persistence within engineering.

The theoretical framework used to guide this study was Lent, Brown, and Hackett’s (1994) social cognitive career theory. The participants in the study were asked to reflect on their experiences prior to college and during their matriculation and the SCCT framework was used to help conceptualize and interpret how these experiences influenced the participants’ education and career choice behaviors. The SCCT framework was used to illustrate how person inputs and background contextual affordances influence one’s learning experiences, which have been shown to contribute to the development of self-efficacy and outcome expectations and result in the blossoming of interests, goals, and actions towards educational and occupational pursuits. The framework posits that a person’s educational and career development “trajectory is affected by many variables…and is not forged by any one of them, but rather the complex interactions among them” (Lent, 2013, p. 115).

In the following sections of this chapter an outline and description of the research questions, methodological approach, the role of the researcher, the research site, sampling strategies and participants, procedures, pilot study, data collection, data analysis, trustworthiness, and implications for practice will be presented.

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 an interpretation of 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?

Methodological Approach

Qualitative research methods allow researchers to gain an in-depth understanding of a problem or topic through the lived experiences of the participants. “This means that qualitative researchers study things in their natural setting, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them” (Denzin & Lincoln, 2011, p. 3). Qualitative studies are inductive and inferential and explore questions related to what, why, and how, as opposed to, for example, “how much” and “how many” in quantitative studies (Tuffour, 2017). In addition, qualitative methods provide the researcher with more latitude and adaptability in exploring the phenomenon as it appears. Specifically, phenomenology is the study of individual experiences and aims to understand the individual’s perceptions and meaning of a phenomenon or experience as it relates to a relevant or specific context and allows the researcher to interpret these experiences and meanings behind them. The goal of phenomenological research is to place the participants’ experiences at the center of the inquiry and to gain a deeper understanding of the phenomenon through the lived experiences of the participants.

An Interpretative Phenomenological Analysis (IPA), grounded in an epistemological assumption and orientated in a constructivist worldview, was chosen as the methodological approach for this study. An epistemological assumption calls for the
researcher to be interconnected with the participants in the study and that data, interpretations, and findings be traced to the participants and their subjective experiences. In a constructivist worldview or paradigm, the aim is to acquire knowledge through the participants’ subjective meanings and perceptions of their lived experiences. IPA research is committed to the examination and interpretation of how people make sense of their lived experiences through three philosophical areas – phenomenology, hermeneutics, and idiography. Phenomenology philosophy influences IPA research through its focus in engaging with people’s experiences and how they are situated in the world. In IPA, “one key value of phenomenological philosophy is that it provides us with a rich source of ideas about how to examine and comprehend lived experience” (Smith, Flowers, & Larkin, 2009, p. 11). Hermeneutics, the theory of interpretation, guides IPA in its examination of an emerging phenomenon and how the researcher interprets its appearance. The idiographic approach informs IPA in its adherence “to the particular, in sense of detail, and therefore depth of analysis…and is committed to understanding how particular experiential phenomena (an event, process, relationship) have been understood from the perspective of particular people, in a particular context” (Smith, Flowers, & Larkin, 2009, p. 29).

In summary, the IPA approach allowed for an in-depth exploration of women’s lived experiences and an interpretation of their experiences and factors that were influential in the context of choice and persistence in engineering. The data collection method entailed an organized and flexible schedule through in-depth, one-on-one interviews and the analysis was conducted using a systematic, iterative, and inductive process.
Role of the Researcher

In qualitative studies the researcher serves as the instrument for collecting data and “decides which questions to ask and in what order, what to observe, what to write down” (Mertens, 2015, p. 261). It is important that the researcher acknowledge and set aside any predispositions and experiences of the phenomenon that he or she brings to the qualitative study. My role in this study was the primary instrument for collecting, coding, and analyzing data from the interviews that were carried out. In this role there is the potential that my predispositions or biases could impact the outcome of the study. To safeguard against potential researcher biases or judgements the use of bridling, memoing, and journaling procedures were important in preserving the analysis, findings, and outcomes for this study. Creswell and Poth (2018) described how researchers can accomplish this:

Reviewing and then discussing how biases, values, and experiences impact emerging understandings is actually the heart of being reflexive in a study, because it is important that the researcher not only detail his or her experiences with the phenomenon but also be self-conscious about how these experiences may have potentially shaped the findings, conclusions, and the interpretations drawn in a study. (pp. 229-230)

Researcher reflexivity or the phenomenological reduction are important methodological approaches in phenomenological studies as it allows the researcher to consistently examine one’s positionality, perceptions, experiences, and understandings of the phenomenon and how these assumptions can influence the study. A common technique used to accomplish this in phenomenology is called bracketing. In bracketing “the everyday understandings, judgments, and knowings are set aside, and phenomena are revisited, naively, in a wide-open sense…” (Moustakas, 2011, p. 33). However, I recognize that bracketing can be a limiting approach as my positionality in this study came from an open and curious stance, which I believe is an ideal, less-biased approach.
in examining and comprehending the participants’ experiences. Nevertheless, it is imperative for phenomenological researchers to be fully aware of their pre-understandings and judgements but equally important to call them into question and reshape them throughout the research experience. Therefore, I followed a bridling approach (known as the bridled attitude) to allow for openness to the phenomena in the study and I will elaborate on this approach in the analysis and trustworthiness section of this chapter.

It is important to acknowledge my role as I am of the opposite gender of the participants in this study. To avoid any awkward or uncomfortable feelings or potential issues regarding my “outsider” position I made a concerted effort to tether my approach throughout the study in an empathic, compassionate, and transparent fashion. I also conveyed to the participants my genuine interest in investigating choice and persistence among women in engineering and that I was eager to learn about their experiences. It is my belief that this approach allowed me to establish a trusting rapport with each of the participants, which helped facilitate an open, honest, and safe interview environment.

Lastly, it is also significant to disclose my dual-position in this study as I am a doctoral student in the College of Education and an administrator in the College of Engineering – the location of the study. As the Assistant Dean for Undergraduate Affairs, my responsibilities include directing and administrating the college’s academic support services, experiential and career development services, and retention initiatives as well as assist in the overall administration of the college. Due to my position at the site, additional protections were included in the institutional review board (IRB) protocol and informed consents to make the participants aware of my dual role in the study and the additional steps that were in place to avoid any potential for coercion or undue influence.
These were necessary steps to safeguard against any conflict of interest issues between myself and the participants throughout the study.

Site Description

The site selected for this study was a large, state-related research university located in the Northeast region of the United States. The institution has a total student enrollment of over 40,000 students with over 29,000 undergraduate students and 10,000 graduate students represented from all 50 states and 127 foreign countries (All statistics reported in this dissertation are from the University Factbook, 2017b). Female students represent 54 percent of the total enrollment, while male students represent 46 percent of the total enrollment. The institution’s student enrollment by race/ethnicity is as follows: White, non-Hispanic 53.8 percent, African American 11.7 percent, Asian 11.3 percent, International 8.5 percent, Hispanic/Latino 6.3 percent, Unknown/Other 5 percent, Two or more races 3.2 percent, American Indian/Alaska Native 0.1 percent, and Pacific Islander 0.1 percent. The student to faculty ratio is 14 to 1 and the average undergraduate class size is 30. The institution’s overall freshman-to-sophomore retention rate is 90 percent, four-year graduation rate 52 percent, and six-year graduation rate 71 percent.

The institution offers 170 Bachelor’s programs, 176 Master’s programs, and 68 Doctoral programs and is comprised of 15 schools and colleges including the College of Engineering. The College of Engineering has a total student enrollment of over 2,100 with over 1,900 undergraduate students and over 200 graduate students. Male students represent 79 percent of the total enrollment, while female students represent 21 percent of the total enrollment. The College’s student enrollment by race/ethnicity is as follows: White, non-Hispanic 50.3 percent, International 16.6 percent, Asian 11.3 percent, African American 10.6 percent, Hispanic/Latino 4.9 percent, Unknown/Other 3.7 percent, Two or
more races 1.8 percent, American Indian/Alaska Native 0.1 percent, and Pacific Islander 0 percent. The college’s freshman-to-sophomore retention rate is 77 percent, four-year graduation rate 28 percent, and six-year graduation rate 48 percent. The average SAT score for the most recent incoming freshmen class was 1252 and average high school grade point average was 3.57. The student classification breakdown in 2017 was 454 freshmen, 434 sophomores, 434 juniors, 392 seniors, and 239 fifth-year seniors.

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. The first criterion sampling technique was utilized to identify which students met the criteria of the persistence phenomenon that was under investigation. Persistence was defined as a student having completed a minimum of three years of study in engineering and enrolled in one of the two contiguous Senior Design Project Capstone courses. As illustrated in Table 3.1, the sampling procedure returned a total of seventy-six female students identified as having met the persistence criteria.
Table 3.1

Number of Students That Met the Persistence Criterion

<table>
<thead>
<tr>
<th>Course Subject &amp; Number</th>
<th>Course Title</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 4173</td>
<td>Senior Design Project I for Environmental</td>
<td>1</td>
</tr>
<tr>
<td>ENGR 4174</td>
<td>Senior Design Project I for Bioengineering</td>
<td>11</td>
</tr>
<tr>
<td>ENGR 4175</td>
<td>Senior Design Project I for Civil Engineering</td>
<td>9</td>
</tr>
<tr>
<td>ENGR 4176</td>
<td>Senior Design Project I for Electrical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 4177</td>
<td>Senior Design Project I for Mechanical</td>
<td>6</td>
</tr>
<tr>
<td>ENGR 4296</td>
<td>Senior Design Project II</td>
<td>46</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>76</strong></td>
</tr>
</tbody>
</table>

The second criterion sampling technique was applied to determine how many of the seventy-six students had originally matriculated to the College of Engineering directly from high school as a first-year student and were continuously enrolled throughout their academic career. This strategy was used to ensure that the students’ paths to persistence were similar to avoid any outliers or anomalies (e.g., transfer student, irregular enrollment patterns, etc.) in the sample. The was accomplished by cross-referencing the seventy-six students registered for the Senior Design Project Capstone courses against their Cohort Code and enrollment history. The University uses an internal coding system that assigns a Cohort Code to every student once they matriculate to the institution that identifies the student as either a “New Undergraduate Freshman” or “New Undergraduate Transfer.” Additionally, student enrollment histories were reviewed to ensure the sample consisted of continuously enrolled students. As displayed in Table 3.2, the sampling procedure returned a total of forty-seven students eligible to participate in the study. An invitation to participate in the study was sent to all forty-seven students through an email generated from a mail merge by using Microsoft Word, Excel, and Outlook; sixteen students indicated that they were interested in participating in the study.
Lastly, a maximum-variation sampling method was used to maximize the variability of the participants for the study by mirroring the overall demographic makeup of the female student body within the College of Engineering. This approach was employed to help broaden and develop a deeper understanding of choice and persistence among a diverse sample of women engineering students.

The final sample for the study consisted of eleven female undergraduate engineering students that at the time of the study were registered in one of the two contiguous Senior Design Project Capstone courses. To protect the anonymity of the participants I will list the demographic breakdown separately and it was as follows: five White, three African-American, two Asian, and one Hispanic. The final sample is illustrated in Table 3.3. Additionally, five female faculty members, who majored in engineering as undergraduate students, were selected to participate in the study as a method of triangulation and to strengthen the trustworthiness of the findings.

Table 3.2

*Number of Students That Met the Matriculation Criterion*

<table>
<thead>
<tr>
<th>Cohort Code</th>
<th>Cohort Code Description</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>1336UGFR</td>
<td>Fall 2013 New Undergrad Freshman</td>
<td>3</td>
</tr>
<tr>
<td>1436UGFR</td>
<td>Fall 2014 New Undergrad Freshman</td>
<td>5</td>
</tr>
<tr>
<td>1503UGFR</td>
<td>Spring 2015 New Undergrad Freshman</td>
<td>1</td>
</tr>
<tr>
<td>1536UGFR</td>
<td>Fall 2015 New Undergrad Freshman</td>
<td>33</td>
</tr>
<tr>
<td>1603UGFR</td>
<td>Spring 2016 New Undergrad Freshman</td>
<td>3</td>
</tr>
<tr>
<td>1636UGFR</td>
<td>Fall 2016 New Undergrad Freshman</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>47</strong></td>
</tr>
</tbody>
</table>
### Table 3.3

*Final Sample of Student Participants*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Participant Code</th>
<th>Major</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 1</td>
<td>P-1</td>
<td>Mechanical Engineering</td>
</tr>
<tr>
<td>Participant 2</td>
<td>P-2</td>
<td>Bioengineering</td>
</tr>
<tr>
<td>Participant 3</td>
<td>P-3</td>
<td>Bioengineering</td>
</tr>
<tr>
<td>Participant 4</td>
<td>P-4</td>
<td>Civil Engineering</td>
</tr>
<tr>
<td>Participant 5</td>
<td>P-5</td>
<td>Mechanical Engineering</td>
</tr>
<tr>
<td>Participant 6</td>
<td>P-6</td>
<td>Bioengineering</td>
</tr>
<tr>
<td>Participant 7</td>
<td>P-7</td>
<td>Civil Engineering</td>
</tr>
<tr>
<td>Participant 8</td>
<td>P-8</td>
<td>Bioengineering</td>
</tr>
<tr>
<td>Participant 9</td>
<td>P-9</td>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>Participant 10</td>
<td>P-10</td>
<td>Bioengineering</td>
</tr>
<tr>
<td>Participant 11</td>
<td>P-11</td>
<td>Electrical Engineering</td>
</tr>
</tbody>
</table>

**Procedures**

Approval for access to the research site was granted by the Dean of the College of Engineering in September of 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 on October 8, 2018 and approval was granted on November 26, 2018. This was an important and necessary quality assurance step for the study and ensured that proper protocols were in place to avoid ethical issues as well as established procedures to address any ethical concerns throughout the study. 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. “Anonymity means that no uniquely identifying information is attached to the data, and thus no one, not even the researcher, can trace the data back to the individual providing them” (Mertens, 2015, p. 353). Steps to ensure anonymity included assigning codes to mask any personal identifiable information that could be traced back to each participant. “Confidentiality means that the privacy of individuals will be protected in that the data provided will be handled and reported in such a way that the data cannot be associated with the research participants personally” (Merten, 2015, p. 353). 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 interviews and ten faculty interviews. Interview scheduling was managed in “Grades First,” an appointment scheduling platform, through the utilization of the “Grades First” appointment campaign feature which allowed participants to select a day and time that was most convenient for their schedules. The focus of the first interview explored the choice phenomenon and the focus of the second interview explored the persistence phenomenon. The setting for the student participant interviews was the researcher’s private office located in the College of Engineering and
the setting for the faculty participant interviews was either the researcher’s office or the faculty participant’s office depending on the faculty participant’s preference.

