Examining the Personal Nature of the

K-14 Engineering Pipeline for Young Women

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DEDICATIONS

I would like to dedicate this dissertation to my family, most especially my two children, *Sage Elizabeth* and *Hunter Michael.* Never underestimate the power you have when you believe in yourself and remain focused on a goal. Thank you for your patience with my travels overnight for executive weekends and for understanding that I would rather have been at swim meets and hanging out with you, spending lazy weekends watching Netflix movies and playing outdoors.

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ABSTRACT

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This mixed-methods study examined young women's perceptions of their K-14 STEM pipeline experiences and their resulting choice to enter and persist in an engineering major. Despite the increase of women in the STEM workforce, women remain underrepresented among engineering majors (Beasley & Fischer, 2012; Heilbronner, 2012; Neihart & Teo, 2013). Few studies exist that utilize a retrospective approach to understand how the culmination of young women's K-14 experiences have influenced their formation of individually held perceptions that lead to engineering persistence. It is this study's aim to utilize a mixed-methods approach to answer the following research question: How do young women's perceptions of their K-14 STEM experiences influence their decision to enroll and persist in an engineering major? These perceptions are explored through an ethnographic approach focusing on young women enrolled in engineering programs during their junior and senior years of study at a small private liberal arts university with eight engineering majors. The mixed-methods approach follows a sequential design method (Creswell, 2013) and utilizes questions in a quantitative Likert-type survey from the Academic Pathways for People Learning Engineering (APPLES) survey (Eris, Chachra, Chen, Sheppard, & Ludlow, 2010) and the Motivated Strategy Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia, & McKeachie, 1991). The quantitative study results will lead to the development of open-ended, structured questions for conducting a qualitative focus group. Anonymity of all participants is maintained.

Keywords: STEM, young women, perceptions, pipeline, intervention, underrepresentation, engineering, persistence, retrospective, self-efficacy

CHAPTER 1: INTRODUCTION TO THE PROBLEM

Overview

In 2005, a congressional report provided an overview of the growing concern over the United States' diminished global standing in mathematics, science, and innovation (National Academies of Science, Engineering, & Medicine [NASEM], 2005). This report prompted a nationwide effort for federal, state, and local agencies to implement the committee's recommendations for improving science literacy across K-16 educational settings. In response to the report, the National Science Foundation (NSF) began developing Next Generation Science Standards and cultivating a nationwide effort for 21st-century science literacy. By 2010, the American Association of University Women (AAUW) had released a report outlining gender inequalities in engineering-degree completion and underrepresentation in science, technology, engineering, and mathematics (STEM) careers (Corbett, Hill, & St. Rose, 2010). This report gave rise to focused efforts to develop science literacy in public schools for all students and to provide funding for equal access to STEM opportunities in public schools.

Some frightening statistics were revealed in the congressional report *Rising above the Gathering Storm Revisited* (2010). In an examination of 65 countries/regions, United States students ranked 15 in science literacy among top students, with 15-year-olds' science-proficiency ranking as low as 23. Even more disappointing is the quality of mathematics literacy in the United States. Ranked at a mere 28 for mathematics literacy among top students, our nation continues to fall behind. Additionally, 15-year-olds' mathematics proficiency was estimated to be about 50%, with the United States ranking

31 out of 65. These data translate to the United States ranking a meager 27 in the proportion of college students receiving science and engineering degrees (*Rising above…Revisited*, 2010).

Furthermore, K-14 educational programs that support the STEM pipeline are small in scale (Ralston, Hieb, & Rivoli, 2013), and 78% of high-school graduates do not meet college readiness requirements in entry-level mathematics and science courses (*Rising above…Revisited*, 2010). These statistics led the congressional committee to make four recommendations, including to increase federally funded research in mathematics, science, and engineering and to encourage United States citizens to work in these fields. As we turn to public schools to provide high-school graduates prepared to enter these careers and task our universities with preparing tomorrow's innovative workforce, it is critical to examine our students' perceptions of their own skill development, feelings of self-efficacy, and formation of a STEM identity throughout the STEM pipeline.

Underrepresentation of Women in Engineering

As an underrepresented group in the STEM fields, young women's standards for mathematics achievement are lower than young males, resulting in lower self-efficacy and feelings of self-doubt that negatively contribute to a woman's decision to enter the engineering field (Heilbronner, 2012). According to Bandura (1997), self-efficacy refers to an individual's belief in his or her capacity to perform at a desired level and the effect of his or her own control and confidence to achieve that level. This belief about one's own capabilities can strongly influence academic persistence. Data from a longitudinal study evaluating female engineering students' perceptions of a lack of inclusion in their college engineering environment was assessed using the Longitudinal Assessment of Engineering Self-Efficacy (LAESE) survey, which has a Cronbach's alpha reliability coefficient ranging from 0.72 to 0.87. The study demonstrated that overall, female engineering students maintain a perception of a lack of inclusion in their college engineering environment (Corbett et al., 2010)

The AAUW report *Why So Few?* (2010) indicates that despite recent gains by young women in STEM areas such as biology and the biomedical fields, underrepresentation in technology and engineering fields continues. Influential factors for this trend include gender bias, low self-perception of mathematical ability, and the presence of a stereotype threat, which occurs when individuals feel at risk for performing based on the expectations of their social group. Lower retention rates of first-year college engineering majors (Corbett et al., 2010; Steele, 1997; Steele & Aaronson, 1995; Steele, James, & Barnett, 2007) reinforce the present need for further research examining young women's perceptions as they navigate the STEM pipeline experiences constructed in American schools to advance engineering and innovation for underrepresented groups. The American Society for Engineering Education (ASEE) annual survey observed a growth rate of 6% in the receipt of bachelor's degrees in engineering across all genders in 2014. Most awarded degrees were given for mechanical and civil engineering, and the least were given in engineering science, engineering physics, mining, and engineering management (Yoder, 2015).

For women, however, these numbers are vastly different from the general population. First, women comprised only 20% of degrees awarded in 2014, up from 18% in 2013. A closer examination of the data reveals a significant difference in specific bachelor's degrees awarded to women, with the highest percentage being awarded in environmental, biomedical, biological, and agricultural engineering disciplines and the lowest in computer, mining, and mechanical engineering disciplines. An even starker difference is apparent when the data is broken down by minority representation of women in engineering degrees. In 2014, engineering degrees awarded to women by ethnicity were highest for White and Asian American females and lowest for Hawaiian/Pacific Islander, American Indian, and Black or African American women. Based on the data compiled in the survey, women are underrepresented as both an ethnographic group and a gender. This shortage is cause for alarm and is motivation for continued research on women's experiences, self-efficacy, and individual perceptions leading to persistence in engineering fields.

Problem Statement

Women ages 21-40 continue to advance in STEM careers such as biology, but they remain an underrepresented group at all degree levels and among engineering majors (NSF, 2015). Cited in this reluctance to enter engineering careers is low self-efficacy, which is shaped by one's environment and beliefs about one's own abilities (Corbett, Hill, & St. Rose, 2010; Heilbronner, 2012). The stereotype of a white male as the typical STEM professional (Hughes, Nzekwe, & Molyneaux, 2013) is common, and the presence of a stereotype threat for women (Spencer, Steele, & Quinn, 1999) exists in math and science performance. The development of a positive STEM identity, presence of mentors as role models, feelings of self-efficacy, and increasing confidence in math and science skills are critical to helping young women advance in STEM careers (Hughes et al., 2013; Robnett & Leaper, 2013).

STEM outreach can be small-scale and involve both formal and informal experiences. Examples of formal high-school experiences include engineering partnership programs, Advanced Placement (AP) courses, and pre-engineering classes or cooperative experiences (Ralston et al., 2013). Each of these experiences can contribute to STEM identity-formation, which involves a student associating personal meaning with specific activities and identifying oneself as fitting in with STEM fields and working in a STEM career (Carlone & Johnson, 2007). Experiences occurring outside of school include mentors, innovation opportunities, engineering camp experiences, and outreach programs with university partners (Ralston et al., 2013).

For the purposes of this study, the term *vertical alignment* represents the successive K-14 education experience. Inclusion of STEM interventions is supported by government funding but is up to each school district and does not exist currently in schools as a vertically aligned approach in the K-14 educational setting to support engineering-degree pursuit. Instead, individual schools are presented with options to engage in programs such as Education to Innovate and the Invest in Innovation (I3) grant funding (*Women & Girls in STEM*, 2013). This researcher seeks to look beyond the mere inclusion of STEM and engineering interventions as precursors to engineering-degree pursuit and examine students' perceptions of pre-engineering experiences throughout their K-14 academic career. Specifically, the researcher is most interested in examining female students' decision to enter and remain in engineering majors. Students' perceived experiences provide information to the educational community so that it may purposefully construct a K-14 pipeline that encourages women to excel in the engineering fields through educational experiences and STEM identity development. A better understanding of individuals' perceptions and experiences will contribute to the development of opportunities for young women to more effectively navigate the STEM and pre-engineering pipeline and transition from K-14 coursework to post-secondary engineering degrees. It is hoped that this research will ultimately further the nation's objective to grow in technology and innovation (*Rising above…Revisited*, 2010).

Purpose and Significance of the Problem

The purpose of the proposed study is to examine young women's retrospective perceptions of their experiences in the K-14 STEM pipeline and to examine the influence of specific interventions that led to their pursuit of and persistence in an engineering major at a university. Despite current research that identifies best practices for STEM interventions supporting the formation of a young woman's STEM identity (AAUW, 2010), a persistent research gap exists on the effects of women's experiences on their decision to enter and persist in engineering. Increased knowledge about retrospective reflections on K-14 experiences, including the supports provided that may have influenced persistence, will provide additional insight into how to construct an environment that encourages young women to enter and persist in engineering majors.

Despite the increasing number of women in STEM majors such as biology and the biomedical fields, women continue to be underrepresented in engineering and technology fields due to a lacking identification with the job and work environments (NASEM, 2007; Brawner, Camacho, Lord, Long, & Ohland, 2012; Diekman, Brown, Johnston, & Clark, 2010; Eris, Chachra, Chen, Sheppard, & Ludlow 2010; Mara, Rodgers, Shen, & Bogue, 2009; Ralston et al., 2013). The identified research gap is specific to young women in the engineering field, where limited research exists on students' perceptions of pipeline experiences over time and their impact on coping and ability to persist in engineering majors at universities. The gap also includes research on STEM identity-formation, self-perceptions of mathematics confidence and ability, experiences related to gender bias and its effect on pre-engineering coursework, individual support programming provided by teachers and mentors, recruitment efforts, and incorporation of gender-specific social and familial support networks. These social and psychological factors present in male-dominated professions influence students' beliefs about anticipated roles and their personal fit in engineering (Cech, Rubineau, Silbey, & Seron, 2011). Researching these factors and applying this knowledge to construct a purposeful K-14 alignment of interventions can broadly enhance the possibilities for young women in engineering. By closely examining the experiences of young women who have successfully navigated the pre-engineering pipeline and have persisted in engineering, research findings will contribute to the body of knowledge surrounding female students' feelings of self-efficacy and the influence of individual perceptions on enrollment and persistence in engineering.

Utilizing an ethnographic approach, this mixed-methods sequential study utilized a quantitative survey and a qualitative focus group to provide insight into female students' feelings of self-efficacy and perceptions of the academic, social, and personal experiences that led to their enrollment and persistence in a post-secondary engineering program. The sequential approach allows for qualitative data to contribute to the purposeful sampling of young women, thus building upon the initial data collected. These research findings will help enable K-14 educators to make informed decisions about deliberate efforts to engage and support young women separately from young men, both in their career through pre-engineering and engineering curriculum supports and in the transition from high school to college, in order to facilitate completion of an engineering degree.

Research Question

Several possible research questions exist in exploring students' perceptions of pre-engineering experiences and feelings of self-efficacy that result in their decision to enroll and persist in an engineering major. This mixed-methods research study undertook a closer examination of students' feelings of self-efficacy that influenced persistence in spite of challenges, and how these perceptions impacted young women's STEM identity-development in their junior and senior years of post-secondary study. A quantitative survey of approximately 75 female engineering students at a private liberal arts university comprises the initial research phase, allowing the researcher to gather data on widely held perceptions of the students' educational experiences. Descriptive statistics from this survey guided the question development for the follow-up qualitative focus group study, which provided emerging themes in perceptions among the groups. If additional data was needed, these themes would have provided the basis for individual interviews with five young women, designed to help the researcher gain insight on the origins of those perceptions that influenced their decision to enter and persist in an engineering major. The young women's perceptions provided additional insight into gender-specific supports for young women in the STEM and pre-engineering pipeline and further contribute to the body of knowledge surrounding gender differences in feelings of self-efficacy and perceptions among women enrolled in engineering programs.

The following research question is explored in this study: How do young women's perceptions of their K-14 STEM experiences influence their decision to enroll and persist in an engineering major? This mixed-methods study utilizes a sequential approach, providing the opportunity to construct specific focus group and interview questions based on an initial quantitative survey to gain an in-depth understanding of young women's unique perceptions of K-14 STEM interventions. The questions addressed the experiences, perceptions, and feelings of self-efficacy behind the students' successful navigation of the engineering pipeline.

The quantitative survey data were analyzed utilizing descriptive statistics to identify common experiences and perceptions among women in their junior and senior years of post-secondary engineering study. Specific details of experiences and individual perceptions of STEM interventions were analyzed by coding qualitative focus group data. The focus group was designed to stimulate more detailed discussion of students' formal and informal STEM experiences. In order to determine if patterns existed among focus group participants, the researcher designed questions about students' perceptions of elementary, middle, and high school experiences, as well as college freshman- and sophomore-year experiences (including the transition to college).

Thematic, open-ended, and line-by-line coding of focus group responses provided further insight into the social, personal, and academic reinforcements and challenges that require more in-depth exploration. Open-ended questions allowed students to elaborate on the influences of their combined experiences over time on their development of a STEM identity throughout their academic career. In general, interview questions addressed students' earliest memories of excitement about STEM areas, including scientific inquiry, innovation and design, mathematics confidence and ability, and feelings of empowerment or vulnerability in mathematics. These questions also explored these experiences' impact upon participants' decision to pursue an engineering degree.

Conceptual Framework

Researcher Stance and Experiential Bias

The researcher's paradigms and framework are based on postmodernism, the belief that different views of reality exist and that a socially constructed nature of information is based on individual interpretation (Bloomberg & Volpe, 2012). The existence of gender and social hierarchies exposes young women to interventions and supports for entering STEM majors. This study seeks to understand how female students' perceptions of their own STEM interventions shaped their decision to enter and remain in an engineering major. The researcher's framework is guided by the constructivist stance that a young woman's compiled experiences over time impact the development of her STEM identity in a social construct that is different from young men's. This framework also contributes to the exploration of how social cognitive theory is applied to educational practices that influence perceptions (Bandura, 1997; Bloomberg & Volpe, 2012; Diekman, Clark, Johnston, Brown, & Steinberg, 2011; Kulturel-konak, D'Allegro, & Dickinson, 2011; NRC, 2012).

This study further explores evidence of an underlying stereotype threat, how young women learn from their observation of others when desirable behavior is modeled, and how women see themselves fitting into the role of engineering professionals (Bandura, 1997; Halpern, Aronson, Reimer, Simpkins, Star, & Wentzel, 2007; Leaper, Farkas, & Brown, 2012; Spencer et al., 1999; Steele, 1997; Steele & Aaronson, 1995;

Steele et al., 2007). Experiential Learning Theory (ELT) relies on the principle that learning is not the transmission of knowledge, but the identification with learning. Perceived feelings of self-efficacy, the formation of a STEM identity, and an understanding of how one's intellectual abilities are influenced by knowledge constructed by individual perceptions are integral to one's belief that one's own intellectual abilities are not predetermined, but are constantly being formed by new experiences and learning opportunities (AAUW, 2015; Bandura, 1997; Heilbronner, 2009; Heilbronner, 2012; Carlone & Johnson, 2007; Kolb & Kolb, 2005). All of these factors impact the continued underrepresentation of women in male-dominated engineering fields (Brawner et al., 2012; Diekman et al., 2010; Eris et al., 2010; Mara et al., 2009; Ralston et al., 2013). This underrepresentation of women limits the nation's opportunities for diversity among tomorrow's innovators and widens the gap in our understanding of young women's perceptions and their resulting decisions to enter and persist in an engineering major.

Three research streams support in this study the need for continued research on how young women's perceptions of their STEM and pre-engineering pipeline experiences influence their enrollment and persistence in an engineering major (see Figure 1).

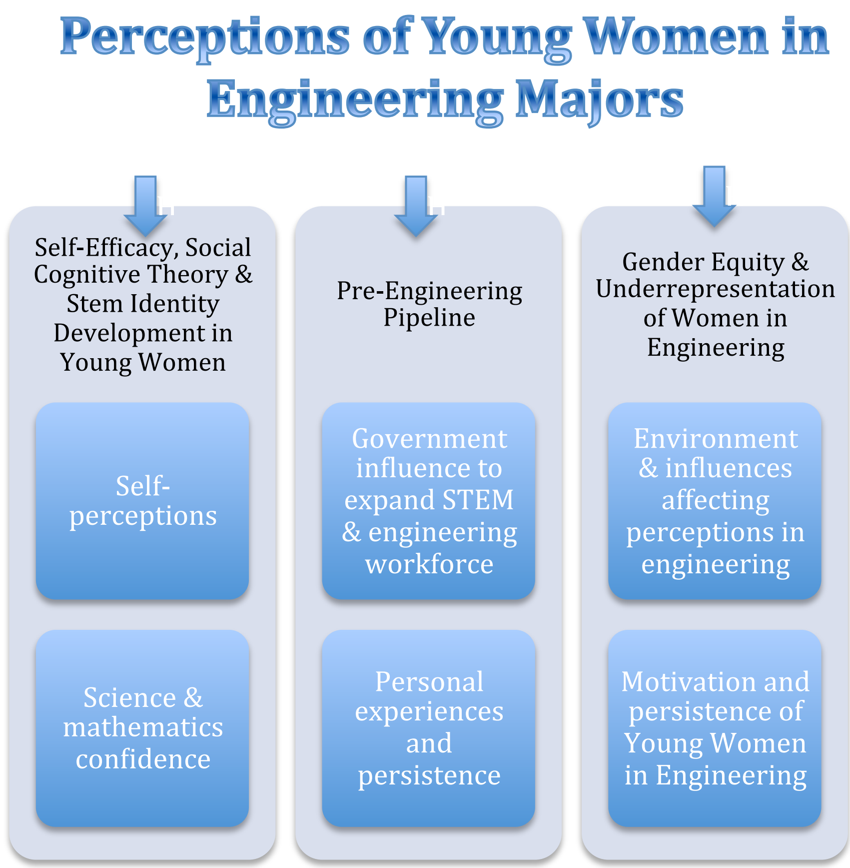

Figure 1. Conceptual framework.

The first research stream examines self-efficacy as it relates to young women's perceptions of learning and ability. This stream includes the social cognitive theory explanation of learning, where behavior that is modeled can influence the learning process (Bandura, 1997). Young women's perceptions and ability to relate and construct new knowledge from the relationship they form with a learning situation can significantly impact their desire to continue in a learning environment where knowledge is constructed by individual perceptions (Bandura, 1997; Carlone & Johnson, 2007; Kolb & Kolb, 2005).

This stream is aligned with STEM identity-formation, specifically for young women in the pre-engineering pipeline. Young women's self-perception in science and mathematics influences them to identify with STEM and engineering careers, thereby affecting their decision to enter into rigorous pre-engineering coursework and study engineering in their post-secondary education (Ralston et al., 2013; Robnett & Leaper, 2013; Stoeger, Duan, Schirner, Greindl, & Ziegler, 2013). Research also indicates that there exists a stereotype of white males as the typical STEM candidates in careers as medical practitioners, engineers, scientists, and computer technicians (Hughes et al., 2013; Steele, 1997; Steele & Aaronson, 1995; Steele et al., 2007).

A second research stream focuses on the pathways to engineering, which for the purposes of this research is referred to as the *pre-engineering pipeline*. This pathway is defined as a student's K-14 experiences, including mentors, engineering cooperative experiences, pre-engineering seminars and classes, and AP courses that contribute to a student's positive identification as an engineer. These experiences build confidence in mathematics and science skills and reinforce the feelings of self-efficacy necessary to persist in engineering (French, Immekus, & Oakes, 2015; Matusovich, Streveler, & Miller, 2010).

A third research stream addresses gender equity in engineering fields and the underrepresentation of young women among engineering majors and within degree receipt, despite the recent increases in other STEM-related fields of study. This stream examines young women's pre-engineering pipeline perceptions and these perceptions' resulting impact on women's persistence in engineering. In one mixed-methods study (Kulturel-konak et al., 2011), a survey of college students found both that women preferred intuitive and feelings-based course structures and that the current environment in STEM coursework reflects an analytical approach to which fewer women find a connection. This study reinforces the fact that learning environments play a role in students' STEM program continuation at the university level. The continued gap in the representation of women within engineering demonstrates further need for exploration of the perceptions that lead to female students' transferring out of engineering majors.