An interview protocol was developed using a semi-structured interview format. This helped provide an opportunity to ask open-ended and non-directive/tour questions (Creswell & Poth, 2018). The benefit of a semi-structured interview format afforded the participants ample opportunity to speak at length and reflect on their experiences. 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. The semi-structured interview 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. The interview format helped “ensure the relevant topics were addressed in the interview [but allowed for probing] to further explore relevant points” (Mertens, 2015, pp. 384-385). Additionally, each interview was recorded using the “Voice Memos” application on an Apple device and were uploaded into a secure filing system in NVivo.

Sample Interview Questions

Questions related to experiences prior to entry to engineering program:
1. Can you describe your Math and Science experiences prior to college?
2. Can you talk about when or how you first got exposed to engineering?
3. Do you recall when you first knew you were going to declare engineering as your major?
4. Can you talk about all of the people that have inspired or encouraged you to pursue engineering prior to enrolling in college?

Questions related to experiences during engineering matriculation:
1. Please describe your experience as a woman engineering student during your first year?
2. What factors do you attribute to your decision to persist in engineering?
3. What have been the most discouraging factors in pursuing an engineering degree?
   a. How did you overcome these factors?
4. In your opinion, what type of support did you find most helpful?
   a. What kinds of support should be available to help women in engineering?
Questions to inform future practice:
1. What recommendations do you have for exposing young girls and women to engineering?
2. What advice do you have for future women interested in studying engineering?

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. The data analysis spiral includes the following activities:

1. Managing and organizing the data
2. Reading and memoing emergent ideas
3. Describing and classifying codes into themes
4. Developing and accessing interpretations
5. Representing and visualizing the data (Creswell & Poth, 2018).

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. Table 3.4 illustrates how the data analysis spiral guided the IPA analytic process in the present study.
Table 3.4

Data Analysis and Representation of IPA Approach

<table>
<thead>
<tr>
<th>Data Analysis</th>
<th>IPA</th>
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<tbody>
<tr>
<td>• Managing and organizing the data</td>
<td>• Create and organize data files</td>
</tr>
<tr>
<td>• Reading and memoing emergent ideas</td>
<td>• Reading and re-reading through the transcript</td>
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<tr>
<td></td>
<td>• Analytic memoing, initial noting, and exploratory commenting</td>
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<tr>
<td>• Describing and classifying codes into themes</td>
<td>• First cycle coding - Theming the Data</td>
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<td></td>
<td>• Developing emergent individual themes</td>
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<td></td>
<td>• Second cycle coding - Pattern Coding</td>
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<tr>
<td></td>
<td>• Looking for thematic patterns and recurrences across cases/participants</td>
</tr>
<tr>
<td></td>
<td>• Developing emergent super-ordinate themes</td>
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<tr>
<td>• Developing and accessing interpretations</td>
<td>• Interpretation</td>
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<tr>
<td></td>
<td>• Organizing emergent themes and using extracts to support interpretations</td>
</tr>
<tr>
<td>• Representing and visualizing the data</td>
<td>• Connecting the themes to the theoretical framework</td>
</tr>
</tbody>
</table>

Specific to this study the first step in the analytic process was the management and organization of the interview data (i.e. audio recordings) into secure digital files with a naming convention for each file. The naming convention used included the participant code and interview number, for example the first participant’s audio file was labeled Participant 1 - Interview 1 and continued to the eleventh participant’s audio file labeled as Participant 11 - Interview 1. Next, each audio file was uploaded into NVivo and the files were transcribed in NVivo’s transcription tool and then securely stored into NVivo’s data filing management system.

Following these initial steps, the second step of the analytic process entailed reading each transcript while listening to the corresponding audio file to format and verify the accuracy of the transcript. The second step continued as each interview transcript was re-read and initial notes and exploratory comments were generated after
identifying specific extracts that were meaningful and substantial to the phenomena in the study. The third step consisted of testing several first cycle coding methods to determine which method suited the analytic process best, ultimately deciding on the “Theming the Data” method. This method allowed for the development of emergent themes followed by the process of searching for connections across these initial emergent themes within individual participant transcripts. This was accomplished by using the techniques of abstraction and numeration. Smith, Flowers, and Larkin (2009) described abstraction as a “basic form of identifying patterns between emergent themes and developing a sense of what can be called a ‘super-ordinate’ theme” (p. 96). Numeration is the process of keeping record of the frequency a theme is supported within a transcript. During the first three steps as the initial interpretation of the data began to take shape, the participants were engaged in member checking procedures to verify the data and ensure the interpretations were accurately reflecting their experiences.

Once the first three steps were completed within each transcript, the fourth, fifth, and sixth steps of the analytic process commenced which comprised of the second cycle coding method – Pattern Coding – and allowed for identification of thematic patterns and recurrences across participants’ transcripts. For the purpose of this study, recurrent was classified as a theme having been present in at least half of the eleven participants. This process ultimately led to the reconfiguring and relabeling of themes and the development of the emergent themes. During the fifth step, an interpretation of the emergent themes working across cases was incorporated in order to increase the depth of the analysis. This entailed using detailed extracts from individual interview transcripts to validate and support the themes at the group level and involved “negotiating these relationships between convergence and divergence, commonality and individuality” (Smith, Flowers,
& Larkin, 2009, p. 107). The sixth step of the analytic process entailed reviewing the themes and the interpretations and determining how the findings aligned and fit with the SCCT framework.

Throughout the entire research project but especially during the analytic process I reflected on my judgements and personal experiences regarding women’s choice and persistence in engineering. This allowed for the adoption of “the bridled attitude” which was an active adherence to accessing my judgements and predispositions throughout the entire research process. Vagle (2018) described the bridling attitude as “the essence of bracketing in that pre-understandings are restrained so they do not limit openness and is an active project in which one continually tends to the understanding of the phenomenon as a whole throughout the study” (p. 74). Bridling my feelings and experiences allowed me to view the results and findings, as they appeared, with a renewed sense of appreciation and openness.

Trustworthiness

Trustworthiness is an important element in validating the quality and rigor of a research study. There have been ongoing discussions and debates among qualitative research circles regarding the topic of validity, trustworthiness, and credibility. Vagle (2018) described validity in phenomenology as the “researcher’s sustained engagement with the phenomenon and the participants who have experienced the phenomenon” (p. 72). This has further been explained as maintaining a receptive and empathetic stance with the phenomenon during the duration of the study (Vagle, 2018). It is common for phenomenologists to tend to this through bracketing, which calls for the complete suspension of one’s judgements and pre-understanding of the phenomenon leading to a renewed discovery of the phenomenon. However, bracketing felt a bit contrived and
retrospective; whereas bridling was a more natural, forward-looking fit that allowed me to be aware of my judgements, reflect on them, and maintain an open stance to the phenomenon throughout the study. My belief is that this approach allowed me to see the phenomena under investigation in a new light as opposed to an attempt to artificially and synthetically encounter them for the first time.

Other criteria for validating a qualitative study are described as credibility and dependability. Credibility criteria are used as a quality assurance measure of the study and its methods (Mertens, 2015). Techniques for credibility used in this study were member checks and triangulation. Member checking was used as a method to verify the findings with the participants as data were collected, analyzed, and interpreted. This was accomplished by providing the participants with a synopsis of the results from each of their interviews and provided them with the opportunity to review the data for accuracy and ensure they reflected their subjective experiences. This validation technique provided the participants an opportunity to serve as an active participant in the data collection and analysis. Triangulation was utilized to check for consistency and convergence in the findings and themes from the student participants’ data with the faculty participants’ data. Dependability criteria were used to ensure stability throughout the duration of the study (Mertens, 2015). This was achieved through the process of an audit trail through analytic memoing and journaling that was maintained throughout the duration of the study.

Pilot Study

In a pilot study conducted during the fall 2017 semester, themes that emerged from the data analysis aligned well with Wigfield and Eccles’ (2000) expectancy-value theory of motivation, which posits that two primary sets of beliefs – competence and value – factor into a student’s choice in selecting and persisting in engineering.
Competence beliefs are identified as an individual’s expectancies for success and are described as one’s beliefs as to how well they will perform on a future task (Wigfield & Eccles, 2000). Value beliefs are identified as a student’s “desire to engage in a task or activity and how well it aligns with one’s goals” (Matusovich, Streveler, & Miller, 2010, p. 291).

The participant’s responses provided evidence that both competence and value beliefs were contributing factors in the choice and persistence in engineering. However, upon further investigation I found several studies that examined the fit of SCCT model and college choice and persistence among engineering students. As a result, I came to the conclusion that the SCCT framework would provide a better overall fit for the purpose of this study.
CHAPTER 4
RESULTS

Introduction

As discussed throughout the first two chapters, numerous studies have examined student choice and persistence in engineering primarily using quantitative methodological approaches. The purpose of this phenomenological study was to contribute to the engineering education literature by gaining a deeper understanding of factors that contribute to women’s choice and persistence in engineering through the exploration of the lived experiences of eleven female engineering students. 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 phenomenological study was guided by the following primary and secondary questions:

1. How might choice and persistence take shape for women in an undergraduate engineering program?
   a. What role does 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?

This chapter addresses findings gathered from twenty-two semi-structured interviews with eleven student participants and ten semi-structured interviews with five faculty participants and begins with a reflection on the qualitative process and an overview of the findings and discussion of the emergent themes from the study.
Reflection on Qualitative Process

While the procedures involved in the qualitative data collection and analysis for this study were often overwhelming, challenging, and all-consuming the approach provided a framework for an extensive investigation of the phenomena that were intended to be examined. Through in-depth interviews and member checking the participants provided me with a renewed and comprehensive understanding of their experiences as engineering students that has contributed to a deeper understanding of factors, challenges, supports, and barriers in the pursuit of their engineering degree.

Additionally, the qualitative approach used in this study has proven to have several advantages. One primary advantage was that it provided a unique vantage point into the participants' experiences. Specifically, the exploration of the participants’ lived experiences presented a bird’s eye view of the interactions of individual, educational, environmental, and social factors throughout their pursuit of their respective engineering degree programs. Another key takeaway from this approach was that it provided a better understanding of and a greater appreciation for the challenges that women are faced with when navigating an academic field in which they are disproportionately represented. Another significant advantage of the qualitative approach in this study was that the use of a semi-structured interview protocol helped guide each individual interview but also provided flexibility in the data collection. That is, the interview protocol combined a general schedule of questions with the freedom to incorporate probing questions for a deeper examination of each participant's unique experiences.

This research experience was truly enlightening but also provided the participants with an opportunity to reflect on their experiences – for some this was the first time that they were truly engaged with their experiences. The subsequent sections of this chapter
will be organized to present the emergent themes related to factors that influence women’s choice of engineering as a major and the emergent themes related to factors that influence women’s persistence within engineering and how these findings aligned with the SCCT framework.

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 “choice of engineering” emerged from their lived experiences during the analysis. An example of relevant differences was parental education and occupation related to STEM or engineering. Father’s education ranged from completion of an associate degree to an advanced or terminal degree, whereas mother’s education ranged from high school diploma to an advanced or terminal degree for the student participants. Father’s education ranged from eighth grade to an advanced or terminal degree; whereas mother’s education ranged from eighth grade to an advanced or terminal degree for the faculty participants. Five of the eleven student participants reported that their mother and/or father was employed in a STEM or engineering field and four of the five faculty participants reported that their mother and/or father was employed in a STEM or engineering profession. Despite these differences five recurrent themes emerged from the data.

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*

It has been well documented in career development literature that an individual’s initial interest in an academic major or occupation is significantly influenced by access and exposure to learning experiences related to that domain. Learning experiences are described by Lent (2013) as “personal performance accomplishments, vicarious learning, social persuasion, and physiological and affective states” (p. 118). Specific to engineering, participation in or exposure to STEM or engineering related learning experiences have been shown to be highly influential in the development of an individual’s interests for these fields (NAE, 2018; Painter et al., 2017; Shapiro & Sax, 2011). Examples of these influential learning experiences include participation in advanced placement math and science courses, STEM-related curriculum or activities in K-12 setting, problem-solving activities, STEM competitions, summer camps, and extracurricular activities or clubs.

The student and faculty participants were asked to reflect on when they were first exposed to engineering. Of the eleven student participants, eight reported participating in learning experiences that were directly related to STEM or engineering prior to their decision to pursue engineering and the remaining three student participants reflected on
indirect or vicarious learning experiences related to STEM or engineering prior to their
decision to pursue engineering. Of the eight student participants, three reported learning
experiences in STEM or engineering related activities that were directly affiliated with
their high school:

I did the Technology Student Association all through High School, which is what
got me really interested in the first place. (P-1)

So, I was dual enrolled in senior year of high school in a program called
Biotechnology at a Technical Career Center…I got to work with Chinese hamster
ovarian cells in high school. Not a lot of people can say that, and it was really,
really cool. (P-3)

And then at my high school we had like a Project Lead the Way I don't know if
you've heard of that. It's like engineering classes in high school and I started out
doing that. When you take those like what are you going to be when you grow up
quizzes it's always like engineer something, something, something like engineer
was always in there and I decided to take one of those like my freshman year in
high school. (P-7)

Additionally, five of the eight student participants described experiences in STEM or
engineering related programs that were not affiliated with their school:

My mom always took me to like the STEM camps for girls, I guess. Like I went
to a NASA camp and I did some pretty cool stuff. I guess she knew about these
programs through her work. And so, I always was like yeah science is super cool.
I was always really interested in it. (P-2)

When I was a senior in high school. I was part of a cotillion program and we had
a big sister like program within that program. And my big sister she was a civil
engineer and she introduced me she actually was the first person to introduce me
to NSBE and took me to the scholarship event. (P-4)

When I was in high school, I did a program at Jefferson University that was more
also more biomedical sciences, but they exposed me to bioengineering things like
a professional lab setting and just biochemistry in general so that's what guided
me towards bioengineering, so I knew I wanted to be an engineer but not which
department. (P-6)

During high school science competitions…you would like design your own
experiment kind of and see how you go about like dissecting this or how you go
about making this chemical and you would put to a test compare how you how
you like that process or someone else's ideas…just like exposure and getting to
think outside of like a high school environment. (P-8)
It was this initiative from my Country's Science Foundation… Yeah that was pretty interesting. So that also increased my interest. (P-9)

These findings were consistent with the faculty responses as all five faculty participants reported learning experiences that were directly related to STEM or engineering prior to enrolling in college, for example:

I remember that was kind of an elective physics technology lab where we learned a bit of a drafting and we made this little car for some like science competition. (F-1)

She would buy me things that were like toys. I guess you could say that were more engineering related knowing that I liked that and that, that was my experience was really more at home than in high school. (F-2)

So, engineering specifically I would say I was exposed to through a research opportunity as a high school student. (F-3)

So, we had like this dining table with everything was set on it and my Dad you know started like drawing and doing calculations. So, I, you know, sometimes watched him and asked questions. So, I would say that was my first kind of experience. (F-4)

So, when I started going to the university on the weekends and over the summers and I was I was hooked. I mean I just couldn't get enough of learning all of this new stuff [neuroscience, math, and science courses] and feeling inspired and excited. (F-5)

Through their successful participation in hands-on STEM and engineering activities the student and faculty participants were able to not only gain valuable learning experiences but also a sense of personal performance accomplishment. According to Lent (2013) “compelling success experiences with a given task or performance domain tend to strengthen self-efficacy in relation to that task or domain...” (118). Therefore, it can be posited that the participants’ learning experiences helped reinforce their self-efficacy expectations regarding their interests and ability to succeed in engineering. It can also be advanced that these positive experiences helped shape the participants’ outcome expectations that are intimately related to the possibility of pursing engineering as a
major. According to Lent (2013) “people develop outcome expectations regarding different academic and career paths from a variety of direct and vicarious learning experiences, such as perceptions of the outcomes they have personally received in relevant past endeavors…” (p. 119).

Additionally, three student participants reported indirect exposure to engineering and described these experiences in an informal or exploratory context, for example:

I asked my physics teacher what you can actually do with physics besides teaching and being in academia and she kind of was just like I guess you could do engineering… she kind of just planted the seed…So I did a lot of research myself. (P-5)

But then I researched like engineering…looking at the pictures and some of the research people are doing it was just pretty fascinating. (P-10)

My dad, he likes to say that he was the one that told me about engineering. I don't know if that's true, but I do remember well he's a mechanic, so he's been like he's kind of operated in that world a little bit…So I think like engineering it was kind of a step in that direction. (P-11)

While these three student participants reported indirect experiences related to STEM or engineering, compared to the other eight student participants, their experiences can still be considered influential in their educational choice behavior. For example, their experiences helped shape their development of outcome expectations towards engineering and the prospects of selecting engineering as an academic pathway. For these participants this occurred by researching and gathering information through their indirect experiences, secondary sources, and social persuasion (Lent, 2013).

In summary, the findings for the STEM or Engineering Exposure theme illustrate how exposure and participation in STEM or engineering activities provided the participants with critical direct and/or vicarious learning experiences. As a result, these experiences helped strengthen the participants’ self-efficacy expectations towards engineering and informed their outcome expectations regarding engineering as an
academic major. These findings illustrate the interplay of the learning experience, self-efficacy expectation, and outcome expectation variables that have been shown to mold an individual’s academic and career interests as advanced in the SCCT model of career-related choice behavior. The findings in this theme also correspond with prior studies as they have shown that learning experiences prior to entering college are considered a significant factor in career-related choice behavior among students in engineering (NAE, 2018; Painter et al., 2017; Shapiro & Sax, 2011;).

Choice Theme II: Self-Efficacy in Math and Science

Engineering is defined as the profession in which knowledge of mathematical and/or natural sciences gained by study, experience, and practice is “employed in research, development, design, manufacturing, systems engineering, or technical operations with the objective of creating and/or delivering systems, products, processes, and/or services that lead directly or indirectly to an improvement in our quality of life” (Committee on the Education and Utilization of the Engineer, 1985). An engineering degree program prepares students for the profession through the study of foundational mathematics and natural science courses in topics such as differential and integral calculus, multivariate calculus, differential equations, statistics, calculus-based physics, chemistry and biological sciences.

In order to succeed and persist in these rigorous subjects it is important for students to hold positive beliefs regarding their capabilities in mathematics and science prior to matriculating in an engineering degree program. It has been well documented in the engineering literature that strong self-efficacy beliefs in mathematics and science are an important determinant in developing one’s interest in pursuing engineering (Carnasciali et al., 2013; Mau, 2003; Painter et al., 2017; Seymour & Hewitt, 1997). The
development of strong self-efficacy beliefs in engineering related subjects will normally occur during a student’s formative and adolescent years through prior learning experiences and performance accomplishments in rigorous mathematics and science coursework.

Participants were asked to reflect on their mathematics and science experiences prior to college and the student participants reported completing mathematics courses from pre-calculus through multivariable calculus as well as advanced placement courses in a variety of mathematics and natural science subjects. Below are extracts highlighting selected student responses:

In high school I was in the Honors classes for math and science. I took all of the AP sciences that were offered. I did multivariable calculus so calc 3 my senior year. (P-2)

I was in the Gifted and Talented, and advanced placement classes was pushed to do double up with math so take trigonometry and college algebra at the same time one year. (P-4)

In high school I took physics CP my junior year and then physics AP my senior year. (P-5)

Yeah so, my school is very heavy on the maths and sciences. I ended up taking up to like calc 2 in high school with AP. I took chemistry for multiple years and I ended up taking AP physics as well. (P-6)

I took AP classes in high school. Those were mainly like Calculus and Physics. And. Like. Biology. (P-8)

The faculty participants reported similar experiences in having completed advanced courses in mathematics and the natural sciences, for example:

So, in high school I did have access to AP calculus, and I took physics honors my junior year of high school and physics AP my senior year of high school. (F-1)

So, the highest level of math that they had was pre-calculus and that's what I took. (F-2)

I ended up taking algebra in eighth grade and that allowed me to get to Calculus in my senior year. (F-3)
We have very extensive courses on differential calculus, algebra, probability, and things like that. (F-4)

I ended up having to take a summer course at a community college so I could kind of skip ahead and get into the harder, more challenging science and math classes. (F-5)

Moreover, ten of the eleven student participants and all of the faculty participants revealed how their positive learning experiences in mathematics and science served as a source of confidence in their ability to succeed in these subjects, which helped cultivate and bolster their self-efficacy beliefs in gateway subjects closely associated with engineering. As a result, these experiences and developments were shown to be strong determinants in molding their interests in engineering. Of the ten student participants that reported positive learning experiences in mathematics and science prior to college, six of them reflected on how their passion and self-efficacy beliefs in both mathematics and science were instrumental in their major selection. Below are selected extracts illustrating the participants’ experiences:

I just didn't see myself giving up science and or math in particular. I like love Calculus and I don't know why but I just, I love that sort of stuff and so I was like well I was going to pick something that does both. And so, I did bioengineering. (P-2)

When I realized that I didn't really want to be a doctor I still wanted to do math and science and pursue math and science something that math and science related and that's when I started looking into engineering. (P-4)

So, I had a lot of opportunities growing up to expose myself to these classes that are required for engineering and that kind of allowed me to take on the major without being afraid that I don't have a good basis in it. (P-6)

So, I don't know I've always been more inclined in the math and sciences than like the English. I took as many as you needed but science, I took more than you needed, and math took more than you needed as I was encouraged by my teachers to take as many maths as possible if I wanted to pursue engineering in college. (P-7)
I was always interested in science and math. So that is why I was like interested in electrical engineering. (P-9)

I was good at math. I liked science and that that's what I wanted to do, to combine those two in a major. (P-10)

Three of the ten student participants reported how their passion and self-efficacy in science was instrumental in their decision-making process for selecting engineering as a major, for example:

I eventually ended up going into a program where it was a dual credit program for high school students, and it let me explore science in a whole different way and it kind of led me into bioengineering as a major. (P-3)

So, it was partly because I enjoyed physics. (P-5)

One of my really good high school teachers was like my AP bio teacher and she really got me into science and really looking into pursuing a STEM major. (P-8)

Finally, one of the student participants reported how her positive learning experiences in mathematics in comparison to her learning experiences in a history heavy curriculum at her school helped grow her confidence and interests in engineering which guided her in selecting engineering as her major.

I remember, I think I especially liked it because it in contrast to history it was very quantitative so I yeah, I just I was also good at it. So that was generally why I think I liked math, specifically it was calculus AB that prompted that and gave me confidence which later made me feel more like oh I can totally pivot from history to engineering and be fine. (P-11)

The faculty participants reported similar experiences as they reflected on how their passion and self-efficacy beliefs towards mathematics and natural science courses helped cultivate their interests in engineering and provided them with a source of validation in selecting engineering as a major, for example:

I knew of it. I knew that I was good at the math and science. (F-1)

So, I just loved math and you know knowing, figuring out that it was applied math is probably what drew me to it. (F-2)
It seemed interesting. It was heavy in math and science which were definitely my interests going into college. (F-3)

I think I really liked math in general and I knew I wanted to be an engineer. (F-4)

So, it turned out it was a lot more interesting than just pure biology to me. There was a hands-on aspect, there was more math, which I knew I really enjoyed. (F-5)

The findings for the *Self-Efficacy in Math and Science* theme are consistent with prior research that has examined factors that are influential in student choice behavior in STEM and engineering domains. Studies have shown that high self-efficacy in mathematics or science is a strong predictor of interest in engineering and entry into an engineering program (Carnasciali et al., 2013; Mau, 2003; Painter et al., 2017; Seymour & Hewitt, 1997). Additionally, the findings within this theme were consistent with the SCCT model as it suggests that interest in an activity is likely to grow and persist when individuals perceive themselves as capable within a given subject or performance domain. Moreover, the findings also align with SCCT’s illustration of the direct relations between self-efficacy and interests, which informs one’s choice goals and choice actions. In other words, the participants’ strong self-efficacy beliefs towards subjects related to engineering helped spark their interests in engineering and fueled their goals and intentions in selecting engineering as their major.

It is important to recognize that only one student participant reported significantly discouraging experiences in mathematics courses during her high school career as she was conditioned, through negative reinforcement, to believe that she was “really bad at math” (P-1). What is even more thought-provoking about her experience is that the math teacher who provided her with the highest levels of discouragement in high school was a woman. This seems counterintuitive and it was extremely disheartening to hear about her experiences with this particular teacher, but it provided me with a renewed understanding
and appreciation of some of the difficult challenges that young girls and women are faced with when pursuing domains or fields in which they may be disproportionately represented.

**Choice Theme III: Engineering Expectations**

According to Lent (2013) “outcome expectations refer to beliefs about the consequences or outcomes of performing particular behaviors” (p. 118). In other words, outcome expectations refer to what one expects or anticipates will happen if they choose to engage in a particular task or choice behavior. Outcome expectations are characterized as self-evaluative (e.g., expectancy of financial stability, wealth, lifestyle), validation or reinforcement from others (e.g., approval, affirmation), and physiological (e.g., reduced stress, fear, or angst). The participants were asked to reflect on how they arrived at their decision to select engineering as their major and what motivated them throughout their decision process.

While the participants’ responses were varied, reflecting their individual and unique experiences, the common element that emerged was how an engineering degree could provide them with opportunities that could assist them in reaching their personal, social, and career goals. As the participants began to identify opportunities associated with an engineering degree, it allowed them to develop a set of beliefs regarding how pursuing and obtaining an engineering degree might yield certain consequences or outcomes. This process allowed the participants to evaluate and reflect on the fit between an engineering pathway and its perceived outcomes with their personal and career-related values.
Several of the student participants described how their outcome expectations formed from a self-evaluative lens as obtaining an engineering degree would provide them with considerable and gainful career opportunities.

I decided that if I don't choose to go into medicine engineering is a great fallback there are great career opportunities for it. (P-2)

So, it has a huge part in being like the financial stability that comes with being an engineer. There's so many jobs out there that I think are that are so accessible to engineers. (P-5)

I was gonna just study French but then I said to myself I can study by myself...And obviously career opportunities are better if you choose engineering over a language. (P-9)

I don't remember an exact point, but I just remember wanting a job, that I could move up in ranks and I also wanted to make money and I want to be respected and it seemed like those were all the result of an engineering degree. (P-11)

For these four student participants it was evident that pursuing a field that would provide them with excellent career prospects and/or financial stability was something that was extremely important to them. These personal values helped guide their beliefs regarding the benefits and consequences of an engineering degree and its utility and practicality in helping them achieve these goals. As the students become more knowledgeable of engineering, through direct exposure or secondary information, their outcome expectations continued to take shape. As a result, these students developed outcome expectations that were closely aligned with their personal and career values, which helped cultivate and reinforce their interest in engineering.