These three research streams provide a framework for further study of young women's individual perceptions and their resultant decision to enter and persist in engineering. The findings from students' personal reflections and the themes that emerge from students' experiences and perception-development will advance the body of knowledge on supporting women as an underrepresented group in the field of engineering separate from their male colleagues.

Definition of Terms

The following key terms are utilized throughout this research: *STEM* (Science, Technology, Engineering, and Mathematics) and *STEM identity*, which is the formation of one's own personal connection to the STEM majors and studies (Carlone & Johnson, 2007; Hughes et al., 2013) as it relates to each young woman's current reality. For the purposes of this study, the term *pre-engineering pipeline* represents students' K-14 STEM and engineering experiences. *Self-efficacy* refers to one's feelings of adequacy in one's own ability (Bandura, 1997) and self-perception of achievement. Additionally, *underrepresentation* means the limited presence of women as a subgroup in the engineering field. The term *engineering* is meant to encompass the eight engineering majors of academic study at the institution being researched, including biomedical engineering, chemical engineering, civil engineering, computer engineering, computer science and engineering, electrical engineering, environmental engineering, and mechanical engineering. Finally, the term *retrospective* refers to looking back at situations that have occurred in the past.

Assumptions, Limitations, and Delimitations

The experiences of the students who completed the quantitative survey and qualitative interviews are assumed to represent more than one individual person and can be broadly applied to develop an understanding of the challenges that exist for young women as a culture-sharing group. This knowledge will be utilized to support the construction of experiences resulting in female students' perceptions that lead to their decisions to enter engineering majors.

The small representative sample of junior and senior women at a small private liberal arts university is a significant weakness of the study. This small sample size limits the generalizability of the information to all young women in engineering majors who have experienced the pre-engineering and STEM pipeline. However limited, this sequential mixed-methods study will contribute specific and detailed knowledge of the influence of young women's individual perceptions on their resulting decisions to enter and persist in an engineering major. Through a retrospective examination of the students' K-14 experiences, it is possible to direct relevance to the alignment of the pre-engineering pipeline. This research is intended to shrink the gap in current research on the impact of individual perceptions on women's persistence in engineering.

The delimitation of the study is this researcher's decision not to interview and survey students across more than one university. Instead, it is the researcher's intent to examine more deeply the individual perceptions of young women who have persisted in engineering. This retrospective reflection on experiences and feelings of self-efficacy can provide specific information on the personal impact of young women's experiences in the pre-engineering pipeline.

Summary

Research on young women's individual perceptions of their experiences in the STEM pipeline contributes to the existing body of knowledge on STEM and engineering pipeline constructs that have enabled female students' successful transition to and retention in an engineering major. The quantitative descriptive data obtained from junior and senior female engineering students provides insight into perceptions resulting in their persistence in engineering separate from their male counterparts. The emergence of themes from the qualitative focus groups provides a personalized view of women's pipeline experiences and allows for a sampling of young women to represent a larger underrepresented ethnographic group in engineering.

CHAPTER 2: LITERATURE REVIEW

Introduction

The following three streams of literature have surfaced in relation to young women's advancement in engineering majors: 1) Self-efficacy, the social cognitive theory, and the formation of a STEM identity; 2) pre-engineering pipeline experiences; and 3) gender equity and the underrepresentation of women in engineering.

Despite recent increases in women's pursuit of STEM and engineering careers, including biology, the biosciences, and agricultural engineering, women continue to remain an underrepresented subgroup in male-dominated engineering majors (AAUW, 2015; Banning & Folkestad, 2012; Corbett et al., 2010; Heilbronner, 2012; *Rising above…Revisited*, 2010). Literature has most notably examined factors that influence self-efficacy and the development of a STEM identity as contributing to this underrepresentation. The perception of one's own self-efficacy, or the belief in one's own capacity to bring about a desired result (Bandura, 1986, 1997; "Self-efficacy," 2015), is paramount to understanding what drives individuals to persist and be successful in both personal and academic aspects of their lives. Individual experiences contribute further to the belief in one's ability to complete activities in relation to his or her peers. In this way, self-efficacy plays a role in the continuation of mathematics and science activities and courses that aid in the development of a STEM identity, or the ability to identify with oneself as a future professional in the STEM field (Bandura, 1997; Hutchinson, Follman, Sumpter, & Bodner, 2006; Ponton, 2002; Ponton, Edmister, Ukeiley, & Seiner, 2001). Research also indicates that students' participation in formal and informal STEM interventions and pre-engineering experiences, such as cooperative education experiences (co-ops), camps, mentoring, and hobbies such as robotics, leads to their future selection of STEM and engineering majors.

Other underlying factors in the educational environment, including stereotype threat, affect the selection of engineering majors. Stereotype threat refers to the belief that one is less competent in his or her abilities to perform because of the presence of a perceived threat that results from being an underrepresented group or female minority in a male-dominated profession (Bandura, 1997; Leaper, Farkas, & Brown, 2012; Halpern et al., 2007; Spencer et al., 1999; Steele, 1997; Steele & Aaronson, 1995; Steele et al., 2007). Stereotype threat can exist for students who are members of an underrepresented or minority group, and it can occur based on race and gender for students who are both female and members of a minority race. For the purposes of this research, the demographic of interest is women in a male-dominated profession (Chen, 2013). Aggregate data is separated by ethnicity to further examine the impact of minority women's perceived experiences on feelings of self-efficacy as they contribute to persistence in engineering.

The constructivist viewpoint of the educational model and application of the social cognitive theory, which suggests that changes in the environment affect changes in the individual, to the educational setting implies that changes in the academic environment can affect academic achievement. The individual's perceived experiences, which shape self-efficacy, provide a social construct for impacting one's identity development as a successful engineering student (Bandura, 1997; Cech et al., 2011; Halpern et al., 2007; Heilbronner, 2009). Current research supports the theory that both formal and informal experiences (Densen, Hailey, Stallworth, & Householder, 2015; Hughes et al., 2013) contribute to women identifying with themselves as future engineers and developing their STEM identity. However, it is important to explore further the individual's perceptions of experiences that result in engineering persistence. Further educational research is needed to provide insight into students' feelings of self-efficacy as a motivating factor for their persistence in engineering disciplines so the K-14 community can support more effectively women in engineering and university programs.

Review of the Literature

The following three areas of research have emerged surrounding young women's entrance and persistence in STEM majors, specifically engineering: 1) Self-efficacy, the social cognitive theory, and the formation of a STEM identity; 2) pre-engineering pipeline experiences; and 3) gender equity and the underrepresentation of women in engineering. Figure 2 further depicts these areas of research.

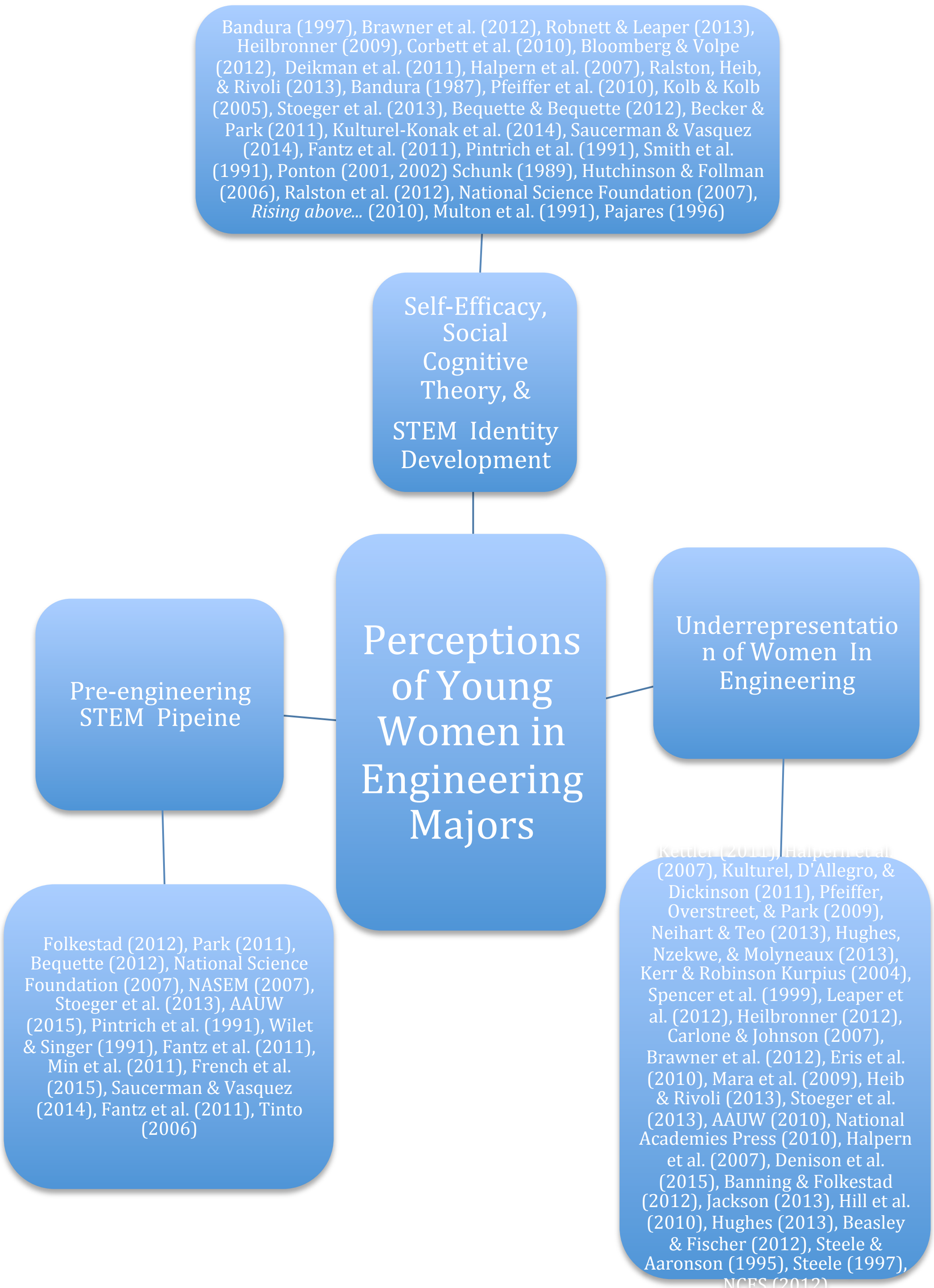

Figure 2. Literature map.

Stream 1: Self-Efficacy and STEM Identity

Generally speaking, the social cognitive theory is applied to educational practices to describe students learning from the observation of others when desirable behavior is modeled (Bandura, 1997). This theory provides insight into one's formation of self-efficacy, which Bandura (1997) defines as "beliefs in one's capabilities to organize and execute the course of action required to produce given attainments" (p. 3). Self-efficacy is the primary basis for the social cognitive theory; it affects students' feelings of ability as they relate to interactions in behaviors and personal beliefs in the environment in which they are learning. Social cognitive theory is integral to the belief and acceptance that one's own intellectual abilities are not predetermined but are constantly being formed by new experiences and learning opportunities; these abilities can be improved over time and are influenced by the connection made with the learning experience (Kolb & Kolb, 2005). Both environmental and individual factors affect young women's connection to learning in the classroom, including differences in learning styles and the ability to connect relevance to the material being taught (Kulturel-konak et al., 2014).

Strategies to nurture girls in the classroom must be utilized to keep these students actively learning and highly engaged. Self-esteem must be reinforced in order for girls to realize that learning STEM subjects is achievable (Heilbronner, 2009). Through careful instructional and social grouping, schools can provide a setting in which gifted and talented girls can be encouraged in their ability to perform math and science skills, ultimately reinforcing their self-esteem in subjects that may have been stereotypically considered only for boys.

Psychological barriers also exist that decrease STEM participation throughout young women's academic career. The research indicates that that students receive subtle messages about the growth mindset for math ability and teachers' perceptions that male students have greater mathematics ability, despite similar test performance by both male and female students (Saucerman & Vasquez, 2014). In addition to teacher and mentor influence, societal stereotypes and media messages send girls a message that STEM careers are more suited for men and that scientists are rigid and unfriendly (Saucerman & Vasquez, 2014). In the transition experience from middle to high school, these messages can translate into the influences that encourage students to participate in challenging and expanded electives in mathematics, science, and computer technology; AP courses; partnerships with local colleges; and partnerships for research opportunities in private industry. All of these psychological factors and subtle messages can develop the experiences that lend themselves to students' decision-making surrounding their entrance into and completion of STEM transition-to-college programs.

One study of 331 freshman engineering students at Colorado State University investigated pre-collegiate factors that influenced self-efficacy of engineering students within two different populations (Fantz, Siller & DeMiranda, 2011). One population was comprised of male and female students who had participated in both formal and informal experiences prior to entering the engineering major. Formal experiences included rigorous pre-engineering classes specifically identified as aligned with national technology standards. The informal experiences included participation in summer camps, engineering-related hobbies, out-of-school programs, day programs, visits to universities, and interactions with engineering professionals. Utilizing the MSLQ, which was developed to measure college students' motivational orientation (Pintrich, Smith, Garcia, & McKeachie, 1991), the researchers incorporated the concept of engineering by replacing the term "class" with "engineering classes." A self-efficacy score was recorded. A Cronbach's alpha score of 0.70 was determined for the internal consistency of the responses, and descriptive statistics were utilized for all demographic variables. Seven engineering experiences were found to be statistically significant in impacting students' self-efficacy relative to their peers who did not have any pre-engineering experiences. Five of the seven significant pre-engineering experiences were related to hobbies, while the other two were middle- and high-school technology and pre-engineering classes (Fantz et al., 2011). Study results indicate that programming, electronics, video-game production, robotics, and model-rocket building, along with courses that had a structured curriculum aligned to national standards, significantly impacted students' engineering-related self-efficacy.

Other studies on the role of self-efficacy in engineering education focus on increasing college students' self-efficacy, the sources of students' self-efficacy, and measuring self-efficacy in general (Hutchinson et al., 2006; Ponton, 2002; Ponton et al., 2001), but little research exists on the personal examination of the development of self-efficacy (Fantz et al., 2011; Schunk, 1989) leading up to the enrollment in and continuation of an engineering major following the K-14 experience. According to Schunk (1989), self-efficacy instruments are utilized often to measure pre- and post-self-efficacy scores, despite other recommended methods of data collection, including longitudinal survey data that would yield a smaller sample size but provide valuable information on how self-efficacy changes over time in the academic setting. Regarding self-efficacy beliefs and persistence in engineering, research indicates that self-efficacy affects the choice to pursue and continue in engineering (Pajares, 1996; Multon, Brown, & Lent, 1991) in the university setting.

In 2005, a congressional report was delivered to address the crisis in science, mathematics, and technology innovation as compared to other countries. International test scores revealed that K-14 education was failing to develop the next generation of innovators, engineers, and scientists who would lead the country to economic prosperity (NASEM, 2007). One especially specific call to action was to expand the STEM pipeline, increasing the number of students who enroll and are successful in AP, pre-AP, and International Baccalaureate (IB) courses. Two years later, the National Science Board (NSB) approved a national action plan for 21st-century STEM education (NSF, 2007). This action plan outlined two goals: 1) horizontal coordination among states in STEM program development, and 2) vertical alignment of K-14 STEM activities through NSF grants and interagency cooperatives to address the needs of developing a competitive workforce.

NSB support represented a deliberate federal effort to fund programs that would further develop the STEM pipeline in grades K-14, such as governor’s schools, summer research institutes, and afterschool programs (Halpern et al., 2007; Pfeiffer, Overstreet, & Park, 2009; Stoeger et al., 2013). However, in 2010, the same congressional committee reconvened and determined that despite the substantial financial investment in American education and the planning among government agencies, there was a lack of advancement in international mathematics and science test scores and STEM career skills

(*Rising above… Revisited*, 2010). The following facts were taken from the congressional report update on student progress and American education:

1. The US ranks 27th among developed nations in the proportion of college students receiving undergraduate degrees in science or engineering.
2. According to the ACT *College Readiness* (2008) report, 78% of high-school graduates did not meet the readiness benchmark levels for one or more entry-level college courses in mathematics, science, and reading.
3. Thirty years ago, 6th-grade boys outnumbered girls 13:1 in mathematics scholastic aptitude tests. However, this gap has narrowed, with a current ratio of 4:1, indicating a need to focus on the adequate preparation of future engineers and look beyond academic differences to explain the gender gap that currently exists.

These findings and data are significant because they allude to the reasons students lack the STEM skills these educational interventions were intended to provide. These facts, coupled with the reality that students are not receiving their education from highly qualified science and mathematics degree-holding teachers, contributes to students' declines in testing proficiency and lack of preparedness for college and STEM careers.

Historically, the STEM and engineering pipeline has been focused on informal experiences coupled with various formal curriculum initiatives. Examples include teacher training, administrative commitment, and local school supports designed to assist in the construction of self-efficacy in engineering and pre-college STEM coursework (Ralston et al., 2013). However, the supports' implementation levels vary by school. Research suggests that taking an integrated mathematics approach to STEM courses and making connections to informal STEM experiences, integrating creative-thinking activities, and introducing students to the engineering design process can positively affect students' critical thinking skills and attitudes toward math, which are closely tied to young women's self-perception of achievement and influence their decision to continue in a STEM major (Becker & Park, 2011; Bequette & Bequette, 2012; Ralston et al., 2013). Opportunities to talk with female engineers, including faculty, alumni, and engineering students, also allow young women to achieve a stronger STEM identity in the pipeline experience (Ralston et al., 2012). Few retrospective studies surrounding perceptions and mathematics interventions over an academic career are present in the literature addressing their relationship to women's pursuit of engineering degrees and careers.

Several studies address the influence of friendships and social supports on a student's development of a STEM identity. Interest in engineering careers can be constructed in K-14 schools to create social experiences in which a positive STEM identity can be supported (Robnett & Leaper, 2013; Stoeger et al., 2013). These social supports frame a context that enables girls to develop a stronger perception of self-efficacy in their pursuits of engineering and STEM-related subjects, excluding medicine and the social sciences. In one study, 468 high-school students participated in a survey about STEM career interest. Respondents were 13-18 years old and from diverse ethnicities, and all of them had indicated previously that spending time in friend groups was important to them. Quantitative data was analyzed using descriptive statistics and Spearman zero-order correlations for all variables (Robnett & Leaper, 2013). Notably, friendship groups accounted for the variation in STEM career interest. Friend groups composed primarily of girls who did not support a STEM climate had a negative impact on females' STEM interest, whereas boys demonstrated a higher interest in STEM careers regardless of friend groups.

Stream 2: Pre-Engineering Pipeline

Several factors contribute to the problem of retention in engineering, including cognitive factors such as GPA and SAT math scores; non-cognitive factors like interactions with peers and professors; individual characteristics like family educational background, gender, and ethnicity; institutional characteristics like environment, type, and size; and the relationship between individuals' feelings of self-efficacy and their skills and personal attributes (French et al., 2005; Tinto, 2006). Despite models for retention and focus on engagement during the freshman years, however, many universities are not making significant changes in student retention rates (Tinto, 2006).

Min, Zhang, Long, Anderson, and Ohland (2011) confirm that these survival factors do indeed allow for risk to be calculated each semester and provide information on what interventions would effectively contribute to retention. Their study of a longitudinal database including 100,179 engineering students from nine universities over 19 years revealed that engineering students leave the major most often during their third semester and that, of all factors, SAT math scores below 550 were the most significant predictor of this loss. Further supporting this research, French et al. (2005) note that GPA continues to be a predictor of retention; findings indicate it would be worthwhile for universities to conduct freshman-year seminars focused on academic achievement and success in engineering courses. The researchers also indicate that more qualitative work is needed in the areas of how students perceive seminars and how individual experiences are shaped by academic success.

Matusovich, Streveler, and Miller (2010) conducted a case study of 11 engineering students who successfully persisted in their engineering degree. The researchers examined the relationship between students' reasons for choosing an engineering major and their success in engineering persistence. They published data collected using Eccles and Wingfield's (2002) expectancy-value theory, which assigns a value to the importance of completing a task, in this case completing an engineering degree. This examination of successful undergraduate students indicated that personal values of earning of an engineering degree were closely connected to students' self-identity and engineering identity, implying that universities should work to connect their academic programs to align with students' values in order to retain engineering students.

Another longitudinal survey (Eris et al., 2010) focused on the outcomes of the PIE survey. Students were administered the survey seven times, twice each during their freshman, sophomore, and junior years, and three times during their senior year. Based on findings, students were classified as persisters or non-persisters based on whether or not they remained in engineering. The findings also indicated that increased mentor involvement in high school might lead to students' increased desire to study engineering and that their intention to complete the major decreased in the two semesters prior to their departure from engineering. Increasing student confidence in math and science and fostering an intention for students to complete the major were noted as possible interventions to prevent engineering dropouts.