A number of the student participants also described how their outcome expectations were framed from a self-evaluative lens as obtaining an engineering degree would provide them with a sense of self-fulfillment.

I felt like it would be a justification to be completely honest. And I wanted to be a successful one to show that I don't know that I could do it. (P-1)
I'm picking bioengineering because my idea was to go to college bio premed and my parents heavily stressed that I should do that if I really wanted to go to med school as a future doctor going the M.D. route and I really was interested in bioengineering more so than that. (P-3)

I was like wow because she's in the position where she can just if she wants to go work in another country right now, she can do that. And I really want to be able to do that as well. (P-4)

But it was more like it was an idealized thing just what I see people accomplishing. That's what I wanted to be a part of. (P-6)

So basically, everything that motivates me is like something. If I enjoy it then I'll keep doing it if I don't enjoy it then I want out like I don't want to do it. I don't want to do something that I don't like. So, it's basically like you can do so many different things within the civil engineering field that I know I'll find something that I like. (P-7)

It's more of can I stay motivated for 15 years and Doctors do great work but if I can be out working and still making great impact in four or six years versus 15 years and I rather do engineering instead. (P-8)

It was just pretty fascinating. It wasn't simply engineering but it wasn't simply science or biology either. I just like the fact that it was very combined. (P-10)

These seven student participants shared how they were mainly concerned with pursuing a field that would be interesting and satisfying – ultimately serving as a source of self-fulfillment. Self-fulfillment “consists of carrying to fruition one’s deepest desires or one’s worthiest capacities… it is a bringing of oneself to flourishing completion, an unfolding of what is strongest or best in oneself” (Gewirth, 2009, p. 3). For these six students they viewed engineering as an opportunity to pursue the things they enjoyed and valued most, which would lead to a sense of satisfaction and a rewarding and meaningful career. These outcome expectations were guided by their values and served as a catalyst in the development of their interests in engineering.

The faculty participants’ experiences were consistent with the student participant findings as the faculty participants reported similar perceptions of the consequences or
outcomes pursuing an engineering degree would yield. To illustrate this the faculty extracts are presented below:

I knew I knew I wanted something that I could make money doing. (F-1)

I always knew I loved physical things. So just handling things quite frankly so I always knew I was gonna be a mechanical engineer and nothing else. (F-2)

I was debating between environmental engineering because I essentially loved rivers or biomedical engineering because that was a nice overlap with my previous interests in medicine. (F-3)

So basically, the way that things go in my country is that you either should be an engineer or a medical doctor if you want to be successful in life. (F-4)

I was excited to do something different. It was exciting to be offered something that not a lot of people had talked about to me like it just sounded really interesting. (F-5)

The findings in the Engineering Expectations theme illustrate the important role outcome expectations play in regulating and influencing a number of important phases in choice behavior. According to the SCCT model, outcome expectations are derived from the interactions between one’s learning experiences and self-efficacy expectations (Lent, 2013). Furthermore, outcome expectations, along with self-efficacy expectations, are identified as direct influencers on one’s academic and career interests. Outcome expectations are also directly linked to an individual’s choice goals, performance goals, and choice actions. Lent (2013), defined choice goals as “the type of activity or career one wishes to pursue and performance goals as the level or quality of performance one plans to achieve within a given task or domain” (p. 119).

Furthermore, to put this into context the findings under this theme suggest that as the participants established a set of beliefs about the consequences related to an engineering degree, they began to develop goals directed towards these outcomes and took action to execute their goals. For example, a number of the participants perceived
engineering as a profession that could provide them with desirable career opportunities (outcome expectations). These outcome expectations helped shape and grow their interests towards engineering (interests) and informed their decision to consider engineering as a major (choice goals). This ultimately guided them to take appropriate steps and actions towards achieving their goals by applying and enrolling in an engineering program (choice actions).

*Choice Theme IV: Engineering Agency Beliefs*

One of the key challenges for the engineering profession has been the lack of knowledge of the profession and the strong emphasis on technical skills, which have been documented to be a major deterrent for underrepresented populations. This is especially true for women as they “tend to express interest in helping and people-oriented professions, which are not common perceptions of engineering careers” (NAE, 2018, p. 96). To overcome these challenges, it is critical for the engineering profession to promote the importance of social skills in the profession and how engineers can have a positive impact on society.

This change in messaging is important as recent studies have shown how altruism or agency beliefs have been linked to a student’s decision to pursue engineering and is particularly true among women in engineering (Godwin et al., 2016; NAE, 2018; Seymour & Hewitt, 1997). According to Goodwin et al. (2016), agency beliefs refer to “how students view the world with a critical mindset to advance the world as a more equitable place” (p. 314). Agency beliefs in engineering can be operationalized as a student’s attitudes or strong desire to use their interests linked to engineering for a greater social purpose and how an engineering career can allow them to accomplish this goal.
Participants were asked to reflect on what motivated them to pursue engineering and what being an engineer meant to them when they were in high school. Nearly all of the eleven student participants’ responses were related to agency beliefs as they viewed engineering as a profession that makes a difference in the world, which was something that resonated with them as involvement in a profession that would have a greater social purpose was congruent with their values and goals. Eight of the student participants reflected on the importance of entering a profession that would directly allow them to help others and make an impact in the world. Connecting engineering to their personal values and goals served as a valuable source of motivation in their interest in pursuing an engineering degree, for example:

I also want to be involved in a major that would allow me to make a positive impact in helping people and making the world a better place. (P-1)

When I actually looked more into engineering and the benefits of engineering and thinking about the area I grew up in and you know it’s pretty kind of run down and it could definitely be built up. I was like oh I could do this. So, engineering you can do this. (P-4)

Like you're very much in and like in a position to be a part of huge projects and kind of like projects that affect the future, so I thought that was cool. (P-5)

So, growing up I kind of had that idealized notion that I could go into a field and develop solutions to the problems that I was seeing and bioengineering is clear like I would I could work in the industry and come up with a solution like prosthetics or medicine or anything like that. (P-6)

So, I wanted to do something that still had an impact on people's lives but more behind the scenes. (P-8)

That would allow me to help others in a positive way as I could use my strengths in these subjects in a major to help people positively. (P-10)

I wanted to have an impact. I wanted to directly help people. (P-11)

Being able to make an impact in the world. (P-7)
Additionally, two of the student participants focused their responses on what being engineer meant to them in high school as they viewed engineering as a profession that involves solving critical societal problems. While their responses did not directly reveal a desire to use engineering as a means to help others and make the world a better place it can be asserted – through their perceptions of the profession and its societal impacts – that their academic and career interests were closely anchored by their agency beliefs. As a result, their beliefs and values helped serve as a motivating force in growing their interests and decision to pursue engineering, for example:

Like engineers are helping make the world a better place in my eyes, I guess. (P-2)

Solving problems and making the world a better place. (P-9)

Lastly, one of the student participants (P-3) shared that during middle school her class viewed a science fiction movie that showcased engineering and how the use of reproductive technologies could genetically modify human beings to be less susceptible to illnesses or diseases. The idea that engineering had the capacity to accomplish this was fascinating to her and was what piqued her interest in engineering. While she did not directly state that her motivation to pursue engineering was to help others or make the world a better place it can be inferred that her interests in engineering were informed by her fascination of pursuing a field that involved problem solving and having an impact on society.

The faculty participants’ findings were similar to the students’ findings as three of the five faculty participants’ responses can be linked to agency beliefs. Two of the faculty participants shared a rudimentary or causal understanding of the impact engineering has on society, while the other faculty participant mentioned the desire to pursue engineering as a means to be involved in a profession that could directly help people.
I think it was more like design and making things efficient. (F-4)

I did learn a little bit more about what bio engineers do, you know heart valves and stents and pacemakers or a lot of cardiovascular devices. (F-5)

I wanted to be able to do something that seemed enjoyable and in some way. Mattered to humanity in some way. (F-1)

The differences in the student and faculty participant responses may be due to the shift in today’s societal values and awareness surrounding the engineering profession as well as how information is acquired and transmitted. For example, the faculty participants enrolled in college before the expansion of the internet and explosion of mass media, which could have resulted in not having the same access to media coverage or awareness of important societal issues compared to how this information is more readily available today.

The findings for the Engineering Agency Beliefs theme are consistent with the engineering education literature as 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. The findings are also consistent with the SCCT model as agency beliefs intersect several of the variables in one’s career-related choice behavior. First, the findings illustrate how agency beliefs are linked to outcome expectations as the participants reported the desire to help others and make an impact in society and they viewed engineering as providing them with the opportunity to do so. Second, the findings suggest that agency beliefs are also connected to self-efficacy expectations as the participants’ confidence in their skills and abilities and desire to use them for a greater social purpose helped guide their interests and choice behavior in pursuing engineering. Lastly, the findings revealed that agency beliefs were connected to engineering goals as the participants’ interest and desire to pursue
engineering was informed by their values and intentions of helping others and making the world a better place.

**Choice Theme V: Pre-College Environmental Support**

Prior studies examining student career choice behavior in engineering have identified three central factors that are shown to be influential in a student’s selection of engineering as an academic major. These factors have been described as individual, learning experiences, and environmental. The findings related to the *Pre-College Environmental Support* theme revealed the important and influential role environmental factors play in the participant’s decision to pursue an engineering degree. In SCCT, environmental factors have been categorized as affordances and are defined as distal, background influences and proximal environmental influences (Lent, 2013). Examples of distal, background influences are cultural and gender role socialization, socioeconomic status, role models, and skill development (Lent, 2013). Proximal environmental influences refer to environmental supports and barriers and can influence the relationship between interests, choice goals, and choice actions (Lent, 2013).

Family support plays a pivotal role in a student’s choice of engineering (Godwin et al., 2014; NAE, 2018; Painter et al., 2017). Specific to female students, it has been found that fathers have the greatest positive influence on engineering career choice (Godwin et al., 2014) and egalitarian families tend to provide important support that is integral in choice and success in engineering (Assessing Women in Engineering, 2015). Mentors and teachers play an important role in helping develop or validate a student’s interests in engineering. Teachers and mentors serve as important role models that help strengthen a student’s self-efficacy in engineering, which is especially true for female students (NAE, 2018; Shapiro & Sax, 2011).
The participants were asked to reflect on all of the people that have inspired, encouraged, and supported them in their interest in engineering and decision to pursue an engineering degree. Each of the student participants reported receiving favorable environmental support and encouragement during their adolescence towards their interests in engineering. Of the eleven student participants nine of them referenced how the parental support and encouragement they received was significant and instrumental in growing their interest in engineering and decision to pursue engineering. Of these nine student participants, six shared how both their mother and father served as a source of support towards their interests and goals in engineering. Below are selected extracts highlighting the participants’ responses:

My dad was really encouraging about...I don't know like challenging yourself and I was fortunate, like the way my mom was so behind it. (P-1)

My parents were highly supportive of that being engineers themselves. (P-2)

My parents are big key players. They always wanted me to become a doctor and I then when I told them I wanted to be an engineer. They were a little iffy but once they realized that I had my crap together and I knew or sort of kind of knew what I wanted to do they were behind it. (P-8)

But like honestly, I guess my parents were the biggest support system. (P-7)

Mainly my parents were helping me and they both definitely knew it was going to be a good outlook when it comes to salary wise. So, it's like they had no clue, so I had to kind of school them on it a little bit just to sell them on the fact that this is what I wanted to do. But they were very supportive and like if you want to do this and just do it. (P-10)

Like my parents have been super supportive but just in the cheering me on from the sidelines kind of way or encouraging me just to go to college in general. (P-11)

Additionally, two of the nine student participants referenced the support they received from their mother and how this was critical in developing their interests and encouraging them to pursue an engineering degree, for example:
She's (mom) kind of the reason I did it because she's always pushed me to do whatever I can do to the best of my ability. And she's always shown me that you know I should push myself as much as possible because I have the potential for it. (P-3)

my mother in terms of career she thought that was a good idea to choose engineering. (P-9)

Finally, one of student participants described the support she received from her father, who studied mechanical engineering and was a practicing engineer, for example:

And then my father influenced me a lot because my mom's a nurse and so I always knew I wanted to go into medicine, but I didn't want to work with people. And so, my dad kind of just he said become an engineer which is a lie because we work with people all the time. (P-6)

In addition to parental support, ten of the eleven student participants reflected on the support they received from important role models such as teachers, mentors, or family members throughout their lives and how these individuals played a significant role in the development of their interests and goals in engineering. Of these ten student participants, four reported a male role model, for example:

Actually, I had an advisor, he was a mechanical engineer and he was really really supportive, and it almost meant more because he was such a hard guy that when he opened up and he was so supportive he was like a protective bear. (P-1)

The biggest for engineering and like stem is definitely my grandpa because he worked in the engine rooms and when he was in the Navy and he was a career Navy like he was a Navy his whole life and like he's always admired like almost like worship like the engineers of like in the Navy and he was very impactful and encouraging me to do like engineering type stuff because that's always been in my ear. (P-7)

But yeah so, he was probably one that inspired me because we had different modules for physics, and he did the electricity module. So that is why I was like interested in electrical engineering. (P-9)

And my calc AB professor was an engineer and then went back to teach and when I heard him say that he was an engineer first I was like Oh, so I feel like he provided an example for me. (P-11)

The remaining six student participants reported a female role model, for example:
I didn't have to imagine what like a strong woman might be or in engineering would look like because my mom was that and I could really see myself doing what she does. (P-2)

She (name omitted) was incredibly instrumental in me actually picking bioengineering. (P-3)

We had a big sister like program and my big sister she was a civil engineer and she introduced me she actually was the first person to introduce me to an engineering society and took me to the scholarship event. (P-4)

My one physics teacher that kind of put the idea in my head otherwise it was something that I really never knew any engineers growing up. She kind of just planted the seed. (P-5)

My physics professor she helped me a lot and encouraged me to go into engineering despite the fact that I wanted to be more bio-chem. (P-6)

Another big influence on me was my high school teacher, the one I was talking about she I guess just like really just showing me more than what we learn in class like what she does in her research and everything that was cool too. (P-8)

The faculty participants reported similar examples of support compared to the students as four of the five faculty participants provided examples of significant support from either their families, teachers, or role models, for example:

Parents for sure. Guidance counselor at high school physics teachers, my honors and AP physics teachers. (F-1)

Actually, my mom is a math teacher and so she is probably the one who had the most influence on me, so she was the engineering influence. My dad's always been supportive. It was always supportive. Just whatever I wanted to do. (F-2)

I had a very supportive community for me to pursue things that interest me and since it turns out that was engineering, they were supportive of those notions. (F-3)

It's mostly my family. Basically, I'm my dad. My mom also and like in parenthesis years so when I was very young like 7 years old I wanted to be a teacher because my mom is a teacher and then my dad as I got older I thought you know engineering might be a better choice and now I'm doing kind of both things so they were all supportive and my family like my uncles and my cousins they were all supportive. (F-4)
The findings for the *Pre-College Environmental Support* theme fit with the SCCT model as it posits 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). These findings are also consistent with the engineering education literature as numerous studies have shown that environmental support plays 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). Specific to women, it has been found that fathers have the greatest positive influence on engineering career choice (Godwin et al., 2014) and egalitarian families tend to provide important support that are integral in choice and success in engineering (Assessing Women in Engineering, 2015). In addition, mentors and teachers play an important role in helping develop or validate a student’s interests in engineering.

All of the student participants indicated that at least one form of positive environmental support was present during their adolescent years and played an important role in the development of their academic and career interests and goals. Of the eleven student participants, eight revealed how they received support from a combination of sources – parents and teachers or other role models or similar permutations – and how these sources were impactful in encouraging their interests and goals in engineering. These combinations of support were significant for these eight student participants as they provided stable and variable levels of support helping validate and strengthen their interests, goals, and ultimately choice to pursue engineering. The remaining three student participants reported that they received support from one source – one referenced parental support and the other two referenced teacher or role model support – towards their interests and goals in engineering. The likely reason they only experienced support from
one source can be attributed to availability of resources and/or the fact that they were extremely self-motivated and self-sufficient in terms of progressing their interests, goal-setting, and choice actions. Regardless of the source of support or encouragement these findings confirm prior research related to student choice as it has been advanced that strong environmental supports are influential factors in the development and sustenance of a student’s career interests, goals, 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

It is widely known that an engineering degree is extremely challenging and rigorous as the curriculum requires a high level of mathematical and science sophistication, the ability to solve complex engineering problems, and an advanced understanding of engineering design. To accomplish this the curriculum is designed in a sequential and cumulative fashion to foster transfer of knowledge and skills from course to course and semester to semester. In order for students to achieve this necessary transfer of knowledge and to obtain content mastery the acquisition of higher order thinking skills such as critical thinking and problem solving is paramount. If a student is unable to acquire and apply these skills in their learning it may affect their academic performance and ultimately impede their persistence.

In addition to academic challenges that students must overcome in progressing through the rigor of an engineering curriculum, students may also be faced with additional environmental barriers that may serve as obstacles in face of their persistence. This is especially true for women as they try to navigate a male-dominated program and culture. To gain a better understanding of their experiences and potential obstacles they may have encountered student and faculty participants were asked to describe their first-year experience in one word, reflect on their experiences as a woman engineering student, and detail what the most discouraging factors in their pursuit of an engineering degree were.

Each participant was asked to describe their first-year experience in one word and the student and faculty participants’ responses were categorized as informative,
reassuring, or challenging. Of the eleven student participants, five described their first-year experience using words related to informative, for example: *Enlightening* (P-1), *Exploratory* (P-2), *Enlightening* (P-3), *Eye-opening* (P-9), *Exploratory* (P-11).

Additionally, three student participants described their first-year experience using words related to reassuring, for example: *Interesting* (P-5), *Good* (P-7), and *Easy* (P-10). Lastly, the remaining three student participants described their first-year experience using words related to challenging, for example: *Change* (P-4), *Stressful* (P-6), and *Challenging* (P-8). The faculty participants’ responses were similar to the students’ as they described their first-year experience using words that correlated with reassuring and challenging, for example: *Adventurous* (F-3), *Fun* (F-4), and *Awesome* (F-5) and *Humbling* (F-1) and *Difficult* (F-2).

This helped set the stage for the participants to reflect on their experiences and detail the barriers they may encountered during their collegiate career. All of the student participants shared how they experienced some form of an environmental barrier during their matriculation in the engineering program. Of the eleven student participants, ten reflected on how noticeable it was that women were disproportionately represented in their engineering courses. Below are selected extracts highlighting how the student participants’ made sense of these experiences:

I had like primarily engineering classes and it's maybe like 10 girls in a class of 60. (P-3)

I've taken classes where I was the only female in a class. (P-4)

I just remember during my first year noticing right away that there were a lot fewer of us. The only thing that could stick out is like that really, I think would make my experience different than the male experiences. (P-5)

There were a lot of teams and a lot of the time it was majority males and just me. (P-6)
It's been like there's only been like three women out of like 20 guys. (P-7)

So, each class I went to especially in the engineering department like intro, I would count to see like how many girls were in the class and I know there is definitely one or two instances where I was the only one or like one of three. (P-10)

It is also important to mention how these experiences made the student participants feel despite entering college with a rudimentary understanding that engineering was a traditionally male-dominated field and profession, for example:

All my partners were men, I guess that is noteworthy They were a lot of guys and I did notice that I was just like where are all the girls? From what I remember which kind of made me uneasy. (P-2)

It was definitely a little intimidating in my classes there were only a handful of women compared to all the men in the class. (P-8)

I've been surrounded by like almost exclusively men in all my classes, but I forget that it's relevant to them sometimes. (P-11)

The faculty participants reported similar experiences as three of the faculty participants referenced the noticeable differences in the gender makeup in their programs:

I had come from an all-girls high school, so it was definitely a culture shock to say the least. (F-2)

So, we were like 10 female students out of hundred in mechanical engineering major. (F-4)

I came from an all-girls high school so just the fact that we were in class with boys. That was already very obvious to me. (F-5)

The realization for these participants that they were disproportionately represented within their field of study presented them with a profound environmental barrier that they needed to reconcile these feelings in order to persist in engineering. Not only were they faced with a challenging academic course load in engineering, but they also had to confront their feelings and develop a sense of belonging within program that was majority male.
In addition to the student participants’ firsthand experiences and observations of the stark differences in enrollment between men and women in their engineering courses, seven student participants recalled instances they experienced explicit or implicit biases regarding their intelligence or capabilities as an engineering student. Below are selected extracts highlighting the students’ experiences:

Freshman year was probably the most challenging just in that as a woman I didn't feel entirely respected off the bat. I felt that I had to prove that I was smart because it was assumed otherwise off the gate and I just say that I really, I haven't had the same college experience of a lot of my male peers have had. (P-1)

I feel like it's because we are told not told but like there is this expectation that we know less than men. (P-2)

It's happened in an offhanded comment or something like that from either professor or a peer where it's just been like “oh you can't possibly know this.” It's like well what do you mean? How could I possibly not know that? And it's like “well you just aren't there.” And I'm like what do you mean I'm not there? And it's like “oh well girls aren't that smart.” (P-3)

It was just like a few times where I had to go the extra mile just to show that I'm right or that I'm doing something the right way because they didn't believe me. (P-4)

One professor was like definitely things like “oh girls don't get it” but like that was a physics person so not really relevant to engineering in general. (P-7)

But then there are always a handful of male students that think that “oh a female can't do this or that.” (P-8)

Like men in the program will use that as kind of like a cop out like oh you interned at (company name omitted) but like they were trying to like to satisfy some quota right. (P-11)

Finally, another student participant commented how the perception of women in engineering contributed to the alienation of her female peers because she had the belief that only one woman could make it in the male-dominated culture within engineering, for example:

I feel like there is a weird sense of competition among women in engineering and I think I felt like there's this drive to prove ourselves. And in that I at least I
definitely thought this like my freshman year was like there could only be one. And like I really wanted to be like the one girl that made it to the top then I guess and in effect I kind of forgot about community and I think that like the needs of women I guess are like community in engineering. (P-2)

Interestingly, only one of the faculty participants described similar encounters with engineering barriers related to implicit bias:

So, like that level of implicit bias is this no longer implicit but the level of bias needs to go away. I don't know how you get rid of it because I mean it's so deeply ingrained in some people. But like when you actually hear it out loud. It sounds so insane. And there's just still so much of that. It's discouraging. Yeah, it also I think it makes women not feel comfortable in their own skin. Like, you know I've been told tons of times that I don't look like an engineer. I don't know what an engineer is supposed to look like am I supposed to be like dull like not having style like what is it supposed to be like when you don't look like an engineer. (F-5)

The other faculty participants did not present similar experiences as the students or the one faculty participant, but they were certainly aware of how women’s intelligence and capabilities were perceived in the engineering culture. The four other faculty participants mainly referenced challenges centered around academic workload, academic adversity, and faculty accessibility or helpfulness. Despite a lack of triangulation between the student and faculty data, the student participants’ experiences of explicit and/or implicit biases regarding a woman’s perceived intelligence or capabilities in engineering are significant as they bring to light socio-structural barriers and challenges that exists in engineering.

The findings for the *Engineering Barriers for Women* theme confirm what prior research has presented regarding the climate in engineering as it has been linked to women’s underrepresentation in engineering (Lichtenstein, Chen, Smith, & Maldonado, 2014). Furthermore, these unhospitable or intimidating environments may have an adverse effect and negative influence on a woman’s sense of belonging and decision to persist in engineering (Chubin et al., 2005; Seymour & Hewitt, 1997). As a result, the
findings illustrate that in addition to having to persevere through the academic rigors of an engineering degree program, women are also faced with social barriers that are proximal to career interests, goals, and choice actions. For example, SCCT posits that “nonsupportive or hostile conditions can impede the process of transforming interests into goals and goals into actions” (Lent, 2013, p. 125). Despite encountering these barriers, the student participants were able to overcome them through the development of coping strategies, which enabled them to maintain their course in achieving progress towards degree completion.

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

How do students, especially women, overcome challenging academic and environmental barriers in engineering? Research has shown that persisting students have learned to neutralize barriers by developing and utilizing barrier-coping strategies to assist them with navigating and enduring through these challenging encounters. The utilization of coping strategies allows students to weigh their interests, goals, and the benefits of taking action on achieving their goals. Furthermore, it has been shown that barrier-coping strategies play a critical role in women’s persistence, helping them strengthen and reinforce their commitment to engineering and completion of their degree (Litzler & Young, 2012).

To examine how the participants approached and responded to environmental barriers they experienced they were asked to comment on strategies they utilized to manage and overcome these conditions while pursuing an engineering degree. Of the eleven student participants, nine shared how they employed barrier-coping strategies directly in response to their disproportionate representation in engineering or perceived attitudes towards women in engineering. These strategies demonstrate how the
participants were able to remain focused and steadfast in their choice implementation process towards an engineering degree. The findings also illustrate how these nine participants made sense of these challenging experiences and the conscious and deliberate actions they took to overcome them.

One of the student participants shared how she was able to make sense of these conditions and made a concerted effort to modify her personality, for example:

In the beginning. I cried a lot I'm not going to lie. And then it was kind of like well you've got to embrace it like this isn't going to change. I feel like I've had to completely change my personality and that isn't necessarily fun. And I think I just hardened a little bit as a person. I wasn't as bubbly anymore. And yeah like I always wanted to be, this sounds bad, but I wanted to be in a position where people couldn't say I was stupid anymore. (P-1)

She also made a concentrated effort to change her physical appearance by adjusting her fashion and cosmetic choices, for example:

Like when I came here, I loved like hair and makeup and like getting dressed up and wearing dresses to class and heals and it just really really negatively impacted me and I changed that. (P-1)

While it was clear that these initial experiences were emotionally frustrating and difficult, she was able to recognize, develop, and implement effective coping strategies that enabled her to neutralize these barriers that she experienced, for example:

A bunch of us (girls) in engineering are regarded as bitchy and I 110 percent prefer that because at least like I don't know. I don't know. It's more I feel has more respect. It's not a hit against my intellect that word. It's a hit against my personality and I'd rather they feel that way than the other. (P-1)

Ultimately these actions allowed her to gain a sense of respect from her male counterparts, which gave her the confidence that she made the right choice in pursuing engineering as her major, for example:

Where I am now, I'm finally respected. Finally, it's taken three years to be here. (P-1)
Additionally, four of the nine student participants commented how they turned these negative experiences and realizations into motivating forces to fuel their perseverance and persistence in engineering, for example:

"Just honestly kept me going. It's more of a motivational factor than it is discouragement." (P-4)

"And that was just like frustrating. But then after that I kind of learned to kind of just stand up for what I believed and be a little more like firm and what I'm trying to say." (P-5)

"Even back then even though I felt kind of intimidated being in an all-male culture I started taking a more assertive role because I just wanted to get good grades, so I did feel intimidated, but I didn't let it stop me from anything." (P-6)

"So definitely intimidating but just a way to keep pushing forward I guess and be more inspired by like myself to be the only one in the classroom of like my demographic." (P-10)

Others commented how these experiences propelled them to action as a change agent and used this to attempt to transform the cultural or social dynamics within engineering, for example:

"A group of us made a group chat and we're like “We need to have like a wine night or whatever” but we like actually got together and we're able to talk about these things that we all individually experience but have never really been able to share because we had never had an outlet for it." (P-2)

"I kind of tried to bridge the gap between engineering and women. We started a girl’s squad for engineering where we do girls nights for all the girls in engineering." (P-3)

"Well I either tried to become friends with them or just like work together with them in some ways. That barrier is not there anymore, and you see that when you work with them like just students trying to get through college." (P-8)

Lastly, one of the student participants described using self-actualization coping strategies as she fully accepted who she was/is and was able to logically and rationally make sense of the situations she was experiences, for example:

"I think some people have some internalized like thoughts that women can't, can't be as good right. And as long as I haven't had those like when I don't have those
thoughts it doesn't affect me, but they try to make it affect me. But I think the point where that became relevant was like junior year. But at that point I had already interned at (company name redacted) and I was already president (student organization name redacted). So, it was like I felt I didn't feel untouchable, but I made myself feel untouchable in my head so that I was like “You know you can't get to me like you're weird. I just think for me I've never felt like I was super like super intelligent but other people equate good internships and like that to success. So, it's like if you're going to use that metric then don't come at me. (P-11)

Consistent with the student findings in the Engineering Barriers for Women theme, the faculty participants referenced utilizing coping strategies that mainly correlated with academic workload, academic adversity, and faculty accessibility and helpfulness barriers. While triangulation of data between student and faculty participant responses was only moderately applicable the students’ data provided a rich and in-depth understanding of how women respond to barriers related to gendered stereotypes and biases.