Psychological barriers also exist for young women that decrease STEM participation throughout their academic career. Noted in the research are the subtle messages that students receive about the growth mindset for math ability and teachers' general perception that male students have greater mathematics ability, despite similar test performance between male and female students. In addition to teacher and mentor influence, societal stereotypes and media messages often send girls the message that STEM careers are more suited for men and that scientists are rigid and unfriendly (Saucerman & Vasquez, 2014). In the transition experience, this message can translate into students' decision to participate in challenging and expanded electives in mathematics, science, and computer technology; AP courses; partnerships with local colleges; and partnerships for research opportunities in private industry. All of these psychological factors and subtle messages can develop experiences that lend themselves to decision-making surrounding the entrance and completion of STEM transition-to-college programs.

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Stream 3: Underrepresentation of Women in STEM and Engineering

A qualitative study involving the California-based Mathematics, Engineering, and Science Achievement (MESA) program was conducted on underrepresented student populations (Densen et al., 2015). Given the success of the MESA program as an informal experience that is effective in recruiting and retaining underrepresented students in STEM careers, this grounded theory approach utilized focus group interviews across five groups of students who participated in the program. This program is co-curricular and supports disadvantaged students by providing opportunities for minority students to be successful in STEM disciplines. The following eight themes emerged as influential to student success in the findings: 1) Informal mentoring, 2) makes learning fun, 3) time management, 4) application of math and science, 5) feelings of accomplishment, 6) builds confidence, 7) camaraderie, and 8) exposure to new opportunities. The study's findings imply that these themes should be incorporated into both formal and informal learning environments to teach and reform the way STEM content is taught.

In addition to disadvantaged and minority students, research exists to support a nurturing environment for young women in engineering. Specifically, a more supportive environment and reinforcement for women is needed to increase their representation within STEM degrees and careers (AAUW, 2010; Kerr & Robinson Kurpius, 2004; *Rising above…Revisited*, 2010). Women continue to be underrepresented in engineering majors and require additional interventions to improve these outcomes (AAUW, 2010).

Banning and Folkestad (2012) conducted a qualitative data analysis (QDA) study of 101 dissertation abstracts from 1990 to 2010 by searching the WEB of Science and Academic Search Premier databases using the terms, *education*, *science*, *technology*, *engineer*, and *STEM/SMET*. The researchers analyzed the data through deductive and inductive coding analysis to determine topics addressed by the dissertations and to develop groupings for a thematic structure of the dissertation abstracts. Findings indicated that the first dissertations meeting their search criteria were found in 2003 and in 2006. In 2009, the year containing the most dissertations (26), dissertation focuses shifted towards STEM topics and the STEM pipeline with a focus on retaining underrepresented individuals. The researchers used peer examination in the QDA study to indicate that more research is being done on STEM-related areas. Findings also indicate that research is focused primarily on the quality of STEM programming, with little information available on improving the individual environments in which the learning occurred (Banning & Folkestad, 2012). While these results indicate that a focus on STEM research has increased in the recent decade, the study does not provide any information on the quality of these studies. However, the study notes the use of the pipeline metaphor to describe conditions of underrepresentation, retention, and K-14 instructional activities. It also notes that 40% of the dissertations focused on STEM recruitment and retention, and of the 101 studies, 80% had targeted diverse populations. The most significant finding is that, of the studies on retention, most focused on the individual student, with only two studies addressing the environment as a primary focus. Thus, the researchers reinforce the need for continued exploration of the environment and its perceived impact on retention in STEM disciplines such as engineering.

The literature also notes best practices in developing young women's self-efficacy and providing opportunities for their social learning support (Bandura, 1997; Halpern et al., 2007; Heilbronner, 2009). Standard methods of instruction in the science and mathematics classroom should be included to further diminish the formation of stereotypes and improve girls' self-perception of math and science ability and skill acquisition (Halpern et al., 2007). One mixed-methods study involving over 70,000 students at eight higher-education institutions compared students entering and remaining in an engineering major. Findings demonstrate that the only engineering major that continues to experience growth among female students is industrial engineering (Brawner et al., 2012). Data was collected through student interviews; the responses included a common theme of nurturing environments, which were described as providing warmth, supportive staff members, and a valuable social network. Thus, the environment embedded into departmental culture and the degree program play a significant role in recruiting and retaining women in engineering majors and in women's STEM identity development (Brawner et al., 2012).

This point is also evident at the secondary- and middle-school levels; in the report *Why So Few?,* the AAUW (2010) examined eight research studies involving math and gender. The studies demonstrated that enrollment in advanced calculus courses were positively correlated with students' self-perceptions of math and science ability. Low self-perception resulted in fewer young women pursuing careers in science and engineering (Corbett et al., 2010). Environment and culture influence a girl's STEM identity and pave the way for interventions to increase confidence in STEM-related coursework and majors. The AAUW committee subsequently recommended enabling girls to feel respected in the classroom and encouraging their pursuit of high-level science and mathematics classes in their middle- and high-school years.

Research also indicates there is a stereotype of white males as the typical candidates for careers as medical practitioners, scientists, and engineers (Beasley & Fischer, 2012; Hughes et al., 2013). In one mixed-methods study, by Hughes et al. (2013) utilized survey and interview techniques to assess two camp experiences, one co-ed and one all-girls. In the camps, two informal educational interventions were included: role models and authentic STEM research activities. Data was collected on a small sample size of 54 middle- and high-school girls. The results of the survey instrument indicated Cronbach's alpha of 0.811 on STEM interest. Results also indicated that no significant differences existed between the two camps regarding the development of a positive STEM identity, but both informal interventions improved participants' STEM interest scores on the post-camp survey (Hughes et al., 2013). Despite the findings that environment played a stronger role in the development of STEM identity than the inclusion of single-sex programming, more research on a larger sample size is needed.

Gaps remain in research on the potential relationship between interventions to encourage selection of a STEM major in college and young women's long-term decision to pursue STEM careers in male-dominated fields. The existence of a social-psychological threat is referred to as stereotype threat, where a decrease in overall performance occurs when an individual perceives a negative stereotype as evident (Spencer et al., 1999; Steele, 1997; Steele & Aaronson, 1995). In academic settings, such as testing situations, young women and minorities perform at lower levels when they are aware they are being compared to their white male counterparts (Spencer et al., 1999). In the field of engineering and STEM majors, dropout has been attributed to stereotype threat for women and minorities (Steele et al., 2002).

The National Center for Education Statistics ([NCES], 2012) collected data on approximately 19,000 first-time postsecondary students entering STEM majors in 2003-04. Over a six-year period, researchers compiled transcripts and reviewed course completion and remedial-course enrollment, among other indicators. More than half of the females (51.6%) and nearly half of the males (48.8%) were enrolled in a remedial mathematics or English course during their post-secondary academic career. Of these students, only 39.5% of the students had taken a pre-calculus course and only 22.3% of STEM post-secondary students had taken a calculus course prior to college. In contrast, 11.4% of males and 12.9% of females were enrolled in a remedial English course, indicating the need for transition programs to focus on supporting STEM students in the area of mathematics and strengthen the possibility of STEM degree-completion. In addition to an identified need for remedial coursework, STEM-related GPAs were significantly lower for students who had taken Algebra II or less (an average of 2.4), while students who had completed Calculus earned an average of 3.0. This data continues to support the importance of high-school mathematics preparation as a contributing factor to STEM coursework success.

In another qualitative study, Jackson (2013) interviewed five young women in a community-college STEM program to explore the supports that existed in their college experience. Findings revealed that young women had received significant support along their academic journey, including from family, faculty, and mentors who had encouraged them to persevere and be successful. Given the pre-engineering coursework and need for remediation for young women, it is imperative that the pre-engineering and transition pathway be examined specific to individual experiences. Many women in the study noted that their families had been the source of their encouragement to pursue STEM programs, but all indicated that their interactions with college faculty and mentors had decidedly influenced their decision to remain and continue in a STEM program. The need to understand the personal experiences that shape female students' decisions to remain and persist in the face of challenges can only improve K-14 STEM identity-formation and aid in this underrepresented subgroup's transition to college programs.

Separate research has been conducted on course material with which women and men prefer to interact in college. The findings of one mixed-methods study (Kulturel-konak, D'Allegro, & Dickinson, 2011) indicated that female college students preferred intuition- and feelings-based course structures and that the current environment in engineering and STEM coursework reflected an analytical approach with which fewer women could connect. This finding indicates that the design of the course environment impacts women's connections to the major. Generally speaking, gender differences in learning styles correlate to a low female enrollment and degree completion in STEM coursework.

Synthesis

Research currently exists examining the immediate effects of STEM interventions on young women' self-efficacy and STEM identity, but little retrospective data is available on how students' K-14 experiences and personal perceptions of those interventions impact their choice to enter and persist in an engineering major. ThThis study's focus is to collect retrospective quantitative and qualitative data on female students' perceptions of self-efficacy leading to their persistence in pursuing an engineering degree. Given the national focus on STEM and the widespread initiatives to expand the engineering field for underrepresented groups, more research is needed to examine data that influences persistence in engineering degrees and careers.

Conclusions

Three streams of literature are relevant to advancing young women in engineering majors: 1) Self-efficacy, the social cognitive theory, and the formation of STEM identity; 2) pre-engineering pipeline experiences; and 3) gender equity and the underrepresentation of women in engineering. Women continue to be an underrepresented subgroup in engineering; several factors contribute to this underrepresentation, including the belief that one can complete activities relative to her peers and identify oneself as a STEM-career professional (Bandura, 1986, 1997; Hutchinson et al., 2006; Ponton, 2002, Ponton et al., 2001). Underlying subtle messages referred to as stereotype threat (Steele, 1997; Steele & Aaronson, 1995; Steele et al., 2007) can exist in the academic environment, implying that underrepresented groups such as young women cannot achieve the same levels of success in mathematics and engineering. This can impact young women's STEM identity-formation (Cech et al., 2011; Halpern et al., 2007; Heilbronner, 2009) and ability to develop as successful engineering students.

Additionally, both formal and informal experiences contribute to women's self-identification in the engineering profession (Densen et al., 2015; Hughes et al., 2013). Schools can support a setting in which young women are encouraged in their ability to develop math and science skills and that reinforces the development of feelings of self-efficacy and STEM identity-formation (Heilbronner, 2009), which research shows begins to decline as early as age 9, during the middle-school years.

Research also demonstrates that factors influencing self-efficacy include both formal and informal experiences (Fantz et al., 2011). One study utilizing the MSLQ, developed by Pintrich et al. (1991), identified seven factors in an informal setting that impacted students' self-efficacy, including programming, electronics, video-game production, robotics, model-rocket building, and courses aligned to national standards. Even with implementation of the NSB's action plan for STEM education (NSF, 2007), advancement in mathematics and science scores did not increase (*Rising above…Revisited, 2010*). Interventions were in place, but implementation varied by school (Ralston et al., 2013). Study findings indicated that it would be beneficial for universities to conduct freshman-year seminars on academic achievement and success in engineering courses (French et al., 2005).

Case study research by Matusovich et al. (2010) implied a relationship between students' reasons for choosing an engineering major and their relationship to success in engineering persistence. The study indicated that the values of earning an engineering degree were closely connected to students' self-identity and engineering identity. Eris et al. (2010) examined the administration of the PIE survey to students at their college; the researchers considered students to be persisters or non-persisters based on whether or not they remained in the engineering program. The researchers found that these particular students had been affected two semesters prior to their departure from engineering, making the case for mentor involvement during students' course of study to prevent engineering dropout. Retention in engineering appears to be influenced by several factors, including cognitive skills, personal attributes (French et al., 2005), SAT math scores, and non-cognitive factors such as family educational background, gender, ethnicity, and environment (French et al., 2005; Tinto, 2006). Additionally, opportunities for minority students to be successful in engineering need to be provided in a more supportive environment that provides reinforcement and additional interventions (AAUW, 2010; Kerr, Robinson, & Kurpius, 2004; *Rising above…Revisited*, 2010).

Based on 2012 (Brawner et al.) data, industrial engineering is the only engineering major that continues to experience growth among female students. Data indicated that a nurturing environment existed with supportive staff members and a valuable social network, which played a significant role in recruiting and retaining women in engineering majors. Research also indicates that environment plays a larger role than single-sex programming in the underrepresentation of women in developing a STEM identity (Hughes et al., 2013). In academic settings, the existence of a social-psychological threat, stereotype threat, is present and encourages young women and minorities to compare themselves to their white male peers (Spencer et al., 1999). In a longitudinal study by the NCES (2012), more than half of all females entering STEM majors had been enrolled in remedial mathematics or English courses during their post-secondary programs. Students identified as needing remedial courses were those who had taken Algebra II or less with an average GPA of 2.4.

Understanding the supports and individual experiences of young women in their journey to enroll and persist in engineering can help us uncover how these specific experiences shaped their decisions to be persisters. A qualitative study by Jackson (2013) examined the supports that existed in the college experience for young women and revealed that young women had received significant support along their journey.

In an effort to expand upon this research, it is necessary to continue to examine the personal experiences that lead to enrollment and persistence in engineering for the ethnographic group of young women through a retrospective examination of their K-14 experiences.

CHAPTER 3: RESEARCH METHODOLOGY

Introduction

STEM programming is widespread in schools across the United States. National, state, and corporate partnerships exist to expand these programs, yet national mathematics and science scores are failing to improve in international rankings (*Rising above…Revisited*, 2010). Recruitment of the best and brightest engineers and scientists is a top White House priority, with the goal of continuing technological advances and innovation. Programs also exist to encourage selection of STEM majors by underrepresented populations, such as young women, but these numbers remain significantly lower than their male counterparts (AAUW, 2010). Given both the funds and the available programming, why do these efforts not yield a larger increase in female enrollment in STEM-related college disciplines?

Research Rationale

This study's purpose is to examine the perceptions of young women as an underrepresented group in engineering programs as they have navigated the STEM and pre-engineering pipeline and made the decision to enroll and persist in an engineering major. Although a significant amount of research exists noting the underrepresentation of young women in STEM and engineering career entrance, less research exists on the retrospective individual perceptions of interventions over time that have shaped the lives of women who do continue in the engineering field. Few longitudinal studies exist, and the individual personal experiences leading to perceptions that result in engineering persistence leave a gap in the current literature.

This chapter provides the framework, guiding questions, and research design for a study conducted at a private liberal arts university in rural Pennsylvania. The primary research question the study aims to investigate is as follows: How do young women's perceptions of their K-14 STEM experiences influence their decision to enroll and persist in an engineering major?

Research Design

This mixed-methods study is designed to learn more about perceptions by young women in engineering as an underrepresented population and to determine if similar themes emerge from their perceptions that exist within the population at large based on feelings of self-efficacy and persistence among engineering majors. Creswell (2013) indicates that mixed-methods designs are utilized to better understand a research problem through qualitative and quantitative designs. Additionally, ethnographic designs employ qualitative procedures for describing, analyzing, and interpreting shared patterns of beliefs by a cultural group (Creswell, 2013). In this study, a quantitative survey was distributed to young women as an ethnographic group to determine if patterns in perceptions existed within the group.

In the second phase of the mixed-methods study, the researcher analyzed open-ended focus group responses to gain a more detailed understanding of the patterns emerging from the initial part of the study, which gauged female students' deeply held perceptions surrounding their pre-college STEM and pre-engineering experiences, as well as the effect of their university experiences on the students' persistence in engineering. The quantitative data collected from the study was analyzed utilizing descriptive statistics to measure central tendency. For the qualitative design, focus group data was collected and analyzed through open coding, thematic coding, and line-by-line coding. This coding process revealed related terms and patterns, enabling the researcher to examine relationships among data (Creswell, 2013; Merriam, 2009).

Site and Population

Population Description

According to the Institutional Research Fact Book (2015) for the research site where this study was conducted, the university has 702 degree-seeking undergraduate engineering students. The College of Engineering contains six engineering departments and eight majors, including biomedical engineering, chemical engineering, civil and environmental engineering, computer engineering, computer science engineering, electrical engineering, and mechanical engineering. Thirty-two percent (225) of the engineering students across all six departments are women.

Information on the population involved in the research study was obtained from the research site's Office of Institutional Research (OIR); the study group consisted of 112 full-time undergraduate female students, ages 19-21, in their junior or senior year at the research site. In order to participate in the study, the students could be enrolled in any engineering major; the study sample was purposefully selected as a representative ethnographic group across all engineering majors. A purposeful sampling method was employed for the focus groups to ensure that participants represented the ethnic breakdown of the larger group of young women enrolled in engineering at the research site. Students may or may not have utilized university supports, including intervention programs designed to assist with skills development for struggling students.

Site Access

The researcher's proximity to the site allowed for the qualitative focus group interviews to be conducted on-site. The study was supported by the Dean and Assistant Deans of the College of Engineering at the research site, who agreed to email potential study participants to facilitate the participation of young women in the survey. The research site anticipates using the study to gain insight on minority students' perceptions and experiences on campus and to improve the overall undergraduate experience, including the persistence of women in engineering. To facilitate the research, Institutional Review Board (IRB) approval was sought from the research site, and following the Drexel University IRB approval of the study, a letter of reliance was provided to the site ensuring minimal risk to participants. Additionally, the Dean of Engineering at the research site approved the researcher's attendance at a Society of Women Engineers (SWE) meeting on campus to further explain the study's significance.

Site Considerations

The university has several five-year dual-degree programs, including a Bachelor of Science in engineering and Bachelor of Management for engineers; a Bachelor of Science and Bachelor of Arts in engineering; and a combined Bachelor of Science/Master of Science in engineering. There are no concerns with political affiliations or philosophical constructs. Access to students required IRB approval, obtained during the fall 2015 semester. Additionally, notification to the SWE student chapter board was provided to ensure they were aware of the study objectives and recruitment process.

Research Methods

The first part of this mixed-methods study (Creswell, 2013) involved disseminating a quantitative survey to all female junior and senior students (*n*=112) enrolled across all engineering majors at the research site. Qualitative focus groups were conducted to explore students' perceived K-14 experiences. These questions focused on students' retrospective reflections of experiences that had encouraged their continued pursuit of an engineering major. Participants answered questions about self-perception of mathematics and science competency; the influence of family, K-14 faculty, and teachers; the availability of mentors; and participation in STEM and pre-engineering programs. Factors of motivation were assessed through the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1991) to examine women's feelings of self-efficacy and determine if patterns existed among the women in the engineering program.

The initial quantitative survey of engineering majors was distributed to all participants (*n*=112). The survey instrument (the Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey) was expected to yield a 33% response rate (*n*= 37) (Nulty, 2008), which is consistent with online response rates for surveys of college students. This average was predicted given that the Dean of Engineering had distributed the request to participate through an online link in an email to students. From the quantitative survey response, 10 study participants were selected for two focus groups of five students each; the students were selected as a representative population. Survey respondents indicated their willingness to participate in additional research at the end of the quantitative survey. This purposeful sampling selection process attempted to mimic the ethnic background and minority representation of female engineers at the research site. All study participants were over the age of 18 and did not require parental consent.

Qualitative focus group questions addressed women's perceptions of high-school and college coursework, classroom experiences, family influence, formal and informal STEM experiences, and interactions with faculty and peers that may have contributed to or discouraged their entrance and persistence in an engineering major. An exploration of K-14 interventions determined if common experiences existed among focus group participants.

Stages of Data Collection

Student data was obtained from junior and senior female students participating in the research site's engineering programs. According to Creswell (2013), an ethnographic approach can provide insight into a culture that is shared by members of a social group. In this case, the ethnographic approach enabled the researcher to view and describe the shared perceptions of young women as a cultural group through the lens of examining the self-efficacy and motivation behind their persistence in engineering. The researcher was interested in exploring the relationship between students' conscious awareness of interventions over time and their impact on the students' resultant decisions to enter and persist in engineering majors. Since this was a sequential mixed-methods study, the initial data for the quantitative survey was collected online between February and March 2016 using the researcher-designed Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey, which was created as an online Qualtrics survey. For the second phase of the study, a qualitative survey instrument containing structured, open-ended focus-group questions (Creswell, 2013) was distributed to 10 young women who were representative of the population and demographics of women enrolled in engineering at the research site. Figure 3 provides a visual representation of the study timeline, data collection, and study implementation.

Month	Task	Participants Involved	Purpose
February 1, 2016	• Pilot Study distributed to students • Email Announcement of Upcoming Survey & Notice to Clubs and Faculty	• University students (10) Freshman / Sophomores • Faculty • Student Leaders in Engineering	• Pilot Quantitative Survey • Announce coming survey
February 5, 2016	• Reminder Email Survey is Coming	Assistant Dean	• Reminder recruitment
February 8, 2016	• Email Survey Link Distribution	Assistant Dean	• Distribute survey for data collection
February 13, 2016	• Reminder email survey closing	The researcher	• Recruitment reminder
February 15, 2016	• Survey reminder • Close survey at midnight	Assistant Dean	• Recruitment reminder • Close survey to begin data analysis
March 1-9, 2016	• Focus Group Email Reminders, text message or phone call made	The researcher and the 10 undergraduate students at the research site	• Reminder recruitment
March 1-9, 2016	• Conduct Focus Groups	The researcher & Focus Group Participants	• Data collection
March 1-9, 2016	• Conduct Individual Interviews if needed	The researcher and interview students	• To gather more detailed data
Week of May 9, 2016	• Estimated study date completion and report of findings • Final Defense Proposal	The researcher and committee	• To summarize the study and offer implications for future research as a result of conducting the study
June 11, 2016	• Graduation	Researcher	• Commence

Figure 3. Dissertation timeline.