Additionally, the findings for the Women’s Engineering Barrier-Coping Strategies theme adds to the existing engineering education literature as it provides a unique perspective of how women might make sense of these intimidating conditions, and the importance of bringing into action specific strategies to help neutralize and overcome them. These findings relate to 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 implement and achieve one’s career choices in the face of challenges or barriers one’s agility and adaptability are paramount. This was supported in the findings as the majority of the student participants reflected on their experiences and described how the utilization of coping strategies were crucial in strengthening their self-efficacy and reinforcing their interests. Overcoming these challenges also provided the participants with valuable learning experiences that can be viewed as transferable to the
engineering profession as they now have the ability to anticipate and recognize possible barriers and utilize barrier coping-strategies to overcome them.

**Persistence Theme III: Engineering Environmental Support**

Research has shown how stable support systems, comprised of peers, family, faculty, and/or mentors, can have a positive influence on an engineering student’s persistence. This is especially true for women given the social dynamics within the engineering culture. Therefore, in addition to the development and utilization of effective coping strategies, the student and faculty participants reflected on the impact their engineering support systems were in helping them find comfort and succor during their undergraduate experience. To better understand what sources of support were most relevant for them as well as how these networks were established participants were asked to reflect on the following questions:

1. What factors contributed to their decision to persist in engineering?
2. If they experienced difficulty in their coursework, where did they go for help?
3. What source of support did you find most helpful?
4. Describe your interactions or support you received from faculty members?
5. What kind of support should be available to women in engineering?

All of the student participants referenced at least one example of support that they believed positively affected their self-efficacy and goal transformation process, which ultimately played an important role in their persistence. The common thread among the student participants’ experiences was how meaningful and impactful the support that they received was to them and their persistence within engineering. The following extract explicitly captures this:

I definitely think it breaks down to the people in engineering. I think it breaks down to who I've met and how they've encouraged me. And the fact that I felt like I was at home throughout my time here and I don't know if I can say the same if I was at a different college pursuing this degree. (P-3)
Faculty Support

Of the eleven student participants, ten reflected on the support they received from their professors and the significance of these interactions throughout their engineering experience. Selected extracts are presented to highlight the students’ overall experiences regarding faculty support:

I had some really good teachers. Some of the professors here are really excellent and wonderful to talk with, to kind of confide in as well as just role models. (P-1)

I know for a fact that Temple faculty have contributed a lot to me actually staying in engineering. (P-3)

And I've never felt like I couldn't go talk to a professor or a faculty member. (P-5)

I would go to the professor themselves and tell them like listen I don't understand this specific concept and then I'd like I developed a relationship with my professors in the classes I struggle the most. (P-6)

I would go to my professor’s office hours and they usually do a pretty good job of explaining exactly what you need to do. (P-7)

Just like just them being available and to ask questions like through emails, or office hours and staying after class a little bit. That's been very helpful. (P-8)

I had a bad habit of just not talking to teachers at all but once I started asking for some help on like certain questions it made it like made them more approachable. (P-10)

When I got into the power courses like I had more interest so I would go to my professor’s office hours just because I wanted to understand more thoroughly what the slides were trying to say. (P-11)

Additionally, most of the student participants provided specific examples of how individual faculty members provided them with support and how they made sense of these experiences. For example, one of the student participants described how much more helpful she found certain professors during office hours compared to in class:

Like I know for (course name redacted) I went to Dr. (male faculty name redacted) office hours like every week because I didn't understand what I was doing, and he was like way more helpful in office hours than in class. (P-7)
Another student participant commented how it was comforting for her to know that faculty support was available to her and that her professors were responsive to her:

It's kind of nice to know like if you're stuck on something like especially with senior design like it's so easy to kind of figure out who you need to talk to you and like everyone's really responsive here. (P-5)

Another student participant shared that she appreciated how some of her professors exhibited a genuine interest in getting to know more about her personally rather than just from an academic standpoint. This level of interest and care meant a lot to this student participant:

I had an independent study with Dr. (female faculty name redacted) and so she would talk to me and I feel like the first half hour of my like class would be her talking to me about my life and what's going on. And like my goals and where I see myself going, what I see myself doing that summer. So, it was really nice. (P-2)

Lastly, two student participants reflected on the kinds of career support and guidance they received from their professors and how they valued these interactions:

One professor in particular actually gave, gives a lot of very good career advice which helped me a lot considering the fact that they do exactly what I want to do. (P-4)

One of my professors had previously worked at an oil and energy company before and so I went to him and I was asking him what he thought. (P-11)

These experiences helped foster the development of more meaningful and supportive faculty-mentoring relationships between the students and faculty as the initial encounters provided them with a timely source of comfort and encouragement. These deeper relationships had a profound effect on the student participant’s self-efficacy, interests, and sense of belonging in engineering. One of the student participants provided two examples of how the support that she received from two faculty members was crucial to her persistence, for example:
Dr. (female faculty name redacted) was super helpful for me just like awesome, badass woman. She's doesn't take anything from anybody. I loved it. I was all for it. In fact, I had her class kind of when I was still like on this precipice of like “Well can I balance like you know still being kind of like myself and this” and she came in and she was just she's kind of like a harder woman and she had respect and I kind of modeled it a little bit. I respected the heck out of her. “Yeah. Wait. That's what I want. Look at all this success she's had in her life. That's what I want” and I kind of followed the lead on that. (P-1)

Dr. (male faculty name omitted) has been a dream. Dr. (male faculty name redacted) is wonderful and I was feeling down. I've been in his office crying and talking about how I just want to leave the major I hate this and just his support is wonderful. Really directly. He's I guess the point I am making is he's great. And it's been massive support for me as well as for dozens of other students that I know off my fingertips. So, it's like wonderful. (P-1)

Additionally, a number of the student participants described not only how supportive and helpful a number of their professors were for them but how they were able to continue to receive support and guidance from these individuals throughout their academic career. These relationships were also extremely meaningful for these students as they appreciated the unconditional support that they received from their faculty:

Dr. (male faculty name redacted) was very helpful not only like he made the class difficult, but I always felt like he was approachable, and I could talk to him and when I didn't understand like I outright told him to his face once like I hate this class, I can't wait to be done with it. But then he still was willing to put in the hours to help me. Yes. So, Dr. (male faculty name omitted) was very helpful and a lot of the students will say that too. He really puts in the hours to try to get you to understand the topic. (P-6)

Definitely mentorship. I joined the (female faculty name redacted) lab had a very profound effect on me. I was able to find Dr. (female faculty name redacted) and my mentor and have had lots of female mentors. I don't think I would have ever felt comfortable talking about those things to a man, I guess. And that was really important to me. (P-2)

Even when like I don't do the greatest, I don't feel like ashamed and like I'll ask Dr. (female faculty name redacted) questions about like “hey like how did I do this bad or like can I help doing this.” Like I'm gonna have her until I graduate. So, I definitely found with Dr. (female faculty name redacted) that I'm like comfortable with her and just like asking for help. (P-10)
It is evident from the myriad of examples provided by the student participants that faculty support and guidance is critical in a student’s persistence in engineering as the student participants directly attributed their persistence to the support they received from faculty. How the student participants made sense of these experiences can be summarized in the following student extract:

It feels good to have someone who's personally invested in you and it was nice having somebody to validate what I was feeling and then also be invested in me and help me with like my work. If I had an issue it was nice, comforting. (P-1)

These findings illustrate that not only did faculty provide critical academic support, but they also served as valuable sources of encouragement and reassurance, especially during times of doubt, which played an important role in the students’ decisions to persist in engineering.

*Family Support*

In addition to faculty support, the student participants reflected on how they received various forms of support from their families throughout their engineering journey and how impactful that was in their persistence. Of the eleven student participants, eight reported specific examples of family support and the common element among these experiences can be summarized as timely encouragement and reassurance, especially during challenging times. Below are selected extracts illustrating how the students’ described and made sense of the support they received from their families:

My mom and my dad as well have been really, really helpful. (P-1)

Whenever something’s going off or whatever I called my mom and I talk through it and she kind of helps me keep a level head on about things. (P-2)

My mom was the biggest she's like my biggest supporter. (P-4)

So, a big factor of mine is that with my family they've always pushed me. So it was definitely motivating like I'm finishing because I'm finishing. There's no option kind of thing. (P-5)
Talking to my family and like helping me overcome my fears of just being in college. So even when I didn't have a school support system, I had a family support system. (P-6)

My mom is pretty good at that. She is like you do this every semester. You'll be fine. Just get through it. (P-7)

Definitely like family support was a big, big thing, like when I came home tired and they were like there is only one more day just get through this one day you're fine. (P-8)

And then I just talked to my dad I'd call him, and I'd be like I got a bad grade on my exam, but I don't know how I feel about it. He'd be like it's OK. just like words of affirmation. (P-10)

While reflecting on the support they received from their families, the student participants expressed a deep appreciation for the encouragement that was provided to them during their undergraduate career. They also mentioned how the unconditional support helped mitigate stress, anxiety, and the fear of disappointing others. Below we see how this took shape for three of the student participants:

She just wants me to graduate at this point but it's like it's a relief to hear that like she won't be disappointed at me so I'm like just get through it and continue on to the next semester. You're so close to being done. (P-7)

You don't have to get an A. That's always a relief. (P-9)

My dad would tell me “just do what you have to do, don't stress too much about it I'm not going to be disappointed.” I think that's the biggest thing calling him just to make sure he's not going to be disappointed or anything. (P-10)

Another student participant shared that not only did the support and encouragement that she received from her mother aid in her persistence, but their relationship strengthened and grew stronger throughout her experience:

This whole process actually helped us get closer because now it's like to the point where I just call and talk to her about any and everything. And even though she doesn't really understand a lot of what engineering is about she's, she's just listening and just having her listen that really helps. (P-4)
The support that these eight student participants received from their families was pivotal in their engineering persistence as the accessibility to timely familial encouragement helped reinforce their self-efficacy, sense of belonging, and interests in engineering, allowing them to persist in achieving their engineering-related goals. These sources of support were also valuable in that they served as a complement to the other forms of support that the students received within the College of Engineering and provided the students with confidence in the knowing that they had a sturdy support system available to them.