Description of Each Method Used

Prior to conducting the research study, a pilot study was conducted utilizing questions on the quantitative survey instrument (Creswell, 2013) to ensure validity and reliability of the combined instrument. Although the MSLQ and the Academic Pathways for People Learning Engineering (APPLES) survey instruments have been distributed widely in other research, this is the first time questions from the two instruments were combined for one study. This pilot enabled the researcher to determine if the subjects understood the questions, establish the time needed to take the survey, and decide if any questions needed to be modified for clarification. Ten engineering students in either their freshman or sophomore years were asked to complete the survey. Due to the small sample size and the need to exclude the subjects who took the pilot test, no junior or senior women were utilized. All instrument modifications were made following the pilot study conducted from January to February 2016.

The first phase of the study was conducted between February and March 2016. The researcher distributed online the Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey, including demographic questions. The research site’s Dean of Engineering distributed the survey instrument online to approximately 75 female junior and senior engineering students. As an incentive to participate, students who completed the survey were entered into a drawing for an Amazon gift card. Descriptive statistics were utilized in the data interpretation, including measures of central tendency. In the quantitative survey instrument, questions related to students’ retrospective perceptions of their experiences were explored through Likert-type scales. The instrument’s goal was to collect data on individuals’ experiences and perceptions during their K-14 and academic careers and to create a comprehensive picture of the culture-sharing group – in this case, the young women that had persisted in the research site's College of Engineering.

Participants took the survey in an online format. The survey was designed to eliminate any duplicate responses and all data was stored on a password-protected encrypted computer. The Statistical Package for the Social Sciences (SPSS), embedded in Microsoft Excel, was utilized to analyze the data and report descriptive statistical measures from the completed survey.

The qualitative methods portion of this mixed-methods study comprised the third phase of the research. The purposeful sampling and selection of 10 representative young women was made based on ethnicity and students' willingness to participate. Ten participants were placed into two focus groups of five individuals each, and the in-person focus groups were conducted during March 2016 at the research site. The focus groups were randomly assigned and were held in the same location; a half-hour break was incorporated between the first group's expected departure time and the second group's arrival time in order to protect the participants' anonymity.

The selection of students included juniors and seniors currently enrolled in engineering majors and who had completed the quantitative survey and noted their willingness to participate in follow-up research (n=10). The focus group interviews were designed to draw out additional detail on students' perceptions and feelings of self-efficacy experienced during their K-14 academic careers. The focus group questions were drafted at the beginning of the study, but minor changes occurred prior to administration since this study utilized a mixed-methods sequential approach and themes that emerged from the quantitative survey could not be predicted precisely. The focus group interviews consisted of one meeting and lasted approximately 45 minutes to one hour. All responses were recorded with a tape recorder and a voice memo for later transcription through the software package NVivo. These two recording methods helped mitigate any technical difficulties encountered during the recording process. Students were provided light refreshments for their participation and were entered into a door prize drawing for an Amazon gift card.

Participant Selection

For the focus groups, participants were purposefully selected based upon their willingness to participate in follow-up research; participant selection was also representative of the diversity of women in the engineering program. Students who had participated in university supports, such as the Engineering Success Alliance (ESA) program, were also included. The researcher extended focus group invitations to the students by email and emailed save-the-date reminders. Final reminders were sent through email messages. Email message reminders were sent one day prior to the focus groups confirming the date and time.

Data Collection

Data was analyzed utilizing SPSS for the quantitative portion of the mixed-methods study. The surveys were distributed by email and a follow-up email was sent one week after the initial request to increase the number of student responses. To ensure the expected response rate was reached, data collection for the quantitative portion of the study took approximately two weeks. Descriptive statistics, including measures of central tendency, were included in the analysis.

Focus groups were both structured and formal (Merriam, 2009); they were conducted in-person at the research site and were recorded for accuracy and playback for transcribing participant responses. Focus groups took approximately 45 minutes to one hour and one week was permitted for qualitative data analysis, which included thematic, line-by-line, and open coding (Creswell, 2013; Merriam, 2009). Open-ended responses were exported to NVivo data-management software for analysis.

Based on the findings, relationships between the independent variables were explored and themes were identified among participant answers to determine possible relationships between female students' retrospective recall of experienced interventions and development of a STEM identity that led to their pursuit of a university engineering major.

Instrument Description

The researcher designed a new 38-question survey (Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey) for the quantitative portion of the mixed-methods sequential study by combining demographic questions, questions from the MSLQ developed by Paul Pintrich and others (1991) at the University of Michigan, and questions from the APPLES instrument developed by Eris et al. (2010) and adapted from the PIE survey instrument to explore the engineering student experience. The PIE survey was originally developed to identify factors correlated with persistence in engineering as part of the CAEE's (2007) Academic Pathways Study (APS), which identified 21 variables for identification in persistence.

The MSLQ questions were used to identify within the results a measure of motivational orientation for college engineering students (Pintrich et al., 1991). Taking the approach of Pintrich et al. (1991), the survey incorporates the concept of engineering into the MSLQ by replacing the term “class” with “engineering classes.” Additional questions were taken from the APPLES survey in order to determine if a similar pattern of variables existed in key issues related to engineering education. The questions taken from the original APPLES survey examined the student engineering experience, demographics, motivations to study engineering, and the importance of skills that were developed from first-year to senior-year students (Eris et al., 2010). An item analysis is included in the appendices (Appendix A). Both the MSLQ and APPLES instruments have been tested for reliability, but this is the first time a combined survey instrument utilized questions from both instruments; thus, a pilot study was conducted to ensure internal consistency.

Data Analysis

Data analysis was conducted utilizing SPSS as part of Microsoft Excel and focused on analysis and reporting of descriptive statistics, including measures of central tendency for the quantitative survey questions. Qualitative focus group questions were analyzed utilizing NVivo. Open coding, thematic analysis, and line-by-line coding (Creswell, 2013; Merriam, 2009) were utilized to identify themes and terms that emerged from analysis of the open-ended discussion questions. Data analysis of qualitative data was used to examine common keywords and themes for persistence in engineering and to address students’ earliest memories of inclusion or excitement about STEM programming in the areas of scientific inquiry and experimental design.

Individual interview questions were presented in a qualitative instrument, with questions focused on the following issues: 1) Specific experiences that contributed to or hindered the development of a STEM identity and the resulting decision to pursue an engineering degree, 2) perceptions of the K-14 pre-engineering mathematics and science pipeline, and 3) supports and influences during the K-14 journey leading up to participants' junior year that influenced self-efficacy and persistence in engineering.

Ethics

In the present research study, IRB approval was sought with Drexel University as the IRB of record for the study of human subjects. A letter of reliance was obtained from the host institution and all findings without personal identifiers will be shared with the host institution. Through careful design of a study that outlined considerations for respect for persons, beneficence, and justice (Johnson & Christensen, 2012), this researcher aimed to obtain informed consent and establish ethics for data collection and reporting that were carefully constructed and controlled so no harm would result from the research process and confidentiality would be maintained.

The research site's IRB committee also granted access to the site and permission to engage the target population of students. The researcher obtained Collaborative Institutional Training Initiative (CITI) certification in order to demonstrate an understanding of the necessary protections for human subjects in research. Informed consent without parental permission was sought from all participating students, ages 19-22. The informed consent form included the following information: Focus group procedures, including confirmation that the interviews would be taped and recorded for transcription purposes; an overview of the participation-selection process; the study's purpose; the researcher's background information; how the research would be utilized and published; and the opportunity to withdraw from the study at any time without penalty or risk to status within their major or the university. In order to protect anonymity, all participants were assigned a random identification number, and only the researcher knew the identifier.

With respect to beneficence, the risks and benefits to the participants were initially disclosed to the research site in order to gain access to the research population. In addition to site access, the potential for risks and benefits was explained to all research participants. These risks included sharing participants' confidential information with the research site. The researcher guaranteed confidentiality of information and privacy of all family and personal information shared; the researcher also guaranteed that information would not be disclosed in a manner that identified individual participants to the research site's faculty or the general research community. Assignment of random identification numbers guaranteed anonymity of participants' names, program years, and affiliations (Creswell, 2013).

The researcher also clearly communicated the study's benefits by explaining that the research would be utilized to determine if patterns exist for women who persist in engineering. The institution and the participants were provided an overview of the research purpose and assurances were granted that identities of individual students, teachers, and tutors would not be revealed in the results. The researcher also provided the method of reporting, demonstrating that the overall findings were meant to identify patterns in early experiences and supports that were most or least beneficial to young women as an underrepresented group pursuing STEM education. These results will be reported to the institution and the research subjects and utilized to add to the body of research on retention and support for women in engineering, leading to an expansion of the future STEM workforce.

Justice, or the equal treatment of all subjects, was considered in the design of this study. All subjects, regardless of status, ethnicity, socioeconomic status, or background, were treated with the same ethical research practices. All students underwent the same interview and questioning procedures and were provided with the same accommodations during the focus group interviews. Researcher bias and individual perspective were considered. Students could withdraw at any time without penalty or risk.

The researcher will store data for three years on an encrypted, password-protected computer and in a Qualtrics file that is also password-protected. This data will be uploaded to Drexel University's dissertation management system (DMS) site, which is password-protected and is part of the encrypted Blackboard Learn program. The files will only be available to researchers.

Hard copies of miscellaneous notes are stored in a locked file cabinet and will be given to the principal investigator for storage for three years following the dissertation's completion. Survey participants were assigned codes without identifying information on the quantitative surveys, so no participants or the research site have access to identifiable personal information. Data findings from the research study are included in the dissertation and are accessible through Drexel University's library collection.

Ethical considerations are significant in all research-based studies involving human subjects. Through a careful consideration of individuals and their rights, risk to students was minimized and the benefits of the study will potentially provide continued insight into the experiences that contribute to strengthening the population of young women who enter the STEM workforce and remain in STEM engineering professions. CITI training and awareness of the students' need for an unbiased, ethical approach in the research ensure the study was conducted ethically.

CHAPTER 4: FINDINGS AND INTERPRETATIONS

Introduction

This study's findings aim to answer the following central research question: How do young women's perceptions of their K-14 STEM experiences influence their decision to enroll and persist in an engineering major? The study population included young women during their junior or senior year of study in an engineering major at a small, private, rural Pennsylvania university. The purposeful sample represented young women who persisted and were assumed to be graduating with an engineering degree given their academic standing. (See Appendix B for the data-collection instrument matrix). The Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey (see Appendix C) consisted of 38 questions taken from both the MSLQ (Pintrich et al., 1991) and the APPLES, as adapted from the PIE survey (CAEE, 2007; Eris et al., 2010). Survey administration and response rates are noted in the tables. Findings include descriptive quantitative data that represents the ethnographic group of young women in their junior and senior years of study and provides perceptions of these students' academic experiences, as well as the influences of demographic factors on the representative sample. Data on students' sources of motivation and feelings of self-efficacy are also included, with common experiences highlighted that appear to be significantly related to enrollment and persistence in engineering.

Phase One (Quantitative) Findings

Factors contributing to self-efficacy and motivation were included in the quantitative survey instrument to examine young women's retrospective perceptions of the experiences that led to their decision to persist in an engineering major through their junior and/or senior years at the research site.

Survey Administration Procedure

The Assistant Dean of the research site's College of Engineering disseminated an email containing the anonymous quantitative survey link to all junior and senior women within all engineering majors and followed up with additional email reminders to increase the response rate (see Appendix D). The survey was disseminated to a purposeful sample that included female subjects whose undergraduate status at the research site included third-, fourth-, and fifth-year program completion (*n*=112), depending on their academic standing as either juniors or seniors. These students were all 18 years of age or older at the time of survey distribution (February 8, 2016) and did not require parental consent to participate in the study.

Response Rate

The quantitative research survey instrument link was emailed to 60 senior women in year 4 of the regular engineering program, 46 junior women in year 3, and five women who were in year 4 of a 5-year degree program. A higher-than-average survey return rate of about 40% was expected because the Assistant Dean of the College of Engineering had disseminated the survey. Of the 112 students who received the survey, 49% (*n*=54) responded; however, only 36% of students (*n*= 40) completed the survey in its entirety and could have their responses counted as valid. The partial survey responses (*n*=14) were omitted from the results and do not influence the study's findings. The researcher removed one question (Q6) from the findings due to participant confusion.

Sample Demographics

The following figures indicate the demographics of the engineering students enrolled at the research site, where *N*=702 with 32% of the students identifying as female (*n*=224). This enrollment is similar to gender enrollment reported by Yoder (2015), where females comprised 20% of the total population of engineering students for fall 2014 bachelor's degree enrollment at universities in the United States, including Puerto Rico. Figure 4 shows the total distribution of engineering students at the research site during the fall 2015 semester.

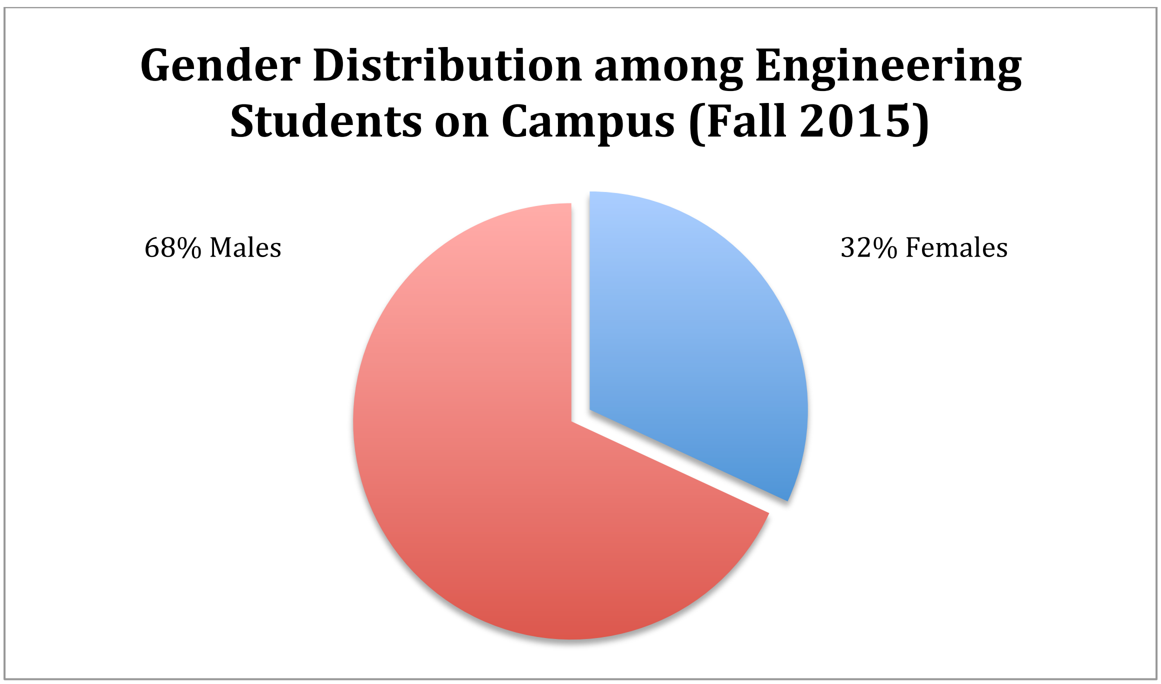

Figure 4. Gender distribution among all engineering students, fall 2015. (*Source:* Office of Institutional Research)

Table 1 shows the total number of female engineering students enrolled at the research site by race. This data was obtained from the research site's OIR prior to the survey distribution. The highest percentage of females in engineering at the research site university are classified as White (72%), followed by Asian/Asian American or Multiple Races (4% each). Black or African American females comprise only 3% of the population and the smallest percentage of female engineers (1.5%) is represented by unknown ethnicities. These data are consistent with national data, which indicated in 2014 that female-awarded engineering degrees were granted most often to White (55%) and Asian American women (14%) and least often to Hawaiian/Pacific Islander women (less than 1%) (Yoder, 2015). Representation of different ethnicities was purposefully included in Phase Two, the qualitative focus group data-collection, to allow the researcher to examine the possible relationship between self-efficacy and participants' decisions to enter engineering.

Table 1

Race / Ethnicity of Institution

Institutional Category	***n***	**%**
Asian or Asian American	9	4
Black or African American	7	3
Hispanic or Latino/a	12	5.5
Multiple Races	9	4
Non-Resident Alien	22	10
Unknown	3	1.5

(*Source:* Office of Institutional Research)

Table 2 demonstrates the total number of students in engineering during their junior and senior years and provides the research site's 2014-15 cohort graduation data. The total number of faculty and engineering students are included to demonstrate the faculty-to-student ratio and the small size of the research site. Thirty-two percent of all engineering students (*N*=702) across all academic-year standings, including 5th-year program students, identified as female. The faculty-to-student ratio, 1:10, was determined based on the total number of students and full-time faculty. The institution's 2014-15 graduation rate was 90% for women who had entered as freshman in the engineering program and were awarded engineering degrees as graduates of the College of Engineering. This data is significant with respect to the sample being identified as a representative ethnographic sample for persistence in engineering, as shown in Table 2.

Table 2

University Engineering Students & Faculty Data (2015-16 SY, 2014-15 Cohort)

Indicator	***n***
# Total engineering students (male & female)	702
# Women (all years) engineering students	224
# Women with junior-year standing	46
# Women in the 5-year degree program	5
# Women with senior-year standing	60
# Full-time engineering faculty	72
Student-to-faculty ratio	1:10
% Women for the representative population sample	16
% Women in engineering	32
% Women entering and graduating as engineers	90

(*Source:* Office of Institutional Research)

Descriptive Statistics

Demographics of sample. The population being studied was a purposeful sampling of junior and senior women at the research site's College of Engineering. They were representative of a larger ethnographic group of female students that have successfully persisted in engineering at the university. Demographic factors, including socioeconomic status of the sample studied, are shown in Table 3. In the survey, this status was self-selected by the respondents (*n*=40) and was based on the federal income guidelines utilized by the research site's OIR. When given the ordinal scale selections of high income (5), upper-middle income (4), middle income (3), lower-middle income (2), and low income (1), 52.5% (*n*=19) of the students identified their families as high or upper-middle income. Only 15% (*n*=6) of the survey respondents identified as lower-middle or low-income earners. Notably, most respondents classified themselves and their families as upper-middle income (*n*=16, 40%) and middle income (*n*=13, 32.5%), representing 72.5% of all respondents. The least-reported category was low income (*n*=2), which comprised only 5% of the respondents.

Table 3

Socioeconomic Status of Study Sample

Income Status	***n***	**%**
Low income	2	5
Lower-middle income	4	10
Middle income	13	32.5
Upper-middle income	16	40
High income	5	12.5

The researcher collected additional participant demographic data to include racial identification, as aligned with the OIR's category descriptions. Table 4 represents the raw data for each race category and gender, as identified by respondents. Students were permitted to identify with more than one group; thus, the total number of responses is greater than the total number of survey respondents. Demographics for the study indicated that Whites (90% of the study population) and Asian/Asian Americans (10%) were the most-represented categories in the sample population, while American Indian/Alaska Native (0%) and Native Hawaiian/Pacific Islander (3%) were the least-represented categories.

Table 4

Racial / Ethnic Identification

Racial/Ethnic Category	*%*	*n*
American Indian or Alaska Native	0	0
Asian or Asian American	10	4
Black or African American	5	2
Hispanic or Latino/a	5	2
Native Hawaiian or Pacific Islander	3	1
White	90	36
Other	0	0

Parental education. Levels of parental education were examined based on current research literature indicating that several factors, including family educational background and environment type (French et al., 2005; Tinto, 2006), contribute to problems with student retention in engineering. Table 5 identifies education levels among respondents' mothers and fathers. The majority of respondents' fathers (81%) and mothers (77.5%) had completed either a bachelor's degree or a master's degree. Only a small representation of the sample (5% of the participants) listed high-school graduation as their mothers' highest education level, while only 8% reported the same for their fathers. No participants identified either their mothers or fathers as having dropped out of high school or a higher-education program. This data suggests there may be a relationship between young women's degree pursuit and parental degree persistence and completion.

Table 5

Parental Level of Education

Mother	***N***	**%**
Did not finish high school	0	0
Graduated from high school	2	5
Attended college but did not complete degree	0	0
Completed an associate's degree	5	13
Completed a bachelor degree	20	50
Completed a master's degree	11	28
Don't know or not applicable	2	5
Father		
Did not finish high school	0	0
Graduated from high school	3	8
Attended college but did not complete degree	0	0
Completed an associate's degree	1	3
Completed a bachelor's degree	19	48
Completed a master's degree	13	33
Don't know or not applicable	4	10

Self-efficacy and academic indicators of success. In addition to parental levels of education, research indicates that academic factors contribute to retention in majors such as engineering. In an effort to examine the academic indicators of female students who have persisted in the engineering field, quantitative survey questions addressed the participants' current major GPA to demonstrate academic achievement within the research site's engineering program (French et al., 2005; Tinto, 2006). Sample responses to university GPA standing are represented in Figure 2. Thirty-nine percent of respondents' GPAs fell into the upper range of 3. Most survey respondents reported higher GPAs that fell in the range of 3.5 – 4.0. Participants' perceptions of their ability to meet the engineering major's demands are also included in Figure 3 to determine if data supported feelings of self-efficacy aligned with academic performance, as measured by GPA within the major. Findings for the sample indicate that 100% of the subjects felt they were able to meet the demands and hard work required of their major, consistent with higher GPA values.

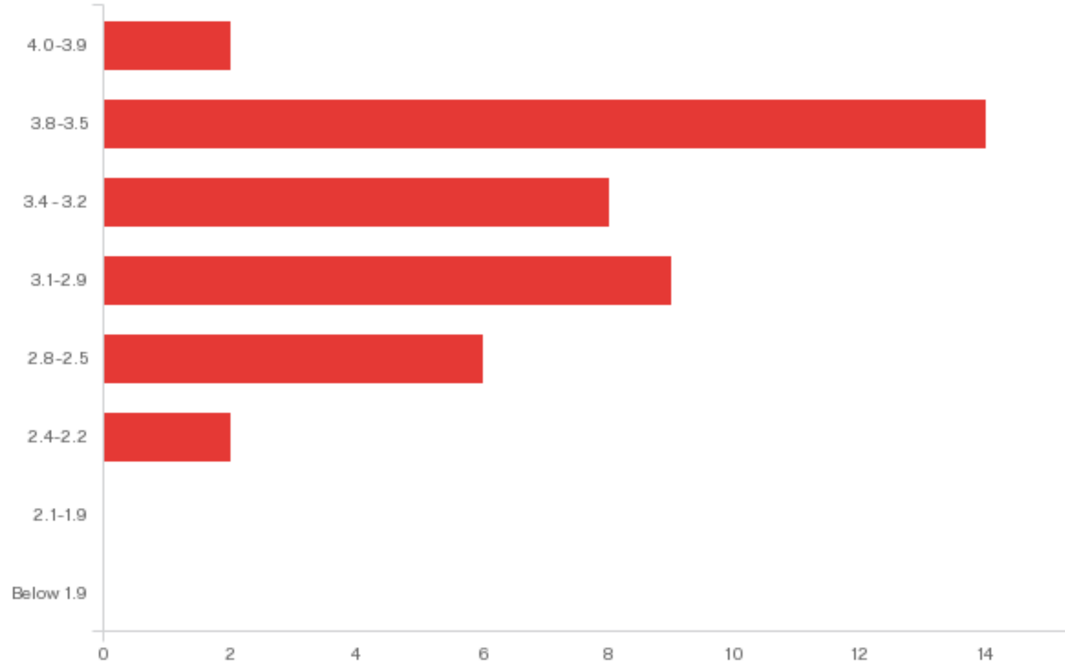

Figure 5. GPAs for SY 2015-16.

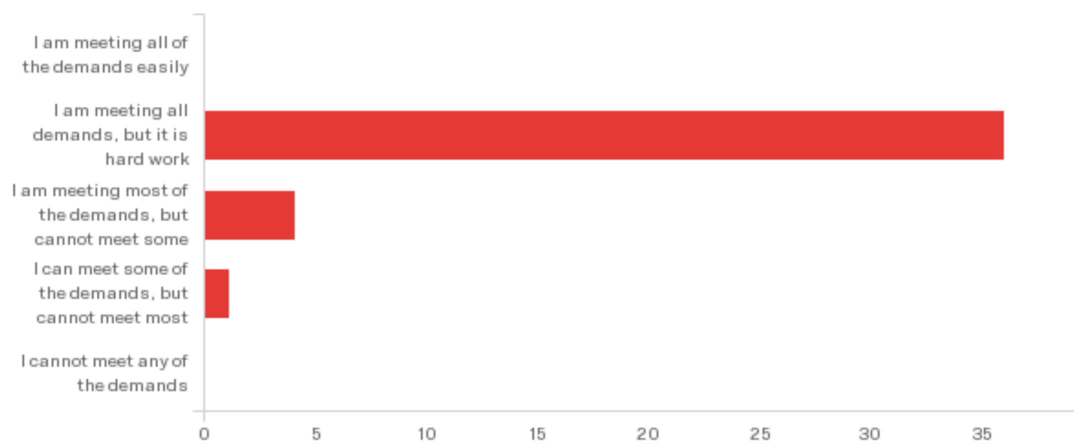

Figure 6. Respondents' self-perceptions of meeting the engineering major's demands.

Research also indicates that formal pre-engineering experiences can include an AP curriculum to advance students in engineering and prepare them for the rigors of a college-level engineering major (French et al., 2005; Ralston et al., 2013; Tinto, 2006).

Subjects were surveyed on their formal pre-engineering academic courses, including completion of AP calculus, mathematics, and science courses. Data displayed in Table 8 indicates that 82.5% of respondents had completed mathematics courses including trigonometry, and 70% of students had completed AP Calculus AB, the equivalent of a first-semester college calculus course, prior to attending the university. Significantly fewer students had completed AP Calculus BC, the equivalent to a second-semester college calculus course (College Board, 2016). These results reveal that within the sample, a majority of the subjects had taken advanced mathematics courses prior to enrollment in the university. Data also indicates that a majority of the subjects had completed both physics (87.5%) and chemistry (92.5%) in high school. Slightly less than half (47.5%) had enrolled in AP physics. The data is presented in Table 6.

Table 6

Study Sample Mathematics Course Completion

Course	***n***	**%**
Trigonometry	33	82.5
Calculus	27	67.5
AP Calculus AB	28	70
AP Calculus BC	16	40
High-School Access to Courses		
AP Courses	39	97.5
College Courses	1	2.5

High-school science courses are also part of academic preparations for a STEM major such as engineering. Table 6 indicates that most students were able to complete an AP course; however, less than 50% were enrolled in an AP Physics course (Table 7).

Table 7

Study Sample Science Course Completion

Science course	***n***	%
Physics	35	87.5
AP Physics	19	47.5
Chemistry	37	92.5

Self-Efficacy and MSLQ Scales

The social cognitive theory applied to educational practices supports the belief that one can execute a course of action to produce desired results and attain success (Bandura, 1997). As young women interact with others in their learning environment, this self-perceived ability affects their perceptions of how they work in groups, think critically, and achieve in courses such as math and science. Participants in this study rated themselves compared to their engineering peers, both male and female, at the university level.

Self-perceived ability was computed as the average of items in question 17 obtained from the APPLES questionnaire; they are listed in Tables 8 and 9. Subjects were asked to rate themselves on their abilities as compared to their classmates using an ordinal scale of 1-5, where 1 = lowest, 2 = below average, 3 = average, 4 = above average, and 5 = highest. Most significantly, the data indicates that the mean of all respondents' abilities is defined as average, despite university GPAs that were identified in Figure 2 as above average. Respondents rated themselves as above average in both the ability to work in teams (M = 4.15) and the ability to solve problems (M = 4.05).

Respondents generally rated themselves as average when compared to their peers in the area of mathematics (M = 3.78) and science (M = 3.68). The frequencies, mean, and standard deviation for self-efficacy is found in Table 8.

Table 8

Study Sample Self-Perceived Ability

	n	***Min***	***Max***	***m***	***SD***
Overall ability	40	2.77	4.62	3.6808	0.43811
Math ability	40	2	5	3.78	0.698
Science ability	40	2	5	3.68	0.656
Critical-thinking skills	40	2	5	4	0.784
Problem-solving skills	40	2	5	4.05	0.749
Ability to perform in teams	40	3	5	4.15	0.662

Feelings of self-perceived ability obtained from the APPLES questions in the survey can be distinguished from the MSLQ self-efficacy measures. In examining the APPLES question data, no significant relationship was found between respondents' socioeconomic status and feelings of self-efficacy (Kruskal Wallis Test = 2.451, p = .653). The literature supports the fact that increased self-efficacy and STEM identity-development can be influenced by friendship groups and social supports that may not exist in lower socioeconomic status groups who may be at risk (Robnett & Leaper, 2013; Stoeger et al., 2013). These results are outlined in Table 9.

Table 9

Relationship Between Self-Perceived Ability & Socioeconomic Status Test Statistics[a, b]

Socioeconomic Status	***n***	***m***	***SD***	***p-value***
Low income	2	3.5769	0.59832	0.653
Lower-middle income	4	3.5769	0.4594	
Middle income	13	3.6568	0.4675	
Upper-middle income	16	3.6683	0.47478	
High income	5			
		3.9077	0.19911	

a. Kruskal Wallis Test

b. Grouping Variable: Would you describe your family as: (Mark one)

Motivation

Given the respondents' self-rating of average as compared to their peers, the researcher was interested in identifying university-level supports respondents utilized when they encountered academic difficulties. The small student-to-faculty ratio of 1:10 at the research site (see Table 2) means that students most likely have had opportunities to interact with faculty and utilize other academic supports for their persistence in engineering when they encounter struggles, such as the writing center, ESA, and mentors. Respondents reported utilizing the writing center and upperclassman mentoring most often to support their success (see Figure 7). It is also important to note that 18% of respondents did not utilize any support services offered by the university, therefore succeeding on their own without assistance from formal or informal supports. Utilization of university support supports are included in Table 10.

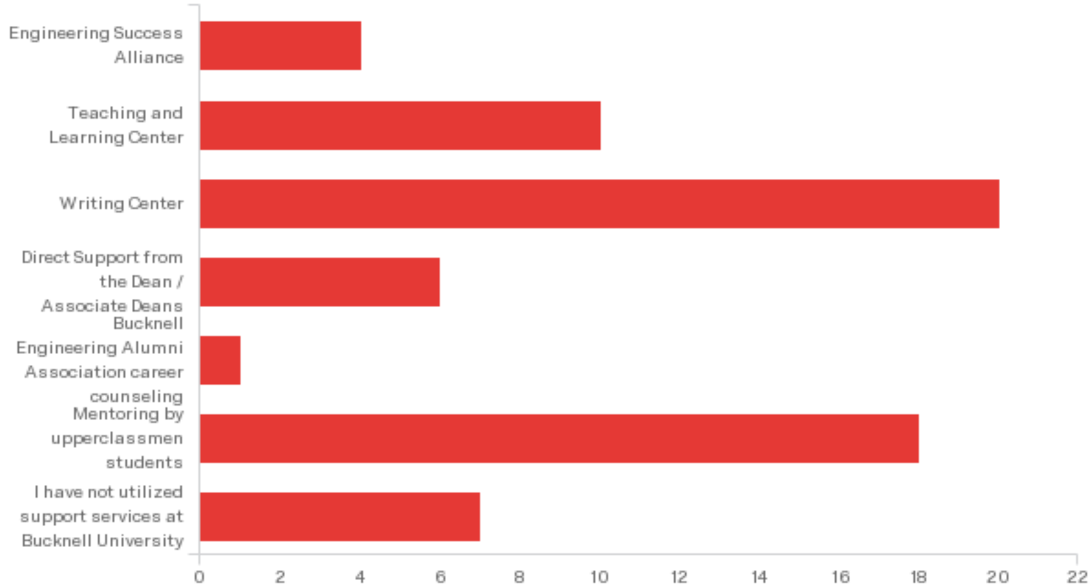

Figure 7. Participant utilization of university supports.

Table 10

Seeking Help From Peers[a]

Engineering courses	***n***	***%***
Yes	38	95
No	2	5
Mathematics courses		
Yes	36	90
No	4	10

a. When I can't understand the material in a courses I ask another student in class for help.

The following variables demonstrate resources utilized by those respondents who sought assistance. Among those who sought assistance, respondents were willing to seek help from professors (87.5%) and other engineering students (87.5%). See Table 11.

Table 11

Use of University Resources for Help[a]

Professors		*n*	%	*Valid %*
	Yes	35	87.5	97.2
	No	1	2.5	2.8
Other engineering students				
	Yes	35	87.5	97.2
	No	1	2.5	2.8
	Missing	4	10	

a. I have sought help from…

Given the data on support services utilized, there appears to be a significant relationship between respondents' GPAs and their utilization of the ESA for support (Fisher's Exact Test = 10.92, p=.010). As noted in the cross-tabulation in Table 12, those students who utilized the ESA appear to be more concentrated in the lower GPA levels.

Table 12

Cross-tabulation GPA & Usage of ESA

GPA	*n*	%	*p-value*
4.0-3.9	2	5	0.012
3.8-3.5	14	35	
3.4 - 3.2	8	20	
3.1-2.9	9	22.5	
2.8-2.5	5	12.5	
2.4-2.2	2	5	
Missing	*4*		

**Normally Pearson Chi Square is done, but expected count less than 5; Fisher's Exact Test was utilized*

a. 9 cells (75.0%) have expected count less than 5. The minimum expected count is .20.

b. The standardized statistic is 2.519.

Motivation and MSLQ Scales

Motivation is measured as the average of the four motivation items obtained from the MSQL inventory. Due to this study's small sample size, non-parametric tests were used when possible. The Kruskal Wallis test, the non-parametric equivalent to a one-way ANOVA, was used to assess for the possible presence of a relationship between motivation, respondents' parents' education, and family income. The Mann Whitney U, the non-parametric equivalent to the *t*-test, was used for the binary variables of race, "being the first-generation college student," and "having an immediate family member holding an engineering degree." Based on data collected from the 40 female participants, the self-rating for extrinsic goals have a mean of 4.12, while intrinsic goals have a mean of 3.92 (see Table 16). Both means fall within one standard deviation and are higher than self-efficacy as a source of motivation. There is no significant difference in motivation across the difference levels of mother's education (Kruskal Wallis Test = 2.663, p = .446). This data is presented in Tables 13 and 14.

Table 13

Motivation and Mother's Education Test Statistics[a,b]

What is the highest level of education that your mother completed?	***n***	***%***	***p-value***
Graduated from high school	2	5	0.446
Completed an Associate's degree	5	12.5	
Completed a Bachelor's degree	20	50	
Completed a Master's degree	11	27.5	
Don't know or not applicable	2	5	

a. Kruskal Wallis Test
b. Grouping Variable: What is the highest level of education that your mother completed?

There is also no significant difference in motivation across the different levels of father's education (Kruskal Wallis Test = 4.326, p =. 228). This data is presented in Table 14.

Table 14

Motivation and Father's Education Test Statistics[a,b]

What is the highest level of education that your father completed? (mark one)	***n***	***%***	***p-value***
Graduated from high school	3	7.5	0.228
Completed an Associate's degree	1	2.5	
Completed a Bachelor's degree	19	47.5	
Completed a Master's degree	13	32.5	
Don't know or not applicable	4	10	

a. Kruskal Wallis Test

b. Grouping Variable: What is the highest level of education that your father completed?

This researcher was interested in exploring what motivations had influenced the participants to enroll in an engineering major in order to evaluate if a commonality existed within the study population that could be shared with the larger ethnographic group. Respondents indicated that teachers (32.5%) and family members (35%) were the most influential factors in their decision to major in engineering, with self as the second most important factor (25%). The least significant factor (2.5%) was having a mentor outside of the educational setting, as displayed in Table 15.

Table 15

Significant Factors in Selection of Engineering Major

Factor	***n***	**%**
Teacher	13	32.5
Mentor	1	2.5
Family	14	35
Self	10	25
Other	2	5

**Identify the most influential factor in selecting engineering as a major.*

Given the closeness in the range of data among the influence of teachers, family, and self as motivation to enroll in an engineering major, it is important to compare whether intrinsic or extrinsic motivations are most influential for young women enrolling in engineering programs. To address this question, this researcher examined the intrinsic and extrinsic goal-motivation scales shown in Table 16.The mean for intrinsic motivation was 3.93 (SD = 1.02), while the mean for extrinsic motivation was 4.13 (SD = .99). Both scales are moderately correlated (r = .515, p = .001), as shown in Table 16.

Table 16

Paired Samples Test

Intrinsic Goal & Extrinsic Goal Correlations	***n***	**Correlation**
	40	0.515
Intrinsic Goal - Extrinsic Goal	**Mean**	**SD**
	-0.2	0.99228

There are no significant differences between the means of intrinsic and extrinsic motivations (t = -1.275, p = .210), as shown by the paired t-test in Table 16. In other words, we cannot say that one dimension of motivation is more important than the other.

Phase Two (Qualitative) Findings

In the second, qualitative phase of this study, the researcher chose to examine the retrospective perceptions of the young women as an ethnographic group by using a constructivist approach wherein the topic is explored with a group of people whose knowledge of that topic has been shaped by their individual experiences (Merriam, 2009).

Participant Selection and Focus Group Design

The participants in this study were viewed as persisting in engineering based upon their standing as either a junior or senior in the college of engineering and the assumption that they would graduate with their respective cohort. The researcher contacted Phase One study participants that completed the quantitative survey and indicated a willingness to participate in focus group interviews. An explanation of the importance of ethnographic research and the constructivist viewpoint guide the philosophical assumptions of this researcher, as explained in Chapter 3, and led to the formation of the focus group questions on motivation and self-efficacy. The second phase of the study allowed the voices of young women who had both persisted and navigated STEM, specifically the engineering pipeline, to be heard. These voices allow the research community to gain insight into the motivations, experiences, and viewpoints that have enabled young women to persist when other students have not in engineering.

The researcher intended to conduct two focus groups consisting of five individuals each. After Phase One, 15 subjects provided their email addresses for participation in the Phase Two focus groups. Of the 15 individuals the researcher emailed directly for participation in the focus group, five were able to participate and consented to the use of their interviews for the research. Three subjects were placed in focus group 1 and two subjects were placed in focus group 2; random participant numbers were assigned to each individual.

Of the five participants, one was Asian American, one was African American, and three were White, representing the three largest ethnicities / races noted in current research as obtaining bachelor's degrees in engineering (Yoder, 2015). This racial breakdown is also consistent with ethnic / racial categorical data obtained from the sample that participated in Phase One of the study. Fortunately, given the small sample size, the participants represent multiple ethnicities. Both focus groups were recorded utilizing voice-memo software, with a USB drive with voice-recording capabilities as backup. The interviews were transcribed and the researcher used both hand-coding methods and NVivo software to analyze responses and transcripts. Ten interview questions were selected for deeper analysis during this phase of the study, but due to data collected from the initial quantitative survey, this number was narrowed to five question. Thus Phase Two focuses on participants' perceptions of mathematics, science, and skills competencies; the influence of family, faculty, and mentors as sources of motivation; interactions with peers; and the development of self-efficacy. The following questions were included in the qualitative focus groups:

1. Describe your perceptions of your exposure to math and science opportunities and experiences K-8. What experiences did you have that were the most influential?

2. Describe your perceptions of your experiences in grades 9-12 in Advanced Placement courses, mathematics, computer programming, pre-engineering courses and co-op experiences. Were there many opportunities for these experiences at your school?
3. Was there one experience in high school that led to your decision to pursue engineering after high school or was it a combination of other factors? Explain.
4. Describe your experiences utilizing university supports in the engineering department. Describe the perceptions you have of the supports on campus, specifically, for retaining female engineers as compared to that of your male counterparts.
5. Why do you believe you have persisted in engineering when so many other women do not persist in engineering?

Open, Thematic, and Line-by-Line Coding of Participant Responses

Following transcription of the focus group responses, open coding was utilized to identify emerging data trends. During the open-coding phase, the researcher was "open" to any segment of data that might be useful to the study; notes were jotted in the margins using a hand-coding process (Merriam, 2009). The subset of these thematic categories is outlined in Figure 5, which demonstrates six themes that emerged from interviews with young women who have persisted in the study of engineering. During the coding, key words, participant phrases, and supporting statements were noted in the margins to assist the researcher in creating categories or themes that emerged from the recorded transcripts of focus group responses. In both transcribed focus groups, the following themes emerged: 1) Influence of others, 2) academic opportunities, 3) motivation, 4) mathematics, 5) university experiences, and 6) culture. Subcategories are also included in Figure 5. Keywords from open coding of the transcript themes are noted in each discussion point below.