Peer Support

The student participants also revealed how valuable peer support was in their persistence in engineering and they identified these experiences as involvement in student professional organizations (e.g., Society of Women Engineers, National Society of Black Engineers, etc.) and peer study groups. Furthermore, they expounded how these sources of peer support were instrumental in nurturing their sense of belonging and helping them establish a sense of community within engineering, allowing them to overcome academic challenges and socio-structural barriers. These experiences were significant for the student participants as it allowed them to come to the realization that they were not the “only ones” to feel a certain way or to struggle academically in engineering. Ultimately, this provided the student participants with an opportunity to make sense of their experiences, helping guide them in their persistence. Below we see how four of the student participants valued their involvement in student professional organizations:

And then SWE I guess is a different part of that. Like having connections in engineering kind of outside the bioengineering realm was important to me because making connections with SWE girls and talking through those things and like seeing them in thermodynamics or like general engineering classes was really cool. (P-2)
The biggest thing is definitely NSBE. I joined NSBE the end of my freshman year and it's like it's great being around people just like you, going through the same things that you are and um a lot of the upperclassmen was encouraging me to keep going and to keep trying. So that was definitely a big impact to continue engineering. (P-4)

There's even the SWE that club that it's all about everyone but having that female support group is really helpful. (P-8)

I realized like after getting involved in SWE my like late sophomore, early junior year making friends in it. If there are things that I want to complain about that you can't get like you can complain about to male friends but it kind of makes them uncomfortable. Like justifiably so. So, it's nice to have like a community to talk about those things with. (P-11)

The extracts above illustrate how the students were able to make sense of the support that was available to them through their involvement in various student professional organizations. The students’ experiences also demonstrate how student professional organizations can serve as an important sounding board and source of encouragement for women as they continue to acclimate and adjust to the engineering environment. Here, for example, one of the student participants describes a pivotal moment as she recalls her interaction with another student in her student professional organization:

Through talks and just more importantly just being there. I think my sophomore year the academic excellence chairperson my sophomore year he would ask me to come to study night every single night. And even if I didn't need help right then and there, he would sit with me and be like “well okay I am here if you need me like don't be afraid to ask” like just them actually like being there in the same room just like it definitely helped me a lot at that time. (P-4)

The majority of the student participants reflected on the meaningful peer networks and study groups that they had access to throughout their undergraduate engineering career and described how these peer groups were established. For example, one student participant reflected on how she was struggling in a particular junior-level course within her major and recognized that her peers were also experiencing the same struggles:
I formed a couple of different study groups with my friends because these courses were something everybody struggled with junior year. So, yeah, I would go to office hours and then study with friends. (P-2)

Other student participants shared their strategy for seeking help from their peers as they tried to identify classmates in their courses that were comfortable with the material or knew it better than they did:

Most of the time I sought I guess help in my peers because there would be people who knew the material better, there would be people who took the precursor class, people who had already known the material before they walked into the class. So, I would kind of seek out the people who knew the material better and have them teach me. (P-3)

I couldn't have done it without my friends. They were all struggling, and we got through the classes just because one person would know one thing and another person would know another and we'd have to put it together. (P-6)

So, then I would just like ask somebody else in the class that probably seems to know what's going on. (P-9)

And then I would talk to some other people in my class that I knew were at a level like above me and ask, “How they were doing” and be like well “How are you studying for this? How did you get that answer or something? (P-10)

Additionally, four student participants described the benefits from their peer study groups as their peers helped motivate them, held them accountable, and provided them with a sense of community:

Having a good group of people to actually study with is to me the most helpful. I think because like I'm very much the kind of person that needs to work out a whole problem in order to figure it out. (P-5)

Definitely friends here like being able to work with them and like we're all together. And that really helped push me to have friends that I can talk to. (P-8)

And just like your peers, like last semester was like pivotal for me and like actually talking to my peers and like getting like group messages together and like talking about work and like I mean you have to find people who are motivated and are going to try to help you. (P-7)

Yeah support from other classmates I think especially other engineering students because it's like a common burden it feels like. (P-11)
Others described how at first, because of their personalities, it was difficult for them to seek help from their peers, but over time they recognized the value in peer support and were able to step outside of their comfort zone:

I think you just have to like talk to your peers more than you necessarily maybe want to. I know like I just wanna go home and don't want to talk to anyone but if you do put the effort out there to create like study groups it's like really, really helpful. (P-7)

I realized I just can't be by myself all the time I just need to like bite the bullet go ask people because if not I would struggle too much. (P-9)

Lastly, below are selected extracts that capture the essence of how the student participants viewed the impact of peer support on their persistence in engineering:

Honestly my peers I can't say anything other than the best things about my engineering family. It is a little family it's like 50 people and the smaller family is like max 20. So, it's been a wild ride, but they've gotten me through it. (P-3)

I think the peer support was the best thing for engineering specifically for college. It was my friends that really helped me because I created a friend group. I created a friend group of people who supported me and like even when I felt like I didn't understand the material I shouldn't be in this class. I had the friend group to rely on and so it helped me to see past the thought of “I'm having difficulty with this class.” (P-6)

As illustrated above, the various forms of engineering support available to the student participants proved to be a significant and influential factor in their persistence. Correspondingly, the faculty participants reported similar support experiences throughout their undergraduate careers. Of the five faculty participants, three of them reflected on faculty support that they received throughout their undergraduate engineering careers:

Well there's one female faculty member that became pretty critical to my forward path. (F-1)

And I remember being in his office hours a lot but being very helpful and actually just very supportive. And I guess you know helped me get through those classes. (F-2)

With the faculty members I felt like as long as I went to them. I always felt decently supported. So, the ones that I sought out information from. In terms of
In addition to the above extracts, one faculty member added how her affiliation with a research group provided her with greater access to faculty support:

You know being in a research group as well I think made it easier to access professors like the ones that I worked with and so you then get more out of them. Because they felt I think more, I don't know they were more inclined to help because you worked with them. So, I think that they just were okay with putting more effort into helping me. (F-5)

This was also an incredibly valuable experience as her involvement with the research group provided her with a strong sense of community:

And then you know just like the thought that they treat you as like just one of the group members which is kind of nice on top of it. That like being invited with the lab group to one of the professor's homes for a barbecue over the summer and it was really nice to just feel like I was part of the group. (F-5)

This renewed sense of community served as a foundation for cultivating her sense of belonging and self-efficacy within engineering, giving her the confidence to seek help from other faculty members within her department. Below, we see how she defined her experience in the research group and this impacted her overall experience within her department:

So, they were more inclusive which made it easier to then access them as well. And that just, I think that whole cycle helped build on itself to get more help, so I felt well supported within the bioengineering department with the other faculty. (F-5)

The faculty participants’ findings were consistent with the student participants’ experiences and illustrate how valuable support from professors and engineering faculty was for these women during their undergraduate careers. Additionally, of the five faculty participants, four of them reflected on the peer support that was available to them and how it contributed to their overall experience in their undergraduate major:
So, we had a couple of informal kinds of study groups in every class I took. There was usually two, three, or four people that we'd meet to do homework and it was like “no we're gonna, we're gonna struggle through this together and help each other out.” (F-1)

But it was really a peer network that helped. Almost always my peers. Yeah, I mean we, we just worked out problems together all the time. That was how we got through those classes. (F-2)

Support from the friends of the college that we had and yeah, we were always encouraging like each other to do this, take that course. Learn this. Be better at that. Like things like that. Or like helping each other with the software. So yeah peer kind of support. (F-4)

They had students who did really well, other undergrads who did really well that were years ahead in those classes and they would run like just smaller workshops. Like you go through problem sets together and they would really take the time to go through every detail. So, I think the balance of this, peer learning and academic workshops, there was just more time to learn things and to struggle through it. And that was like the whole point you could struggle through it together and help each other out. And so, I think it was a really great way for me to learn. (F-5)

The extracts above illustrate how the faculty participants were able to obtain help in their courses through peer support and peer study groups, but also allowed them to find comfort in knowing that alongside their peers they were all struggling together. This provided them with a renewed sense of belonging within their engineering programs, which helped strengthen their self-efficacy and contributed to their decisions to persist.

The faculty participants also reflected on the support that they received from their families:

I guess when I look back because I lived at home because I commuted. My family was always supportive. (F-2)

I think in the very beginning like the very first year for the engineering graphics specifically and then the Statics I went to my dad and he saw Oh okay so he started like solving the problem or showing me how to do that. So that was very helpful. (F-4)

The findings among the student and faculty participants were consistent as both groups reflected on 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. This is consistent with the existing engineering literature as numerous studies have shown how influential faculty, peer, and family support can be on a student’s decision to persist (Chubin et al., 2005; Eris et al., 2010; NAE, 2018; Seymour & Hewitt, 1997; Tate & Linn, 2005).

Moreover, the findings from the Engineering Environmental Support theme help extend the existing literature as the qualitative analysis and results present a unique perspective of how women identify, obtain, and make sense of the various sources of support available to them within engineering. The findings also correspond with the SCCT theoretical framework as the SCCT model 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). In conclusion, the Engineering Environmental Support findings demonstrate how the student and faculty participants were able to locate and obtain the necessary support within engineering to help shape and guide their choice goals and actions, ultimately contributing to their persistence in engineering.
Despite concerted efforts from 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 these trends, especially given women’s proportion in the overall U.S. population and college enrollment, the need for further investigation of the issue has been 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).

The aim of this phenomenological study was to explore the lived experiences of eleven female undergraduate engineering students to gain a better understanding of factors that help shape and influence their choice and persistence in engineering. Lent, Brown, and Hackett’s (1994) social cognitive career theory provided a guiding framework to illustrate how the participants’ educational choice behaviors were influenced by a number of “variables such as personal attributes, learning and socialization experiences, and the resources, opportunities, and barriers in their environments” (Lent, 2013, p.115). 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.

This chapter will summarize the research findings presented in Chapter Four and provide a discussion of the guiding research questions for the study. It will also discuss limitations of the current study, implications for practice at the K-12 and higher education levels, and recommendations for future research. Lastly, this chapter will present recommendations for exposing young girls and women to engineering and advice for future women interested in studying engineering from the point of view of the participants from the study.

Summary of Findings: Women’s Choice of Engineering

The study was divided into two parts with the first half dedicated to the exploration of the participant’s lived experiences prior to college to identify factors that were influential in their decision to pursue engineering as a major. 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 analysis revealed five emergent themes that were recurrent in more than half of the student participants’ and were defined 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.
Summary of 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).

Summary of 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 paths 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.

Summary of 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.

Summary of 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.

*Summary of 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.

Summary of Findings: Women’s Persistence in Engineering

The second half of the study was dedicated to the exploration of the participants’ lived experiences during their matriculation to college to identify factors that were influential in their persistence in engineering. The findings from this 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 illustrated how these dynamic variables coalesced to influence the participants’ goal transformation process and their decision to persist in engineering. The analysis revealed three emergent themes that were recurrent in more than half of the student participants’ and were categorized as (I) Engineering Barriers for Women, (II) Women’s Engineering Barrier-Coping Strategies, and (III) Engineering Environmental Support.

Summary of 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 women 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.

**Summary of Persistence Theme II: Women’s Engr. 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 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.

*Summary of 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 of Findings

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). The study was guided by the following primary and secondary questions:

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 undergraduate engineering program?

The primary research question was broadly constructed to guide an in-depth exploration of women’s lived experiences and sought to understand how choice and persistence might unfold for women in engineering. The findings demonstrated that academic and career choice decisions do not occur in a vacuum, rather they materialize over time through the intricate interactions of numerous variables. This was evident in the participants’ lived experiences as they described multiple variables and factors that proved to be influential in their decision to pursue engineering as well as their persistence in engineering.

To address the first part of the primary research question – how choice of engineering might take shape for women – the findings revealed several recurrent choice themes. These themes encompassed a variety of key variables that were present across the student participants’ experiences and demonstrated the interplay of these variables and their positive effect on women’s interest in engineering. The findings were consistent with the engineering education literature and were closely aligned with the SCCT theoretical framework. For example, nearly all of the student participants revealed the presence of positive learning experiences that exposed them to STEM or engineering disciplines coupled with strong self-efficacy in performance domains linked to engineering. The interplay of these two variables were pivotal in the development of their outcome expectations towards engineering. Put differently, prior performance accomplishments aided in the development of beliefs such as “can I do this” or “I am good at math/science” and learning experiences in STEM or engineering aided in the
development of outcome expectations related to a particular course of action such as “engineering would offer a variety of opportunities for me.” The presence of these three variables and their positive interactions in nearly all of the student participants was influential in shaping and strengthening their initial interests in engineering. This allowed nearly all of the student participants to align their agency beliefs as engineering was viewed as a means to helping others and making a positive impact on society. Lastly, the presence of a supportive environment provided the student participants with validation and encouragement for choosing engineering as their major in college.

To address the second component of the primary research question – how persistence in engineering might take shape for women in engineering – the findings revealed three recurrent persistence themes. Encompassed in the themes were a number of variables that were present across the student participants’ experiences and further demonstrated the significant interactions that occurred among these variables. These findings were consistent with the existing engineering literature and were closely aligned with the SCCT theoretical framework. For example, nearly all of the student participants revealed the presence of barriers within engineering and how they developed coping strategies to overcome these barriers. Lastly, the student participants’ ability to locate support within engineering provided them with the necessary encouragement and was influential in their persistence in engineering.

The secondary research questions were constructed as theory-driven questions related to the SCCT theoretical framework and served as a lever to engage with the SCCT model. To address the first secondary question, the findings revealed that all the student participants were exposed to STEM or engineering learning experiences prior to college. This proved to be extremely valuable and influential for each of the student
participants as it provided them with positive performance accomplishments and served as the bedrock for strengthening their self-efficacy beliefs in engineering and molding their interests in engineering. These findings were consistent with the existing literature as well as the SCCT framework as positive learning experiences have been shown to have the greatest influence on self-efficacy and the development of one’s academic and career interests.

To address the second secondary question, the findings revealed how student participants utilized engineering barrier-coping strategies and how these were instrumental in overcoming engineering related barriers that they encountered. Additionally, all of the student participants reflected on three primary sources of engineering support that they received and how it bolstered their sense of belonging and provided them with a stable sense of community. The combination of these two variables, which are choice actions and proximal environmental influences in SCCT, proved to be valuable in the student participants’ ability to overcoming social and cultural barriers and helped guide their persistence in engineering.

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.

Implications for Practice

The findings from this study provide an in-depth understanding of choice and persistence among women in engineering at the current institution. These insights can be used to help guide and design future initiatives and interventions in K-12 and higher education settings aimed at increasing women’s interest, choice, and persistence in engineering. When developing initiatives to increase young girls’ interest in engineering, educators and practitioners at the K-12 level might take into consideration variables from this study in cultivating women’s interest in engineering. For example, initiatives at the elementary or middle school level might consider providing young girls with increased opportunities to engage in STEM or engineering learning experiences in-school, promoting participation in STEM or engineering-based extracurricular activities, and offering examples of women role models in the engineering profession whom young students can emulate or aspire to be like. These activities, as illustrated in the findings
and in the SCCT model, can help strengthen young girls’ self-efficacy beliefs and outcome expectations in engineering, which could lead to a greater interest in engineering. Furthermore, providing young girls with encouragement to complete coursework that is predictive of success in engineering could help strengthen their self-efficacy beliefs in domains related to engineering, helping shape their academic and career interests towards engineering. Additionally, to offset barriers due to the lack of knowledge regarding engineering, K-12 initiatives should also consider highlighting the social value of engineering to help encourage young girls to view the profession as a career that fits their sense of self and agency beliefs.