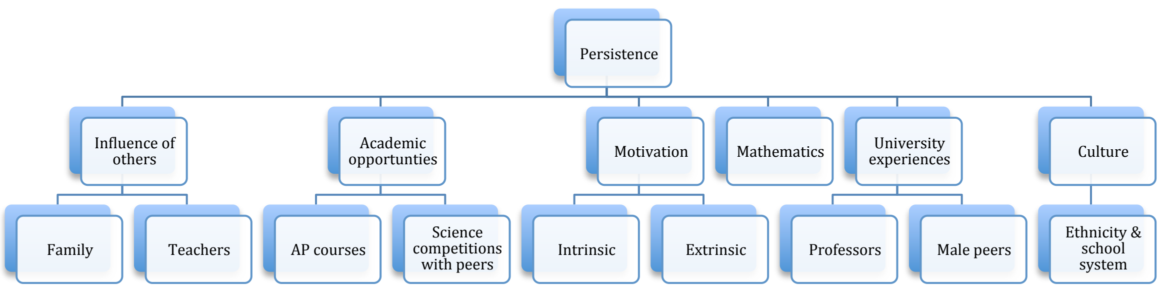

Figure 8. Themes emerging from coding of focus group responses.

Emerging Themes

Theme 1: Influence of Others

Keywords: teacher, mother, encouragement, influential, math, competition, afterschool. Subjects were asked during the focus group to describe their perceptions of their K-8 exposure to math and science opportunities and experiences and to identify any specific influential experiences. Almost all participants mentioned other people's influence in their responses. More specifically, they discussed whether or not they had a strong recollection and/or affinity for their K-8 math and science teachers, with a particular focus on mathematics teachers' influences and whether or not the teachers encouraged them as students. Participant 1 indicated that she had had a "very active science teacher in 6th, 7th and 8th grade, so I participated in […] science-based competition. […] We also participated in […] another competition […] and so I think all three of those really culminated in me understanding that I wanted to go into engineering." She indicated that she had participated in all of the programs the teacher offered because of the teacher's encouragement of her and all of her classmates. The main reason she was active in these math programs was that the teacher was "super encouraging of everyone. […] I participated in all of her programs." Participant 2 in focus group one indicated the opposite experience in grades K-8. She noted, "In middle school I honestly hated all my science teachers." However, she could not recall much that stood out about her mathematics teachers during that time. The third participant in focus group two stated, "I didn't like my math teachers." This mixed response about mathematics teachers' influence was further noted among the young women when they answered questions regarding what about the teacher stood out to them.

In focus group one, Participant 4 verbalized a strong response; she had attended a school that heavily emphasized math skills to prepare students for entrance exams that would determine what type of university they would eventually be accepted into at the end of their high-school career. She specifically recalled an experience she recalled with her 9th-grade teacher: "There's this one incident I remember from my class, a teacher […] she said, 'Well, look at you girls, you did fine in middle school, but you'll be […] finding some difficulty catching up with the boys in high school.'" The participant indicated that this high-school mathematics teacher was referencing the girls' mathematics ability. During the focus group discussion, one of the other two subjects asked the subject how she felt about the statement, and the subject replied, "That was the most awful thing I ever heard in high school."

Participant 2 shared with the group that her mother had heavily influenced her interest in mathematics and science. She said that her mother had signed her up for several afterschool mathematics and science groups during middle school and that she had also encouraged her to learn mathematics.

Theme 2: Academic Opportunities

Keywords: Advanced Placement/AP, math and science, competitions, robotics. Each of the five participants attended different schools with varying academic opportunities. In focus group one, Participant 1 attended an all-girl's high school, Participant 2 attended a boarding school, and Participant 4 attended a school in China that prepared students for testing to continue in a university. The participants shared unique answers to the following questions: "Describe your perceptions of your experiences in grades 9-12 in Advanced Placement courses, mathematics, computer programming, pre-engineering courses and co-op experiences," and "Was there one experience in high school that led you to your decision to pursue engineering after high school or was it a combination of other factors?" Two participants mentioned their enjoyment of science and robotics competitions and game-based competitions where they competed against all-male teams and other schools. Participant 1 noted that a Future Cities game-based competition with her peers was especially significant in allowing her to develop an interest in creating things and using technology. Participant 4 in focus group 1 mentioned that her school was strong in robotics and that she had never really thought about joining the team because it was "just a group of guys"; thus she indicated she was not really bothered by the male-dominated program during middle school. After middle school, however, she indicated she had learned that "the robotics team did not accept girls" and that she had never heard of any girls trying to break into that group of boys. Participant 4 did not indicate in any way that this fact bothered her; she simply accepted the way this opportunity was designed.

Participant 2 from focus group 1 competed in robotics and mathematics competitions at her boarding school, and her school had won several years of competitions in the region. She discussed the joy of the academic competition and her positive interactions with peers and her advisor, who encouraged her in mathematics: "I think math was more concentrated on than science, as least for me, in K-8. I, we, had more practice with it. It was more of, like, a competition. […] I was hard-core math for a long, long, long time. […] I did a lot of math groups, like a lot of afterschool math programs that were mostly game-based."

All the participants in both focus groups discussed AP courses (or lack thereof) with respect to their academic opportunities. In focus group 2, the participants indicated that mathematics was the first area that separated students from their peers into tracks that would determine the high-school mathematics courses they would take. According to Participant 2 in focus group 2, a first-generation college student, "Math is the first one you could actually choose what level you took and then science followed years after that." Participants discussed the availability and rigor of AP courses in each of their schools. Participant 1 in focus group 2 noted that AP science was not introduced until her junior year and that several of her peers at the university had access to more advanced classes that she was unaware even existed in high school. She stated, "Other people […]

already knew engineering […] they had pre-collegiate engineering classes […] not co-ops or anything, but they […] have a program they'd gone to. And I did not know that was a thing. I even have a friend who, also a woman in engineering, she graduated last year, she went to an academy of math and science. […] I felt like I was behind the second I got to school. […] Once I realized that the people had that upper hand […] I felt like I was always trying to catch up."

Other participants noted that the first AP courses they had access to were environmental science, history, and languages. They understood that AP mathematics courses included calculus AB and calculus BC, which need to follow a mathematics sequence, but there was some frustration exhibited by both focus groups that AP sciences had not become available to them earlier. Three participants across both focus groups noted that more males had enrolled in the AP science courses and more females had enrolled in the AP history and English courses. Participant 2, who had attended boarding school, indicated that her school did not have enough teachers to offer multiple AP courses, so to combat this barrier, AP courses such as computer science were offered in Saturday Seminars because the professors wanted to expose the students to the material. Several participants indicated they did not have access to AP computer science and "the only computer classes were Intro to Computers and Digital Media Design, which was basically how to use iMovie. […] We also didn't have any computer programming." The most frequently accessible AP courses across both groups were AP calculus and AP chemistry.

Theme 3: Motivation

Keywords: family, high school, Advanced Placement/AP, physics, stubborn, activist. The researcher was particularly interested in finding additional data on the motivation behind young women's pursuit and persistence of engineering after high school. Two of the focus group questions helped clarify sources of motivation that could be intrinsic, extrinsic, or both in nature. Data from the quantitative survey sought answers to various motivational constructs for the sample population and questions 3 and 5 of the focus group discussion sought further clarification and details.

Focus group question 3 asked study participants, "Was there one experience in high school that led to your decision to pursue engineering after high school or was it a combination of other factors?" In response, focus group 2 participants indicated that there had not been only one experience in high school that led them to pursue engineering. Participant 1 indicated her decision to become an engineer was made in middle school, and high school solidified her area of concentration. She had indicated "a great tie in my AP Bio and AP Chem classes. And, also I was touring colleges […] and I know someone that took Biology and Human Healthcare, so I ended up here." Participant 2 indicated that she had always remembered having an interest in science. She had utilized Discovery Science kits as a child and "high school solidified what I could do in engineering. […] I wanted to be an Imagineer for Disney […] and the big parks will usually take mechanical engineers […] and now that I am a civil engineer, it […] it's different. […] I have family members that are civil engineers." Participants discussed both intrinsic and extrinsic motivations, from the influence of family and the enjoyment of AP classes to picturing themselves as an engineer for a theme park.

Of the three participants in the first focus group, two could not recall any experiences in high school that stood out to them. Participant 1 in focus group 1 and Participant 3 in focus group 2 indicated that their minds were made up in middle school, indicating that the "Future Cities competition is what did it […] I think that was probably the one experience, but high school, if anything, would have gone backwards." Participant 2 indicated she did not know what motivated her decision to enter into engineering, but that she "really like[s] math […] and I really, really like physics, but for a long time […] I wanted to build a roller coaster, like for Disney […] now I'm looking more industrial, like, I want to run a plan floor. There's a […] Stacy's Pita Chips factory 10 miles south of Boston. […] I'd love to work at Stacy's Pita Chips." Participant 4 in focus group 1 indicated that other factors were more important than high school – for instance, her parents are engineers and her mother is a chemical engineer. She indicated that her parents had told her she could do anything she wanted but since all of her family members were scientists and engineers, she indicated she would most likely end up doing the same thing. However, when another participant asked if she felt pressure from her family, Participant 4 indicated, "It's not a lot of pressure, but growing up in such an environment, it kind of steers you one way or the other."

Relative to motivations and persisting in engineering, the focus group participants were asked, "Why do you believe you have persisted in engineering when so many other women do not persist in engineering?" The responses participants shared had a common theme. They indicated that they considered themselves strong women who did not give up on anything easily. Answers in focus group 1 included, "I kind of like being in a male-dominated field in that I like proving people wrong," "I consider myself an extraordinarily strong feminist […] and I really want to do very well and show that I can do very well, mostly for myself. And […] like that stupid kid who thinks girls are dumb, like I want to show him, very wrong." Another participant indicated there is "a small part of me that […] wants to prove that women can do this stuff, too […] but I picked these two [engineering] majors out when I was 12 and so, like, for me to […] go back on that now […] like, I am not being true to myself." During the focus group, the young women began to respond to each other's comments, and Participant 1 noted that "it's the fight to change […] there's a little bit of activist in me and I […] want to make it better for the future." The last part of the discussion among the three participants in group 1 closed with, "I just did my stuff," "You like it and you stick with what you like," and "I think we're all really stubborn also." These responses indicated participants' intrinsic motivation to be successful for themselves and to not give up on something they believe they are capable of doing as well as their male peers.

In focus group 2, discussion of intrinsic factors was also a factor in persistence. Participant 3 immediately and emphatically answered the question, noting that there are different reasons for quitting engineering, such as finding out it is not one's interest and not understanding what it was about when declaring a major. She indicated that other people have said, "It's way too hard; I can't do this. I'm just going to do something else. And […] I've been raised and it's my personal belief that I can do anything I set my mind to and engineering should be no different." Participant 5 indicated that others had said to her, "Oh, it's too hard or too time-consuming […] it's insulting to me if I were to use that as my excuse to quit." She also indicated she would make a decent amount of money in the field, she would be able to create things to better people's lives, and she struggled in the engineering major in college comparing herself to others, but she likes challenges and feels engineering has taught her to work with people and has allowed her to be creative and gain life skills that other majors could not provide college students. She also acknowledges that she is not the smartest person in the room but that "no one can know everything, so it is okay. And it's just hard […] but everything that I've designed, it's got my name on it, it's a brand new idea that I had that no one else will […] You're going to impact the world in some way." These statements indicated her intrinsic motivation to persist even when difficulties arose in her college career. Participants in both focus groups indicated they had a strong sense of self, identification with the career, and identification with themselves as an engineer, as well as a strong sense of self-determination to be successful and prove they could achieve what they wanted to achieve.

Theme 4: Mathematics

Keywords: ability, track, potential, support. Research by Saucerman & Vasquez (2014) indicates students receive subtle messages from teachers that male students have a greater mathematics ability, despite similar test performance between both male and female students. In an effort to identify if self-efficacy existed with the females in the focus groups, question 2, referenced earlier, was posed to the groups. In describing their perceptions of their 9th- through 12^{th}-grade mathematics experiences, participants indicated that a stereotype threat existed for them. Several participants indicated that a math course was the first to be separated out by ability levels in middle school, and of the five focus group participants, three believed they were very good at math. Students who did not have advanced preparations in math or complete calculus BC considered themselves to be farther behind their classmates. Competition-based experiences existed in afterschool math programs and were thought to have influenced the participants' interest in engineering. None of the women in the focus group had to complete any remedial mathematics work in school, indicating that they had been exposed to some material in high school before enrolling in the engineering program. The university considered two of the students in focus group 2 (Participants 3 and 5) to be at-risk students because they were first-generation, minority college students. Thus, they received support from the ESA, including mathematics supports with a weekly required math lab to assist in completion of their coursework. The participants mentioned the help their ESA mentor had provided them in mathematics and in helping them to see their own potential in an engineering career.

Theme 5: University Experiences

Keywords: ESA, professor, dumb, opportunity, Society of Women Engineers/SWE. Question 4 focused on the use of university supports: "Describe your experiences utilizing university supports in the engineering department, and describe the perceptions you have of those supports on campus, specifically for retaining female engineers compared to that of your male counterparts." Responses to this question were largely different between the two focus groups. In focus group 1, a student discussed her scholarship for women in engineering, noting that without it she could not have afforded the university but that there was no scholarship for men in engineering. For chemical engineers, there "is a chem sem where once a week we have alumni […] come back and talk about, like, what they do in the field as a chemical engineer." One participant mentioned a male classmate in response to question 4, as well, as one of the participants was on a team with him this semester: "[H]e thinks girls are dumb inherently […] this is the 21st century; how can you think women are inherently dumb?" The same participant noted that she had had a professor who "thought that girls inherently think differently than boys and are dispositioned to not understand things"; she refused to take a class with him again during her college career.

All three participants in focus group 1 agreed on the positive nature of having an SWE chapter on campus, but all three noted that it was not very active and that many other schools with which they are familiar have more active chapters. Participant 1 added, "[O]ther than SWE, I really can't […] think of one thing that we do to encourage specifically women, which in one sense is good, because it makes women feel like we aren't treated differently." One participant briefly mentioned the ESA program, but she indicated that ESA did not regard the student's gender as much as where students attended high school and what kind of achievements they had.

The second focus group spoke specifically about how they utilized ESA, as that focus group was comprised of a minority student and a first-generation college student. The subjects stated, "[The mentor] would gauge where we are in classes […] prep us. […] I would say that really helped […] and having someone there for math lab really helped. I didn't take advantage of it as much as I should have." The participants also discussed the networking events designed for ESA students and mentioned they felt it had opened new experiences for them that other students did not have. Participants mentioned the professors, specifically one visiting professor. One participant commented, "[W]hen I did go ask for help, I was kind of insulted, told that he didn't understand why I didn't understand the material." Yet another example was cited by the same participant, indicating that another visiting professor was one of the best professors she had ever had and that he had acknowledged her and took the time to encourage her when she was frustrated. The other participant cited her ability to have a professor who was always working in the engineering building as a benefit, because she felt she could stop in and see her when she was struggling and ask her questions.

Theme 6: Culture

Participant statements supported the six themes identified during the coding of the qualitative data, including the two focus group interviews. They are separated by participant and appear in Appendix F, where the ethnographic group was separated by participant ethnicity to allow for data to be presented based on similarities of responses among the sample populations. Participants 1, 2, and 3 were White females, Participant 4 was Chinese, and Participant 5 was African American. This method of displaying key phrases as data provides another lens for qualitative analysis to determine if ethnicity and/or culture plays a role in participants' perceived experiences or if other common themes within the ethnographic group emerge as more important in developing perceptions among young women persisting in engineering.

Results and Interpretations

In a line-by-line hand-coding of keywords within the five interview transcripts, the following words emerged as most-frequently referenced by the participants: *science, different, classes, math, think, people, good, women, professor, time, fun,* and *experiences*. These keywords are aligned to support the six emergent themes for persistence categories revealed in the open and thematic coding: Influence of others, academic opportunities, motivation, mathematics, university experiences, and culture.

Similarities

The focus group data revealed several common themes that resonated across all the subjects, independent of participant ethnicities and/or cultures. Because of the study's small sample size, however, it is difficult to determine if these similarities are specific to this study or representative of a larger ethnographic group. Common motivation-related themes emerged from the qualitative phase of the study, specifically the intrinsic factors of self-motivation, including showing others they can do it, beating statistics as a first-generation college student and minority, knowing they need to work hard, and the intrinsic values of achieving what they set out to do by not giving up. All subjects indicated that the focus of their K-8 education had been predominately on mathematics rather than science, even at the different types of schools they attended.

Several subjects also spoke about finding an interest in their abilities and making class fun during middle school, citing a connection to a teacher that had encouraged them to continue participating in challenging activities. Surprisingly, the individuals interviewed did not have access to many pre-engineering courses or expansive AP offerings, but they did participate in physics and advanced mathematics courses. The response most characteristic of the ethnographic group studied, even across all ethnicities, was the young women's feeling of self-efficacy as demonstrated by their confidence in their abilities and determination to meet the challenges with which they were presented. This motivation for persisting in the study of engineering was more common among the participant statements than any other motivating factor.

Respondents' engineering-related opinions were positive, with helping others and making a good salary mentioned as rewards of completing the major and pursuing the profession. Interviewees shared a common interest in the opportunity for future jobs, and they all clearly communicated a belief in their own ability to complete the program, even if they encountered difficulties and compared themselves to others around them.

Differences

Differences in participants' responses by race/ethnicity did exist, although there were more commonalities than differences. However, with such a small sample size, it is impossible to determine if these differences are related to racial/ethnic differences or are merely specific to this sample. One difference presented by the Asian American transfer student was that in her native country, there was not an option for girls to participate in robotics clubs but that that there was an expectation for every student to graduate and pass university entrance exams to get into the best colleges. She also indicated that her parents were engineers and that her environment had steered her into that major. The African American participant indicated that she had come from a home where she had beaten certain statistics; comparing herself to others, she became determined to beat the odds and become an engineer so she could help others and make a good living.

Summary

The ethnographic approach in Phase Two of the study allowed the researcher to examine experiences beyond the qualitative findings and provided insight into the details behind participants' AP course, middle-, and high-school experiences leading to their enrollment in an engineering major. Participants' university experiences were also examined, and subjects elaborated on the level of determination and motivation behind their persistence in college where others did not persist, revealing an interesting view into the minds of this ethnographic group. The interviews also allowed different races and ethnicities to be represented and for commonalities to be seen that crossed the boundaries and differences among the young women's races. Conclusions and recommendations are outlined in Chapter 5, the final chapter of this study.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

This study's objectives were to examine young women's perceptions of their K-14 STEM experiences to evaluate how these experiences influenced their decision to enroll and persist in an engineering major. The study's aim was to determine if there were shared experiences among the young women as an ethnographic group that could be identified as common factors for enrollment and persistence in engineering. Recommendations based upon the research findings and a discussion on potential interventions to promote persistence in engineering are outlined here, and suggestions for future research are made based on the researcher's interpretation of significant findings.

As explained, underrepresentation of women in engineering continues to exist. With few K-14 educational programs supporting the STEM pipeline (Ralston et al., 2013) and a congressional committee that has called for increased funding in mathematics, science, and engineering, there continues to be a need to examine engineering enrollment and persistence. Low levels of academic self-efficacy and high feelings of self-doubt can negatively contribute to young women's decisions to enter engineering, and this negative belief about abilities can ultimately influence their persistence (Heilbronner, 2012) in STEM-related fields such as engineering. Even when other areas of engineering may experience some gains, lower numbers continue to exist in computer and mechanical engineering disciplines for women (Yoder, 2015). This is especially true for African American women. The population studied in the focus groups is a representative sample, with Whites as a majority and African Americans and Asian Americans as a minority (Yoder, 2015). For qualitative data-collecting purposes, the engineering major concentrations in the study included mechanical engineering, chemical engineering, and computer engineering.

Conclusions

A quantitative survey instrument utilizing questions related to self-efficacy and motivation was developed to determine if patterns existed among women in their junior and senior years that might lead to enrollment and persistence in engineering. A total of 61 women responded to the survey, for a 40% response rate.

Self-Efficacy

Phase One findings from the Combined APPLES and MSLQ Perceptions and Motivations of Persistence in Engineering Survey distribution indicated that respondents demonstrated above-average feelings of self-efficacy, with an average rating of 3.68 on a scale from 1 to 5, with 1 being the lowest and 5 being the highest. Interestingly, though the study participants rated themselves lowest on their mathematics and science abilities, they rated themselves significantly higher on their critical thinking, problem-solving, and teamwork abilities. No significant relationship was found between respondents' socioeconomic status and self-efficacy, and the same was true with the potential relationships between race and self-efficacy and parental education and self-efficacy.

This data supports the conclusion that as an ethnographic group, young women who persist in engineering have higher-than-average feelings of self-efficacy, independent of other demographic variables such as race, parental education, and socioeconomic status. This data was further supported by Phase Two of the study, which consisted of focus group interviews in which the women indicated their beliefs that they were as capable as their male peers as engineers. The data was also reinforced by the respondents' attitudes, which were focused on their own beliefs that hard work and effort had resulted in their success in engineering degree programs.