The results from the study can also be used to inform initiatives and interventions in higher education that are designed to increase women’s choice and persistence in engineering. Engineering programs might use the findings from the study to increase awareness among engineering faculty and administrators of the challenges and barriers that women may face in engineering in an effort to create a more welcoming and supportive environment for women. For example, oftentimes faculty will cluster female students together when assigning groupwork in their courses which may have an unintended consequence of isolating female students from their male peers and creating a chilly climate for these students. Therefore, providing engineering faculty with additional education and training regarding implicit and unconscious biases can help create a more inclusive environment for women and promote a greater sense of respect and community among all engineering students.

Engineering administrators might reflect on the findings in this study to encourage early participation in experiential learning experiences and student professional organizations for women as these experiences proved to be extremely
valuable for the student participants and played a vital role in their persistence. Engineering administrators might also consider embedding peer networking and study group building opportunities during the first few semesters of an engineering program in an effort to promote community building and sense of belonging as the findings illustrated the positive effect peer support had on the student participants’ persistence. Lastly, engineering administrators and faculty could use the results from this study to educate students of the importance of building relationships with their faculty earlier as regular interactions with faculty proved to be valuable in the student participants’ persistence and overall experience in engineering.

Recommendations for Exposing Young Girls to STEM or Engineering

In addition to the implications of the study for professional practice as discussed in the previous section, the student and faculty participants were asked to share their recommendations for how to expose young girls to STEM or engineering. The common themes among the participants’ recommendations were to start as early as possible such as in elementary or middle school, consider attending STEM or engineering programs, interact with people in the profession that you aspire to be like, and provide young girls with images that represent women in the engineering profession. The participants all agreed that exposing young girls to STEM or engineering activities during their early childhood and early adolescent years would be beneficial as these are periods when young girls are exposed to gender socialization. The participants expounded on the importance of connecting with individuals in the engineering profession and how increased imagery of women engineers in the media and social media could serve as a positive influence on young girls’ career interests and aspirations.
Advice for Future Women Studying Engineering

Furthermore, the student and faculty participants were asked to provide advice for future women interested in pursuing engineering as a major. The common themes in their advice were to always believe in yourself, develop a peer network early in your career, stay motivated, don’t be intimidated, and don’t be afraid to put yourself out there.

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.
REFERENCES CITED


Agricultural and Mechanical Colleges, 7 U.S.C. § 304 (1862).


APPENDIX A

IRB APPROVAL LETTER *(Dissertation title amended after approval granted)*

Temple University
Office of the Vice President for Research

Research Integrity & Compliance
Student Faculty Center
3340 N. Broad Street, Suite 304
Philadelphia PA 19140

Institutional Review Board
Phone: (215) 707-3300
Fax: (215) 707-9100
e-mail: irb@temple.edu

Certification of Approval for a Project Involving Human Subjects

Date: 26-Nov-2018

Protocol Number: 2548$  
PI: DUCETTE, JOSEPH  
Review Type: EXEMPT  
Approved On: 26-Nov-2018  
Approved From:  
Approved To: 
   Committee: A1  
School/College: EDUCATION (1900)  
Department: PSYCHOLOGICAL STUDIES IN ED (19040)  
Sponsor: NO EXTERNAL SPONSOR  
Project Title: A Phenomenological Exploration: Choice and Persistence Among Undergraduate Women in Engineering

The IRB approved the protocol 2548$.

If the study was approved under expedited or full board review, the approval period can be found above. Otherwise, the study was deemed exempt and does not have an IRB approval period.

If applicable to your study, you can access your IRB-approved, stamped consent document or consent script through ERA. Open the Attachments tab and open the stamped documents by clicking the Latest link next to each document. The stamped documents are labeled as such. Copies of the IRB approved stamped consent document or consent script must be used in obtaining consent.

Before an approval period ends, you must submit the Continuing Review form via the ERA module. Please note that though an item is submitted in ERA, it is not received in the REO office until the principal investigator approves it. Consequently, please submit the Continuing Review form via the ERA module at least 60 days, and preferably 90 days, before the study's expiration date.

Note that all applicable Institutional approvals must also be secured before study implementation. These approvals include, but are not limited to, Medical Radiation Committee ("MRC"); Radiation Safety Committee ("RSC"); Institutional Biosafety Committee ("IBC"); and Temple University Survey Coordinating Committee ("TUSCC"). Please visit these Committees' websites for further information.

Finally, in conducting this research, you are obligated to submit the following:

- Amendment requests - all changes to the study must be approved by the IRB prior to the implementation of the changes unless necessary to eliminate apparent immediate hazards to subjects.
November 1, 2018

I am writing to verify that Shawn Fagan, the Assistant Dean for Undergraduate Studies in the College of Engineering, has requested permission and has been granted my approval to conduct his doctoral study at the Temple University College of Education titled "A Phenomenological Exploration: Choice and Persistence Among Undergraduate Women in Engineering" in the College of Engineering.

Sincerely,

[Signature]

Keya Sadeghipour, Ph.D.
Dean
GENERAL CONSENT FORM

Title of research: A Phenomenological Exploration: Choice and Persistence among Undergraduate Women in Engineering

Principal Investigator: Joseph Ducette, PhD, Department of Psychological Studies in Education, College of Education (215-204-4998, joseph.ducette@temple.edu)

Student Investigator: Shawn Fagan, EdD candidate, Department of Policy, Organizational, & Leadership Studies, College of Education (215-204-8825, shawn.fagan@temple.edu)

You are being invited to participate in this study that aims to explore factors that contribute to women’s choice and persistence in undergraduate engineering programs at Temple University. As a doctoral candidate in the Higher Education program at Temple University as well as the Assistant Dean of Undergraduate Studies in the College of Engineering the study will be used in my dissertation and to inform future recruitment activities and retention practices for women undergraduate students in the College of Engineering. You and approximately 9 other students will be invited to participate. If you agree to participate, I will conduct two individual interviews that will be audiotaped, will take place on campus, and will last approximately one hour each. You may be contacted after the interview to provide additional information. You will be provided with an additional consent form regarding the parameters of the audiotape practices for this study.

I do not anticipate any risks to you for participating in this study other than those encountered in day-to-day life. If you choose to participate in the study, you will receive a $20 gift card in compensation for your time. You will receive the gift card at completion of the interview or if you should decide to withdraw from the study.

Although the study team has placed safeguards to maintain the confidentiality of your personal information, there is always a potential risk of an unpermitted disclosure. To that degree, all documents and information pertaining to this research study will be kept confidential, unless required by applicable federal, state, and local laws and regulations to be disclosed. The records and data generated by the study may be reviewed by Temple University and its agents, the study sponsor or the sponsor’s agents (if applicable), and/or governmental agencies to assure proper conduct of the study and compliance with regulations. The results of this study may be published. If any data is published, you will not be identified by name.

Taking part in this study is completely voluntary. You may skip any questions that you do not want to answer. If you decide not to take part or to skip some of the questions, this will not affect your current or future relationship with Temple University or your academic standing or academic outcomes in the College of Engineering. If you decide to take part, you are free to withdraw at any time. You are encouraged to ask questions at any point before, during, or after the study.

This research has been reviewed and approved by an Institutional Review Board. You may talk to them at (215) 707-3390 or e-mail them at: irb@temple.edu for any of the following:
• Your questions, concerns, or complaints are not being answered by the research team.
• You cannot reach the research team.
• You want to talk to someone besides the research team.
• You have questions about your rights as a research subject.
• You want to get information or provide input about this research.

You will be given a copy of this form to keep for your records.

Your signature documents your permission to take part in this research.

Signature of subject __________________________ Date ____________

Printed name of subject __________________________

Signature of person obtaining consent __________________________

Printed name of person obtaining consent __________________________

This consent form will be kept by the researcher for at least five years beyond the end of the study.
APPENDIX D

PERMISSION TO AUDIOTAPE

PERMISSION TO AUDIOTAPE

Title of research: A Phenomenological Exploration: Choice and Persistence among Undergraduate Women in Engineering

Principal Investigator: Joseph Ducette, PhD, Department of Psychological Studies in Education, College of Education (215-204-4998, joseph.ducette@temple.edu)

Student Investigator: Shawn Fagan, EdD candidate, Department of Policy, Organizational, & Leadership Studies, College of Education (215-204-8823, shawn.fagan@temple.edu)

I give Shawn Fagan permission to audiotape me for research purposes. This audiotape will be used as part of his research project at Temple University. I have already given written consent for my participation in this research project. I understand that the results of this study may be published and that in the event the study is published, I will not be identified by name. I agree to be audiotaped in a neutral location on Temple’s campus at a date and time mutually agreed upon by the researcher. I give permission for these tapes to be used from the date of the interview to three years after completion of the study.

I understand that I can withdraw my permission at any time. Upon my request, the audiotape(s) will no longer be used. This will not affect my care or relationship with the researcher in any way or within the College of Engineering. I understand that I will receive a $20 gift card in compensation for my time. I will receive the gift card at completion of the interview or if I should decide to withdraw from the study. If I want further information about the audiotape(s), or if I have questions or concerns at any time, I can contact the Principal Investigator and/or the Student Researcher at the locations listed above.

Your signature documents your permission to take part in this research and to be audiotaped during the interview.

Signature of subject ___________________________ Date ____________

Printed name of subject ___________________________

Signature of person obtaining consent ___________________________

Printed name of person obtaining consent ___________________________

This consent form will be kept by the researcher for at least five years beyond the end of the study.
APPENDIX E

INTERVIEW PROTOCOL – CHOICE OF ENGINEERING

Interview Protocol: A Phenomenological Examination of Women’s Lived Experiences and Factors That Influence Their Choice and Persistence in Engineering (Approx. – 1 hour)

Today’s Date:
Time:
This is the first interview for this study

The aim of this research project is to investigate choice and persistence among undergraduate women in engineering. Specifically, I am interested in learning about the experiences that have been influential in your interest in engineering and decision to pursue engineering as a major and the factors that have contributed to your persistence within engineering. I appreciate your willingness to participate today and ask that you review the following informed consent form, which contains all of the confidentiality measures that will be used to ensure your privacy is protected. Your answers will be kept confidential and will not be used to identify you. As we go through the interview, if you have any questions about why I’m asking something, please feel free to ask. If there is a question you do not feel comfortable with, please let me know.

**Demographic:**
Please provide the following demographic information:

1. What is your Age?
2. What is your expected graduation date?
3. What is your major?
4. What is your Race/Ethnicity?
5. What is your mother’s highest level of education?
6. What is your father’s highest level of education?
7. Are any of your family members engineers?

**Prior to Entry to Engineering Programs**
1. Can you talk about your Math and Science experience prior to college?
2. Can you talk about when or how you first were exposed to engineering?
3. Did you participate in any project-based or problem-solving activities related to engineering prior to college?
4. Do you recall when you first knew you were going to declare engineering as your major?
   a. How did you arrive at this decision?
   b. What motivated you to pursue engineering as a major?
5. Can you talk about all of the people that have inspired or encouraged you to pursue engineering prior to enrolling in college?
6. What did an engineer mean to you back in high school?

**Summary:**
The purpose of this study is to identify factors that influence women’s choice and persistence in engineering, describe the essence of the phenomenon from the point of view of the participants, interpret women’s experiences, and to inform future practice for increasing women’s persistence in engineering. I want to make sure that I gave you an opportunity to talk about everything that was and is important to you. Is there anything that I should have asked that you would like to tell me about now?

Please feel free to contact me if you have anything else you would like to add later on:
Shawn P. Fagan, (215) 204-8823 or shawn.fagan@temple.edu.
APPENDIX F

INTERVIEW PROTOCOL – PERSISTENCE IN ENGINEERING

Interview Protocol: A Phenomenological Examination of Women’s Lived Experience and Factors that Influenced Their Choice and Persistence in Engineering (Approx. – 1 hour)

Today’s Date:
Time:
This is the second interview for this study

The aim of this research project is to investigate choice and persistence among undergraduate women in engineering. Specifically, I am interested in learning about what experiences have influenced your decision to pursue engineering and what factors contributed to your persistence within engineering. I appreciate your willingness to participate today, and ask that you review the following informed consent form, which contains all of the confidentiality measures needed to ensure your privacy is protected. Your answers will be kept confidential and will not be used to identify you. As we go through the interview, if you have any questions about why I’m asking something, please feel free to ask. If there is a question you do not feel comfortable with, please let me know.

During Engineering Programs Matriculation
1. Please describe your experience as a woman engineering student in your freshman year.
   a. If you were to describe your freshman experience in one word, which one would you pick?
2. During your first year, how well did you expect to do in your engineering related courses (e.g. math, science, and engineering courses)?
3. How much confidence did you have in your ability to excel in your engineering major?
4. Was the amount of effort it took you to do well in math, science, and engineering courses worthwhile to you?
5. How important was it to you to get good grades in engineering related courses?
6. How much do you like engineering?
7. What factors contributed to your decision to persist in engineering?
8. What have been the most discouraging factors in pursuing an engineering degree?
   a. How did you overcome these factors?
9. If you experienced difficulty in your engineering coursework, where did you go for help and what kinds of assistance did you get?
10. In your opinion, what types of support did you find most helpful?
    a. In your opinion, do women students have different needs than men in Engineering Programs?
    b. What kinds of support should be available to help women in engineering?
11. What types of interactions or support have you had from faculty members?
    a. Did you find faculty helpful?
12. What recommendations do you have for exposing young girls and women to engineering?
13. What advice do you have for future women interested in studying engineering?

Summary:
The purpose of this study is to identify factors that influence women’s choice and persistence in engineering, describe the essence of the phenomenon from the point of view of the participants, interpret women’s experiences, and to inform future practice for increasing women’s persistence in engineering. I want to make sure that I give you an opportunity to talk about everything that was and is important to you. Is there anything that I should have asked that you would like to tell me about now?

Please feel free to contact me if you have anything else you would like to add later on:
Shawn P. Fagan, (215) 204-8825 or shawn.fagan@temple.edu.