Academic Success Indicators

In Phase One of the study, 39% of the respondents indicated higher-range GPAs (above 3.0), with most resting in the 3.5–4.0 range. There was a significant finding that students with lower GPAs had utilized the university's support program for engineers, the Engineering Support Alliance, which is designed to support potentially at-risk students entering the engineering program. This data reinforces that the students who struggle academically were utilizing relevant support services. There was not enough variation in the sample to determine a relationship between AP courses taken in high school and respondents' current GPA. This lack of variation does affirm, however, that students entering the engineering program had enrolled in high-school AP courses as preparation for their fields of study, but that only 40% of students had had the opportunity to take AP Calculus BC, the second-semester equivalent of college calculus.

In Phase Two of the study, the focus groups revealed respondents' frustrations at the lack of AP mathematics and science courses available to them prior to college, explaining that they felt some of their college peers had more pre-engineering experiences or higher levels of AP mathematics coursework than they had been able to participate in before graduation. Every subject in Phase Two had completed at least one AP math course and one AP science course, however, further solidifying the conclusion that AP course preparation was a common high-school experience for this ethnographic group.

Motivation

In Phase One of the study, the quantitative survey instrument revealed that respondents viewed extrinsic goals, with a mean of 4.12 on a 1-5 scale, and intrinsic goals, with a mean of 3.92, as relatively significant motivating factors. Both means fell within one standard deviation and were identified as more significant than self-efficacy as a source of motivation. In Phase Two of the study, motivation was further explored, with a question focused on identifying why the subjects believed they had persisted in engineering when other young women had not. In response, all the subjects indicated an unwillingness to leave a major of study they felt they were capable of achieving, would be a rewarding career, and would support their desire to achieve difficult goals. Several participants also cited proving others wrong, having a sense of stubbornness, and being true to themselves as motivators. This intrinsic goal motivation was apparent in the young women's focus group responses, and evidence statements included in the qualitative data analysis referred to the presence of intrinsic goals among participants throughout the interviews.

It is important to examine grouping for all students, including young women, supports, and relationships, and attitudes of the educators that are facilitating STEM identity-development, both formally and informally. The findings of the qualitative study indicate that most of the participants had determined they would pursue engineering during their middle-school years, supporting literature that indicates the decline in interest in STEM subjects begins as early as age 11, during the middle-school years (Stoeger et al., 2013). The participants in this study indicated that they had participated in and had access to AP courses but that few AP science courses had been offered at their school early in their academic careers. Furthermore, participants indicated an environment that was less supportive in high school than in the middle years, when subjects become increasingly difficult and students' perceived ability can waiver.

Implications

The present study has attempted to identify common themes in preparing young women for enrollment in an engineering major of study, as well as themes that emerged to support persistence within the ethnographic group of young women enrolled in an engineering major. This study is a starting point to have meaningful dialogue at the K-14 levels about strengthening mathematics supports and opportunities available for young women in preparation for AP coursework. While it is apparent that the young women in the study have above-average self-efficacy with regard to their ability to work in teams, solve problems, and think critically, the fact remains that their self-efficacy indicators are lower in core academic areas such as mathematics and science, even for those individuals who have persisted in the engineering field.

It is important for administrators and teachers to reinforce in the middle-school years that mathematics ability is learned and acquired, and that mathematics can be fun and engaging if a teacher takes an interest in his or her female students and helping them believe they can be successful. It is also recommended to engage young women in more robotics and science competitions to establish a culture in which they can enjoy informal programs and where these activities are not perceived to be male-only clubs or activities, as was mentioned in the qualitative focus groups. It is also important to recognize that pre-engineering programs, although helpful, may not occur in schools around the country and that disparities exist in both pre-engineering programs and AP courses. The primary recommendation resulting from this study is as follows: We must consider young women to be an ethnographic group that needs to have intrinsic goal-setting fostered, feelings of self-efficacy developed, and mathematical achievement supported as early as middle school. We must also support young women in addressing the struggle of transitioning to the university setting and pursuing engineering degrees in the current model of education.

Recommendations for Future Research

The researcher recommends the following areas for future research based on the study's findings: supporting the formation of self-efficacy in mathematics and motivating AP course enrollment for young women.

Supports for the Formation of Self-Efficacy in Mathematics

One prospective area for future research is to identify factors that lead to the strong formation of self-efficacy in mathematics during the middle-school and high-school years for young women. These factors are especially critical in building higher levels of self-efficacy and encouraging more young women to develop confidence in their abilities and pursue advanced mathematics in high school. This research focus could help to identify the interventions and supports needed in American schools to encourage more young women to acquire mathematics skills and enroll in advanced mathematics courses.

Motivations for AP Course Enrollment

A second area for future research might include a comprehensive examination of the intrinsic motivations that guide young women in their enrollment in AP mathematics courses in high schools across the country. Preparation in middle school for pre-AP coursework could be the starting point for identifying young women's early motivation for AP enrollment.

Summary

This chapter contained an overview of the present study, findings from the quantitative and qualitative phases of the study, and recommendations for future research. The central research problem and purpose statement served as the foundation for both the survey and focus group interviews, which occurred in the context of an ethnographic approach. The study was designed based on a constructivist viewpoint and an understanding that knowledge builds over time and is influenced by the experiences that result in deeply held perceptions of ability and motivation to succeed. These methods provided a comprehensive understanding of a small sample of young women who have been successful in their pursuit of an engineering degree when other individuals have not been as persistent in their goal achievement. This study provides insight into young women's experiences at a private, rural university in central Pennsylvania.

The Phase One results of this study indicate that young women that have persisted in engineering have done so due to both intrinsic and extrinsic motivational factors. In the quantitative portion of the study, findings demonstrate that the population of persisters at the university largely fell into the upper-middle and middle class socioeconomic status categories and that the majority of their parents had completed bachelor's degrees or above. However, in the qualitative (Phase Two) portion of the study, differences did not emerge among the sample population of persisters based on their socioeconomic, racial, or parental educational levels Rather, the participants' success was largely attributed to a strong sense of intrinsic motivation and a higher-than-average sense of self-efficacy. These feelings of self-efficacy and intrinsic motivation are strong contributing factors to the individual persistence of the young women that comprised the ethnographic group.

Given the small sample size, this study cannot be assumed to represent all young women who persist in engineering, so further research with larger sample sizes would need to be conducted to make conclusions of that nature. This study does, however, contribute to the body of research surrounding the knowledge of factors that contribute to enrollment and persistence by young women in engineering majors.

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APPENDIX A: QUESTION ANALYSIS FOR COMBINED APPLES AND MSLQ PERCEPTIONS AND MOTIVATIONS FOR PERSISTENCE IN ENGINEERING SURVEY

Research Topic	**Question Number (s)**	**Type of Research**	**Data-Collection Methods**	**Data Analysis**
What is the relationship between students' perceptions and persistence in engineering?	6-11; 14-17; 21-24; 29	Mixed-Methods	Online Qualtrics survey; Questions taken from APPLES & focus group; Structured open-ended questions; *Open-ended interview questions if additional data needed	Descriptive statistics (SPSS) and NVivo (open, thematic, and line-by-line coding)
How do students' perceptions influence student motivation in engineering?	18-20	Quantitative	Online Qualtrics survey; Questions taken from MSLQ	Descriptive statistics (SPSS)
Demographic information & info specific to university	1-5; 12-13; 25-28; 30-38	Quantitative	Online Qualtrics survey; Questions taken from APPLES; Researcher- created questions	Descriptive statistics (SPSS)

APPENDIX B: DATA-COLLECTION INSTRUMENT MATRIX

Mixed Methodology / Lyles-Folkman, K. (2013)

Research questions	Mixed methods	Data-Collection Methods	Data analysis
Research question Q1 A: What formal and informal K-14 experiences reinforced the decision to enter into an engineering program at a highly selective university? Variables: Differences in attitudes and perceptions towards continuation of program based on specific interventions at grade bands	Quantitative interventions and continuance data-collection instrument Continuance in program determined by intervention data	Survey instrument distributed to junior students in the engineering program (males and females) Artifacts: Surveys • Numeric data	Quantitative survey software (SurveyMonkey); Coding and thematic analysis • Descriptive statistics from Likert-type scale questions • Frequencies • Means for each question • Visual data display
Research question Q1 B: What K-14 formal and informal experiences posed doubt for entrance into an engineering program at a highly selective university? Variables: Differences in attitudes and perceptions towards continuation of program based on specific interventions at grade bands	Quantitative interventions and continuance data-collection instrument. Continuance in program determined by intervention data	Survey instrument distributed to junior students in the engineering program (males and females) Artifacts: Surveys • Numeric data	Quantitative survey software (SurveyMonkey); Coding and thematic analysis • Descriptive statistics from Likert-type scale questions • Frequencies • Means for each question • Visual data display
Research Question Q3: How did individual perceptions of STEM interventions impact young women's continuance in an engineering major at a highly selective university? Variables: Differences in and perceptions of interventions and the impact of continuance in the engineering program	Qualitative (descriptive) Open-ended questions can provide information on the perceptions of interventions and continuance by junior female engineering students at university	• Focus group with open-ended questions • Individual interviews with open-ended questions	Qualitative survey software (Survey Monkey); Coding and thematic analysis

APPENDIX C: COMBINED APPLES AND MSLQ PERCEPTIONS AND MOTIVATIONS FOR PERSISTENCE IN ENGINEERING SURVEY

ATTENTION: Participant Consent for Research Purposes. You can participate in this study if you are: a female student in your junior or senior year of study in the Engineering Program at Bucknell University. By entering your first and last name below you are agreeing to consent in this research project and collection of your answers for research purposes. You may stop the survey at any time without penalty by not finishing and clicking submit on the last question. Once you have clicked the submit button, your responses will be recorded. Your personal information will remain confidential, and your name will be replaced with a unique participant ID that is unable to be identified by the university or any other personnel. Please provide your name and demographic information below for the purposes of the survey instrument only. By entering my first and last name I understand I am providing informed consent to participate in the research study. (Enter name in the space provided)

Q1 Name

Q2 What is your current academic standing?
- ❍ Junior (1)
- ❍ Senior (2)
- ❍ 5th year Senior (3)

Q3 What is your current major?
- ❍ Chemical Engineering (1)
- ❍ Civil Engineering (2)
- ❍ Electrical Engineering (3)
- ❍ Biomedical Engineering (4)
- ❍ Mechanical Engineering (5)
- ❍ Computer Science / Engineering (6)
- ❍ Environmental Engineering (7)

Q4 Have you changed your major within engineering since enrollment at Bucknell University?
- ❍ Yes (1)
- ❍ No (2)

Q5 (If "Yes" was selected for Q4): What was your major upon entry at Bucknell?
- Chemical Engineering (1)
- Mechanical Engineering (2)
- Biomedical Engineering (3)
- Agricultural Engineering (4)
- Chemical Science / Engineering (5)
- Environmental Engineering (6)
- Civil Engineering (7)

[1]Q6 Please rate the following reasons for entering an engineering major:
- Minimal reason (1)
- Somewhat of a reason (2)
- No reason (3)
- Moderate reason (4)
- Major reason

	Scale point 1 (1)	Scale point 2 (2)	Scale point 3 (3)
My parent(s) want me to be an engineer (1)	❍	❍	❍
A mentor or teacher introduced me to opportunities in the major of engineering (2)	❍	❍	❍
I like to build things (3)	❍	❍	❍
I like to do computer programming (4)	❍	❍	❍
I like to figure out how things work (5)	❍	❍	❍
Engineers make more money than other professionals (6)	❍	❍	❍
I can use engineering skills to better society (7)	❍	❍	❍

[1] This question was removed from the survey because of an error that caused confusion among respondents. The question was designed for a 5-point response scale, but a 3-point response scale was mistakenly offered.

Q7 Rate yourself on each of the following traits as compared to your classmates. We want the most accurate estimate of how you see yourself.
1 - Lowest 2 - Below Average 3 - Average 4 - Above Average 5 – Highest

	1 - Lowest (1)	2 - Below Average (2)	3 - Average (3)	4- Above Average (4)	5 - Highest (5)
Math ability (1)	❍	❍	❍	❍	❍
Science ability (2)	❍	❍	❍	❍	❍
Ability to apply math and science principles in solving real world problems (3)	❍	❍	❍	❍	❍
Critical thinking skills (4)	❍	❍	❍	❍	❍
Problem solving skills (5)	❍	❍	❍	❍	❍
Ability to solve problems with multiple solutions (6)	❍	❍	❍	❍	❍
Communication skills (7)	❍	❍	❍	❍	❍
Self confidence (social) (8)	❍	❍	❍	❍	❍
Self confidence (academic) (9)	❍	❍	❍	❍	❍
Public speaking ability (10)	❍	❍	❍	❍	❍
Business ability (11)	❍	❍	❍	❍	❍
Leadership ability (13)	❍	❍	❍	❍	❍
Ability to perform in teams (14)	❍	❍	❍	❍	❍

Q8 When working on an assignment I prefer to work:
- On individual projects (1)
- On team projects (2)
- Both individual and team projects (3)
- No preference (4)

Q9 What is your major GPA?
- 4.0-3.9 (1)
- 3.8-3.5 (2)
- 3.4 - 3.2 (3)
- 3.1-2.9 (4)
- 2.8-2.5 (5)
- 2.4-2.2 (6)
- 2.1-1.9 (7)
- Below 1.9 (8)

Q10 How stressed do you feel in your current major coursework?
- Very low stress (1)
- Moderately low stress (2)
- No stress (3)
- Moderately high stress (4)
- Very high stress (5)

Q11 How well are you meeting the workload demands of your major coursework?
- I am meeting all of the demands easily (1)
- I am meeting all demands, but it is hard work (2)
- I am meeting most of the demands, but cannot meet some (3)
- I can meet some of the demands, but cannot meet most (4)
- I cannot meet any of the demands (5)

Q12 During the current school year, how often have you interacted with your instructors (faculty, teaching assistants) in your engineering, math or science classes (e.g., by phone, email, IM, or in-person)?
1 - Never   2 - Rarely   3 - Occasionally   4 - Often   5 - Very often
(Mark N/A if you have not taken any engineering, math, or science classes this year)

	1 - Never (1)	2 - Rarely (2)	3 - Occasionally (3)	4 - Often (4)	5 - Very often (5)	N/A (6)
During class (1)	❍	❍	❍	❍	❍	❍
During office hours (2)	❍	❍	❍	❍	❍	❍
Outside of class or office hours (3)	❍	❍	❍	❍	❍	❍
In the Teaching and Learning Center (4)	❍	❍	❍	❍	❍	❍

Q13 Which of the following support services have you utilized at Bucknell University?
❑ Engineering Success Alliance (1)
❑ Teaching and Learning Center (2)
❑ Writing Center (3)
❑ Direct Support from the Dean / Associate Deans (4)
❑ Bucknell Engineering Alumni Association career counseling (5)
❑ Mentoring by upperclassmen students (6)
❑ Society of Women Engineers Involvement (7)
❑ I have not utilized support services at Bucknell University (8)

Q14 Some people are involved in non-engineering activities on or off campus, such as hobbies, civic or church organizations, campus publications, student government, social fraternity or sorority, sports, etc. How important is it for you to be involved in these kinds of activities?

- ❍ Not important (1)
- ❍ Somewhat important (2)
- ❍ Neutral (3)
- ❍ Very important (4)
- ❍ Essential (5)

Q15 (If "Somewhat important," "Very important," or "Essential" was selected for Q14): How often are you involved in the kinds of non-engineering activities such as hobbies, civic or church organizations, campus publications, student government, social fraternity or sorority, sports, etc.?

- ❍ Never (1)
- ❍ Rarely (2)
- ❍ Occasionally (3)
- ❍ Frequently (4)

Q16 How did you gain your knowledge about the engineering profession? (You may select more than 1)

- ❑ From being a visitor at an engineering firm (1)
- ❑ From being a co-op or student or intern (2)
- ❑ From being an employee (3)
- ❑ From a family member (4)
- ❑ From a close friend (5)
- ❑ From school-related experiences (i.e., a professor or class) (6)
- ❑ Other (7) ____________________

Q17 The following has been the most influential in my decision to continue and persist in engineering at college: (Select 1)

- ❍ Friends (1)
- ❍ Family (2)
- ❍ Mentors (3)
- ❍ Faculty (4)
- ❍ Self (5)
- ❍ Other (6) ____________________

Q18 Answer the following questions about motivation using the scale below. If you think the statement is not at all true of you indicate with a (1). If you think the statement is very true of you indicate with a (5). If the statement is more or less true of you, find the number between 1 and 5 that best describes you.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
In engineering classes I prefer course material that arouses my curiosity, even if it is difficult to learn (6)	❍	❍	❍	❍	❍
I want to do well in my engineering classes because it is important to show my ability to my family, friends, employers, or others (7)	❍	❍	❍	❍	❍
I am confident that I can understand the most complex material presented by the instructors in my engineering courses (8)	❍	❍	❍	❍	❍
I am certain I can master the skills being taught in my engineering courses (9)	❍	❍	❍	❍	❍
I usually study in a place where I can concentrate on my engineering course work (10)	❍	❍	❍	❍	❍
I make good use of my study time (11)	❍	❍	❍	❍	❍
I rarely find time to review my notes or readings before an exam (12)	❍	❍	❍	❍	❍
I find it hard to stick to a study schedule (13)	❍	❍	❍	❍	❍
I try to work with other students from my classes to complete engineering course assignments (14)	❍	❍	❍	❍	❍
When studying for engineering courses, I often set aside time to discuss the course material with a group of students from the class (15)	❍	❍	❍	❍	❍
Even if I have trouble learning material in the class, I try to do the work on my own, without help from anyone (16)	❍	❍	❍	❍	❍
I ask the instructor to clarify concepts I do not understand well (17)	❍	❍	❍	❍	❍

Q19 When I can't understand the material in engineering courses, I ask another student in this class for help

❍ True (1)

❍ False (2)

Q20 When I can't understand the material in mathematics courses, I ask other students in classes for help

- True (1)
- False (3)

Q21 (If "Yes" is selected for Q20): I have sought help from (select 1 or more)

- Friends not in Engineering (1)
- Engineering Supports at College (2)
- Professors (3)
- Other Engineering Students (4)

Q22 Do you intend to complete a major in engineering?

- Definitely not (1)
- Probably not (2)
- Not sure (3)
- Probably yes (4)
- Definitely yes (5)

Q23 Do you intend to practice, conduct research in, or teach engineering for at least 3 years after graduation?

- Definitely not (1)
- Probably not (2)
- Not sure (3)
- Probably yes (4)
- Definitely yes (5)

Q24 How likely is it that you would do each of the following after graduation?

	Definitely not (1)	Probably not (2)	Not sure (3)	Probably yes (4)	Probably not (5)
Work in an engineering job (4)	❍	❍	❍	❍	❍
Work in a non-engineering job (5)	❍	❍	❍	❍	❍
Go to graduate school in an engineering discipline (6)	❍	❍	❍	❍	❍
Go to graduate school outside of engineering (7)	❍	❍	❍	❍	❍

The following questions apply to your experiences prior to entering Bucknell University.

Q25 In high school, I achieved a B or higher in the following courses: (Select all that apply)
- ❑ Trigonometry (1)
- ❑ Calculus (2)
- ❑ AP Calculus AB (3)
- ❑ AP Calculus BC (4)

Q26 In high school, I achieved a B or higher in the following courses: (Select all that apply)
- ❑ Physics (1)
- ❑ AP Physics (2)
- ❑ Chemistry (3)

Q27 I attended a(n)
- ❍ Urban High School (1)
- ❍ Suburban High School (2)
- ❍ Private Tuition High School (3)
- ❍ Cyber / Charter School (4)
- ❍ Home School (5)
- ❍ Other (6) ____________________

Q28 Identify the most influential factor in selecting engineering as your major?
- ❍ Teacher (1)
- ❍ Mentor outside of school (2)
- ❍ Family (3)
- ❍ Friends (4)
- ❍ Self (5)
- ❍ Other (6) ____________________

Q29 In high school I had an opportunity to take the following: (select all that apply)
- ❍ AP Courses (1)
- ❍ College Courses (2)
- ❍ Co-operative Work Experience in Engineering (3)

Q30 Are you a first generation college student (first in your immediate family to attend college?
- ❍ Yes (1)
- ❍ No (2)

Q31 (If "No" is selected for Q30): Do any of your immediate family members (parents, siblings) hold an engineering degree? If Yes, identify the family member(s)
- ❍ No (1)
- ❍ Yes (2) ____________________

Q32 What is the highest level of education that your mother completed? (mark one)
- ❍ Did not finish high school (1)
- ❍ Graduated from high school (2)
- ❍ Attended college but did not complete degree (3)
- ❍ Completed an Associate degree (4)
- ❍ Completed a Bachelor degree (5)
- ❍ Completed a Master's degree (6)
- ❍ Don't know or not applicable (7)

Q33 What is the highest level of education that your father completed? (mark one)
- ❍ Did not finish high school (1)
- ❍ Graduated from high school (2)
- ❍ Attended college but did not complete degree (3)
- ❍ Completed an Associate degree (4)
- ❍ Completed a Bachelor degree (5)
- ❍ Completed a Master's degree (6)
- ❍ Don't know or not applicable (7)

Q34 Would you describe your family as: (Mark one)
- ❍ High income (1)
- ❍ Upper-middle income (2)
- ❍ Middle income (3)
- ❍ Lower-middle income (4)
- ❍ Low income (5)

Q35 What is your racial or ethnic identification? (Mark all that apply)
- ❑ American Indian or Alaska Native (1)
- ❑ Asian or Asian American (2)
- ❑ Black or African American (3)
- ❑ Hispanic or Latino/a (4)
- ❑ Native Hawaiian or Pacific Islander (5)
- ❑ White (6)
- ❑ Other (7) ____________________

Q36 Are you willing to participate in a focus group or individual interview lasting approximately 45 minutes as a follow up to this study to help researchers better understand persistence of women in engineering?
- ❍ Yes (1)
- ❍ No (2)

Q37 (If "Yes" is selected for Q35): The best time method to contact me is my:
- ❍ Email (1) ____________________
- ❍ Phone (2) ____________________

Q38 (If "Phone" is selected for Q37): When contacting me by phone, I prefer:
- ❍ Text Messages (1)
- ❍ Phone Call (2)

APPENDIX D: EMAILS TO SURVEY PARTICIPANTS

Examining the personal nature of the K-14 engineering pipeline for young women
Recruitment Materials
February 2016

The following emails are included in this packet

- EMAIL 1: *Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey* Recruitment "IT'S COMING" EMAIL
- EMAIL 2: *Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey* Recruitment Email (with survey link)
- EMAIL 3: *Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey* – REMINDER 1
- EMAIL 4 - *Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey* – REMINDER 2/CLOSE OF SURVEY
- Draft Email to inform Faculty Colleagues about the *Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey*
- Draft Email to inform Student Leaders about the *Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey*

Text Message / Phone Reminders are included in this packet:

- Text 1: Reminder: you have agreed to participate in a focus group that will meet on February (date), 2016. We look forward to seeing you at (time). Thank you!
- Text 2: Focus Group Reminder: (time) in room (number) located in the (name) building. Refreshments will be provided. Thank you for being a part of research to advance women in engineering!

Additional resources related to survey administration, reminders, etc.

Donaldson, K., Chen, H.L., Toye, G. & Sheppard, S. (2007). Targeting Undergraduate Students for Surveys: Lessons from the Academic Pathways of People Learning Engineering Survey (APPLES). *In Proceedings of the 37th Annual Frontiers in Education Conference*, Milwaukee, Wisconsin, October 10-13, 2007. http://fie-conference.org/fie2007/papers/1690.pdf

EMAIL 1: Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey "IT'S COMING" EMAIL

From: Dean
Subject: ATTENTION JUNIOR AND SENIOR WOMEN in engineering, Bucknell needs your voice!

Calling all junior and senior women in engineering, your contribution to current research in Engineering could result in a $25 Amazon gift card.

Bucknell Engineering has been invited to participate in a study on the perceptions of the Science, Technology, Engineering and Mathematics (STEM) pipeline for women through the Education Department at Drexel University. The *Personal Perceptions of Engineering Pipeline and Persistence Survey* is a 15-minute online survey aimed at building an understanding of how women's experiences influence perceptions that lead to persistence in engineering as an ethnographic group. By sharing your experiences, you will have a chance to reflect on your individual educational experiences and contribute to the body of knowledge surrounding the educational pathways for expansion of women in engineering majors.

Please keep an eye out for an email invitation to participate in the *Personal Perceptions of Engineering Pipeline and Persistence Survey* in the next week. Your participation in this survey is voluntary and confidential. Each and every response is valued and will contribute to the advancement of women in engineering.

As a thank you for your participation, all respondents who provide their contact information in the survey will be entered into a drawing for a $25 Amazon gift card.

Thank you,

Dean

* No purchase is necessary for entry into the drawing.

EMAIL 2: Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey RECRUITMENT EMAIL (with survey link)

From: Dean
Subject: ATTENTION JUNIOR AND SENIOR WOMEN in engineering, Bucknell needs your voice!

The *Personal Perceptions of the Engineering Pipeline and Persistence Survey* is now open! And your input is of critical importance. Please complete the survey today to be entered to win a $25.00 Amazon gift card.

Last week we emailed you to inform you about the *Personal Perceptions of Engineering Pipeline and Persistence Survey,* a 15-minute online survey aimed at building an understanding of how women experience the STEM pipeline and engineering experience as an ethnographic group. By sharing your experiences, you will have a chance to reflect on your education and contribute to the body of knowledge to impact future educational pathways for expansion of women as an underrepresented group in engineering.

The *Personal Perceptions of the Engineering Pipeline and Persistence Survey* takes only 15 minutes to complete and enters you into a $25 Amazon gift card drawing. To participate, please follow the URL link below:

http://

We would greatly appreciate your completion of the survey by Monday, February 15, 2015.

Your participation in this survey is voluntary and confidential. Each and every response is valued. The survey results will be available in spring 2016 and we will invite you to weigh on how these results can be used to change engineering education for women.
To thank you for your participation, all respondents who provide their contact information will be entered for a chance to win a $25 Amazon gift card*. Winners will be contacted by email.
We look forward to your input in the *Personal Perceptions of Engineering Persistence Survey*!

Thank you,

Dean

* No purchase is necessary for entry into the drawing.

EMAIL 3: Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey – REMINDER 1

From: Dean
Subject: What's it like to be a woman in engineering?

We need YOUR voice as we try to inform and improve the engineering experience for junior and senior women at Bucknell and nationwide.

Please take 15 minutes to participate in the *Personal Perceptions of the Engineering Persistence Survey and be entered into a drawing for a chance to win a $25 Amazon gift card.*

http://

We would greatly appreciate your completion of the survey by Monday, February 15, 2016. If you have already completed this survey, please disregard this email.

Reminder: To thank you for your time, all survey respondents who enter their contact information will be entered in a drawing a $25 Amazon gift card to be given to Bucknell engineering students!

We look forward to your contributions to this important research.

Thank you,

Dean

EMAIL 4 - Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey REMINDER 2 & Close of Survey

From: Dean
Subject: Junior and Senior women in engineering, - Last chance to win a $25 Amazon gift card!

The *Personal Perceptions of the Engineering Pipeline and Persistence Survey* will close THIS Monday, February 15, 2016! If you haven't already taken it, please click the survey link below and reflect on your experiences studying engineering. It takes about 15 minutes to complete and can significantly impact future experiences for women entering the field of engineering!

http://

Please take 15 minutes to share your engineering experiences and expand the opportunities for women in engineering as an underrepresented group. Join the movement and contribute to this important research. All information is confidential.

Don't forget -- all survey respondents who enter their contact information will be entered in a drawing for a $25 Amazon gift card to be awarded to Bucknell students!

Thank you and good luck with rest of the year!

Dean

Draft Email to inform faculty colleagues about the Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey

Bucknell Engineering has been invited to participate in a research study through the Education Department at Drexel University on the perceptions of the engineering experience of young women as an ethnographic group.

Female students in their junior or senior year of study will be invited to complete the *Personal Perceptions of the Engineering Pipeline and Persistence Survey*, a 15-minute online survey about students' experiences in the STEM pipeline to provide information on factors influencing their persistence in engineering. As a follow up to the survey, students may elect to participate in a focus group and individual interviews to collect additional data on individual experiences.

I ask for your assistance helping to promote the *Personal Perceptions of the Engineering Pipeline and Persistence Survey* with your junior and senior female engineering students via announcements in classes.

Students will be receiving an email invitation with a survey link from Dean Keith Buffinton February 2nd with follow up email reminders. All survey respondents who enter their contact information will be entered in a drawing for a $25 Amazon gift card to be given to a Bucknell student.

The results from the *Personal Perceptions of Engineering Persistence Survey* will be shared with us as part of a campus report and as a result, we would greatly benefit from a large and representative sample of female respondents. Any support you can provide by raising awareness through class announcements and word-of-mouth would be greatly appreciated.

Should you wish to learn more about the *Personal Perceptions of the Engineering Pipeline and Persistence Survey* please contact Mrs. Jennifer Gurski at jsg99@drexel.edu.

Draft email to inform student leaders about the Combined APPLES and MSLQ Perceptions and Motivations for Persistence in Engineering Survey

Bucknell Engineering has been invited to participate in a research study through the Education Department at Drexel University on the perceptions of the engineering experience of young women as an ethnographic group.

Female students in their junior or senior year of study will be invited to complete the *Personal Perceptions of the Engineering Pipeline and Persistence Survey*, a 15-minute online survey about students' experiences in the STEM pipeline to provide information on factors influencing their persistence in engineering. As a follow up to the survey, students may elect to participate in a focus group and individual interviews to collect additional data on individual experiences.

I ask for your assistance helping to promote the *Personal Perceptions of the Engineering Pipeline and Persistence Survey* with junior and senior engineering students via announcements to your membership.

Students will be receiving an email invitation with a survey link from Dean Keith Buffinton in early February. All survey respondents who enter their contact information will be entered in a drawing for a $25 Amazon gift card.

All student information will remain confidential. Findings from *Personal Perceptions of the Engineering Pipeline and Persistence Survey* will be shared with us as part of a campus report and as a result, we would greatly benefit from a large and representative sample of respondents. Any support you can provide by raising awareness through meeting announcements and word-of-mouth would be greatly appreciated.

Should you wish to learn more about the *Personal Perceptions of the Engineering Pipeline and Persistence Survey* please contact Mrs. Jennifer Gurski at jsg99@drexel.edu

APPENDIX E: MEASURES OF CENTRAL TENDENCY FOR SELF-EFFICACY SCALES

The frequencies, mean, and standard deviation for each self-efficacy scale are shown below.

Rate yourself on each of the following traits as compared to your classmates. We want the most ac...-Math ability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2 - Below Average	1	2.5	2.5	2.5
	3 – Average	12	30.0	30.0	32.5
	4- Above Average	22	55.0	55.0	87.5
	5 – Highest	5	12.5	12.5	100.0
	Total	40	100.0	100.0	

Rate yourself on each of the following traits as compared to your classmates. We want the most ac...-Science ability

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2 - Below Average	1	2.5	2.5	2.5
	3 - Average	14	35.0	35.0	37.5
	4- Above Average	22	55.0	55.0	92.5
	5 - Highest	3	7.5	7.5	100.0
	Total	40	100.0	100.0	

Rate yourself on each of the following traits as compared to your classmates. We want the most ac...-Critical thinking skills

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2 - Below Average	2	5.0	5.0	5.0
	3 - Average	6	15.0	15.0	20.0
	4- Above Average	22	55.0	55.0	75.0
	5 - Highest	10	25.0	25.0	100.0
	Total	40	100.0	100.0	

Rate yourself on each of the following traits as compared to your classmates. We want the most ac...-Problem solving skills

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2 - Below Average	1	2.5	2.5	2.5
	3 - Average	7	17.5	17.5	20.0
	4- Above Average	21	52.5	52.5	72.5
	5 - Highest	11	27.5	27.5	100.0
	Total	40	100.0	100.0	

Rate yourself on each of the following traits as compared to your classmates. We want the most ac...-Ability to perform in teams

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3 - Average	6	15.0	15.0	15.0
	4- Above Average	22	55.0	55.0	70.0
	5 - Highest	12	30.0	30.0	100.0
	Total	40	100.0	100.0	

APPENDIX F: FOCUS GROUP INTERVIEW RESPONSES

Table 17

Supporting Statements by Ethnicity: White Participants

1. I had a very active science teacher in 6th, 7th and 8th grade, so I participated in …science-based competition…We also participated in…another competition…and so I think all three of those really culminated in me understanding that I wanted to go into engineering.
2. One team was entirely male and the other was co-ed.
3. I participated in all of her programs. She really made that fun for me.
4. She was super encouraging of everyone…I participated in all of her programs.
5. I did a lot of math groups, like a lot of afterschool math programs that were mostly game-based.
6. In middle school I honestly hated all my science teachers.
7. I didn't like my math teachers.
8. I loved my math teacher…we are the opposite.
9. I always loved my math teachers.
10. I think math was more concentrated on that science, at least for me, in K-8. I, we had more practice with it. It was more of, like, a competition…
11. I can't really remember doing lab-based science in elementary school…There was a lot more accelerated reading and math…
12. I was hard-core math for a long, long, long time.

13. People who are like-minded pursue the same type of subjects you do.
14. I loved my high-school experience. I went to boarding school, which is a little different in that the type of immersion schooling that you get is a lot more intense. I spent, like two out of the seven nights a week hanging out at my physics professor's house...those types of close relationships…I thought that it was great.
15. We had Saturday seminar…I took robotics.
16. We were limited on the number of APs we could offer because we didn't have enough teachers.
17. I went to an all girls' school for high school…we couldn't offer all the APs that we wanted to, but the ones we did offer were very intense and people did well. But I found that there was definitely a disparity in offering science and math…We had two AP English's, we had three AP history's…all the languages.
18. I didn't decide to pursue engineering in high school; I decided in middle school…I picked my dual degree when I was in 7^{th} grade.
19. It was probably the …competition that did it…I think that was probably the one experience…High school, if anything, would have gone backwards…
20. I wouldn't say there was one experience… I don't even remember why I chose chemical engineering….I really liked math and I really, really like physics.
21. My mom always signed me up for those math programs, like afterschool programs.
22. Learning that I don't have to be the smartest person in the room. That was an adjustment, because I used to …No one can know everything so it's okay.

23. I'm on a team this semester with two other people…and then a boy who we know, like, we have established that he thinks girls are dumb inherently.
24. One of my professors that was teaching…he, too, thought that girls inherently think differently than boys…He would…give the females in the classes, like, extra help…that's nice and all, but I know the thinking behind it and I don't like that.
25. She studies with all of the guys, and it's just, like, you know, accepted, and they, like, they've accepted her. But, like, I think that could have gone a very different direction…
26. I kind of like being in a male-dominated field in that I like proving people wrong. I love to prove people wrong…and show that I can do very well, mostly for myself.
27. No matter what discipline you're in in engineering, you're going to impact the world in some way…It's really astronomical, and to have that sort of impact would be…great…I think it has the opportunity to be very rewarding in life.
28. And it's a good salary, too. That's rewarding, as well.
29. I picked out these two, these two majors out when I was 12, and so, like, for me to, like, go back on that now, like, kind of…like I am not being true to myself.
30. You like it and you stick with what you like.
31. I think we are all really stubborn, also.
32. I've never studied before I got to college…I didn't know how to study….I would just breeze through a test and be totally fine. But now I actually really work at the material.

33. For me it was earlier than high school, way earlier…I think high school solidified my want to be…helped me choose to be a biomedical engineer, but not engineering itself.
34. I had a great time in my AP Bio and AP Chem classes.
35. I feel like that it was ESA [Engineering Success Alliance] that's how I even learned to study.
36. I think some faculty could definitely do a better job of being supportive, not only just of female engineers, but just anyone.
37. I think the other defining moment is, mostly at the midterm or at the end of the semester, when you look back at everything you accomplished…
38. There's different reasons for, I think, quitting engineering…It's way too hard, I can't do this...I've been raised and it's my personal belief that I can do anything I set my mind to.

Table 18

Supporting Statements by Ethnicity: Asian American Participant

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1. Middle school…our school is really strong in robotics. So there's just a group of guys… after I graduated, I found out they didn't accept girls…I haven't heard anyone try before, nor did I ever see a girl in the group…
2. Engineering would open up more doors.
3. There's no afterschool session in physics or math...but that was fine. It was just me.

4. You literally did typing…glad we're all ready to be secretaries now…I just felt very much there was no, like, pre-engineering…I took physics in high school.
5. In my city everyone needs to take a Computer Science class and pass one exam to graduate high school.
6. I didn't have any trouble in Intro to Computer Science here, because I took something.
7. I don't think there's one thing that stands out that would encourage me to pursue something in science and engineering.
8. There's this one incident I remember from my class teacher…she said, "Well look at you girls, you did fine in middle school. But, you'll be…finding some difficulty catching up with the boys in high school." That was the most awful thing I ever heard in high school…
9. Some other factors would include, like, my family, because my mom is a chemical engineer…and my dad is a computer engineer and he programs…It kind of steers you one way or the other.
10. I could have just dropped out and gone back to Arts and Sciences because the physics people and geology people are so nice…but not in computer science.
11. It's really like off-putting when you sit in a computer science class and, like, those guys in the corner, they know everything….but I figure them out, and I get a high score…

Table 19

Supporting Statements by Ethnicity: African American Participant

1. This is hard to remember that far back.
2. We really only had AP courses.
3. We didn't have any, like, computer programming or co-op, engineering…but we didn't have any kind of engineering classes, which was really a surprise to me when I came [here]…because a lot of people had high schools that were like that…so people already had the upper hand…
4. I will say that more men took the AP science classes…
5. I felt like I was behind the second I got to school…once I realized that the people had that upper hand, I felt like I was behind, and I felt like I was trying to play catch-up the entire time.
6. They knew how to study once they got to college. They knew their working style, and knew all of these things about themselves that I hadn't necessarily fully explored yet. So there was definitely a learning curve once I got to college.
7. Physics definitely was the one class, though, that really, like, opened my eyes to engineering…
8. Just knowing that we have a network available has really helped encourage for me to stay in engineering major, especially since I'm a first-generation college student, I don't have the connections through my parents as a lot of people do, or actually know really many people, so it's nice knowing that I have that as a backup.
9. Being there for math lab really helped.

10. We had a visiting professor…and he didn't have a positive view of women overall. It wasn't explicitly said, but it was kind of hinted at in the way he would talk to me or other women in the class.
11. For me, it's more of, of the sense of doubt that I see on people's faces when I tell them that I'm an engineer, or like they're surprised…I kind of get a kick out of it nowadays…It's really for me proving them wrong…I've already beaten certain statistics…I want to be different than what a lot of these generalizations come from…and I want to give myself a future that I can be proud of.
12. Oh, it's too hard or too time-consuming, to me…it's insulting to me if I were to use that as my excuse to quit.
13. I'm going to make a decent amount of money…helping other people…That's really what engineering means to me is that you're helping other people....creating things to better the life…and the earth…
14. I've had a hard time not comparing myself to others.

APPENDIX G: QUALITATIVE FOCUS GROUP QUESTIONS

All questions are open-ended and time for each focus group is approximately 45 minutes to one hour.

Q1	Describe your perceptions of your exposure to math and science opportunities and experiences K-8. What experiences did you have that were most influential?
Q2	Describe your perceptions of your experiences in grades 9-12 in Advanced Placement courses, mathematics, computer programming, pre-engineering courses, and co-op experiences. Were there many opportunities for these experiences at your school?
Q3	Was there one experience in high school that led to your decision to pursue engineering after high school or was it a combination of other factors? Explain.
Q4	Describe your experiences utilizing university supports in the engineering department. Describe the perceptions you have of the supports on campus, specifically for retaining female engineers as compared to that of your male counterparts.
Q5	Describe a defining experience at Bucknell that contributed to your own persistence in engineering? Describe the perceptions you have of the departmental supports offered at the university.
Q6	Describe your perceptions of your own ability in mathematics and engineering courses compared to that of your peers. Do you feel others perceive your ability to be any different than that of your male peers?
Q7	Why do you believe you have persisted in engineering when so many other women do not persist in engineering?
Q8	Is there a defining moment when you considered leaving engineering but continued to persist? Who or what caused you to persist?
Q9	Describe the perceptions you have of the future opportunities and jobs that await you after you graduate. What reasons do you have for wanting to continue in an engineering career?
Q10	Do you believe any particular experience or individual could steer you away from continuing in engineering? What advice do you have to give to future female engineers who are doubting their entrance and completion of an engineering degree?

*Individual interviews will be conducted with a sub-sample if necessary. These questions will be basis for interviews

APPENDIX H: IRB APPROVAL FORM

Drexel UNIVERSITY
Office of Research

January 25, 2016

Penny Hammrich, Ph.D.
School of Education
Mailstop: Drexel University

Dear Dr. Hammrich:

On January 25, 2016, the IRB reviewed the following protocol:

Type of Review:	Initial
Title:	Examining the Personal Nature of the K-14 Engineering Pipeline for Young Women
Investigator:	Penny Hammrich, Ph.D.
IRB ID:	1601004125
Funding:	Internal
Grant Title:	None
Grant ID:	None
IND, IDE or HDE:	None
Documents Reviewed:	HRP 211 Application Form, HRP 201Contact Forms, Conflict of Interest Forms, HRP 503 Template Protocol, Site Permission email, Recruitment materials, Data Collection Tools,

According to 45 CFR 46, 101(b) (2), the IRB approved the protocol on January 25, 2016. The protocol is approved Exempt Category 2, this study will enroll a total of 75 subjects recruited from Bucknell University in Lewisburg, Pennsylvania to complete a survey, participate in a focus group, and to participate in interviews.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,
Teresa C. Hinton
Member, Social and Behavioral IRB #3