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JUNE 22 - 26, 2020 #ASEEVC
Paper ID #29505

Exploring the Educational Experiences of Women Who Persisted in Engineering: A Qualitative Case Study

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Abstract

The necessity for a highly qualified STEM work force has created national educational initiatives, both secondary and post-secondary, to address the need for increasing the participation of underrepresented people in STEM related fields. These efforts have included strengthening secondary Career and Technical Education (CTE) programs and preparing students to have a strong foundation in high school mathematics and science courses. While women have closed the gap in academic performance in high school mathematics and science courses, and attainment of post-secondary degrees, they pursue undergraduate engineering degrees at a much lower rate than men. In order for the United States to meet the demand for qualified engineering professionals, women will need to engage and persist in engineering educational pathways. The purpose of this pilot qualitative case study was to examine the educational pathways and experiences of three undergraduate women who are on track to graduate during the 2019-2020 academic year a large, public university located in the southeast region of the United States. By using social cognitive career theory, the pilot study examined how and why three women authored their engineering identities through their secondary and post-secondary educational experiences to gain insight on their pursuit and attainment of an engineering degree and to inform a larger case study. Three themes, congruent with social cognitive career theory emerged from the data: eagerness to learn science and engineering theory, self-confidence in ability, and significance of teacher interactions. Within each theme there was evidence that the participants' secondary educational experiences both aided and created obstacles in their pursuits. The finding from this study speak to the dynamic nature of how educational and environmental experiences can strengthen or weaken a woman's resolve to continue in the field of engineering. Implications for future research, practice, and policy are discussed.

Keywords: engineering, women, STEM education, social cognitive career theory

Introduction

The Bureau of Labor predicts that Science, Technology, Engineering, and Mathematics (STEM) related employment is projected to have a growth of more than 9 million jobs between 2014 and 2022 [1]. In fact, various computer and biomedical engineering fields are projected to have more than four times the job growth by 2024 compared to the average growth for all occupations [2]. The necessity for the United States to have a highly qualified STEM work force has created national educational initiatives, both secondary and post-secondary, to address the need to increase the participation of underrepresented people in STEM-related fields. In fact, the U.S. Department of Education [3] outlined specific goals to increase the quality of education and success of undergraduate students. These efforts have included strengthening secondary Career and Technical Education (CTE) programs and preparing students to have a strong foundation in high school mathematics and science courses [4].

One way to meet the demand of a high-quality engineering workforce is to increase the interest of women who are underrepresented in engineering careers. In fact, women account for approximately 42% of careers in life, physical, and social science occupations but only accounted for only 14% of engineering occupations [2]. While women have closed the gap in academic performance in high school mathematics and science courses, and attainment of post-secondary degrees, they pursue engineering-related degrees at a much lower rate than men [5]. In fact, in 2018, only one out of five undergraduate engineering degrees were awarded to women and disturbingly this number has remained stagnant over the last twenty years [6].

The gender disparity in post-secondary engineering programs and subsequent workforce has been a persistent concern for researchers, educators, and policymakers. Often, engineering is defined by a narrow framing of who can be an engineer and what they do [7]. Increasing the participation of women in engineering requires that stakeholders pay close attention to the type of person we ask students to become as they pursue engineering degrees and study how women embrace or avoid these promoted identities [7]. This identity development can begin as early as the beginning of high school or may not begin until students begin to engage in post-secondary engineering coursework.

Prior to college, many students have limited to no direct experience with meaningful engineering concepts or practices [8]. Research has highlighted the importance of exposure to high quality STEM experiences and participation in quality high school science and mathematics courses in a student's choice of an engineering career paths [4]. Though, a lack of direct engineering experience makes the choice of pursing an engineering career more difficult than other STEM disciplines such as mathematics, chemistry, and biology which students receive direct, explicit experience in high school [9]. Moreover, the majority of students choose engineering as a career path in high school compared to other student's interest in STEM-related subjects developing as early as elementary or middle school. In fact, Cass, Hazari, Sadler, and Sonnert [10] found that only 280 out of 6,860 engineering students were interested in pursuing an engineering career at the beginning of high school.

As the nation's need for highly qualified engineering professionals grows, policymakers and educators have focused their efforts in increasing recruitment and retention of women pursuing post-secondary engineering degrees and engineering careers. While self-efficacy has been found to be a significant factor in predicting academic success of women pursuing non-traditional career paths, such as engineering [11] the exact nature of how engineering curriculum and engineering contexts impacts self-efficacy for women remains unclear [9]. Exploring the factors that contribute to how women develop their engineering identity and persist in engineering programs is necessary in understanding student satisfaction, achievement, and outcome expectations.

The following section presents the theoretical framework and for the proposed research which includes a brief review of notable research on identity theory and women in engineering. The methodology section outlines the proposed participants, data collection, data analysis, and will be followed by a discussion of major findings for this study. The paper will conclude with a discussion of the results, implications of the findings, recommendations for future research, and a personal reflection on the research process.

Theoretical Framework and Literature Review

Engineering Identity Constructs

A student's ability to identify as an engineer has implications for student's academic and personal development, retention, and becoming integrated into the larger engineering community [12]. Student engineering identity development have been centered on three constructs in mathematics and science education that have been researched both quantitatively and qualitatively: interest, performance, and recognition [7]. Specifically, engineering identities are socially constructed and rely on a student's interest in the subject matter, being able to see oneself as understanding the subject matter, and feeling recognized by others [7].

The process of engineering identity development requires that students negotiate the roles they play within engineering as a discipline, with their peers, and within engineering classrooms [13]. Women must author their individual engineering identities that will relate to the group identity of an engineer [13]. Educational experiences within the classroom have the potential to foster agency through participation in engineering and directly influence a woman's pursuit of engineering both at secondary and post-secondary levels [8]. Development of this identity will require active participation in engineering curriculum and social integration into engineering academic communities [13].

Social Cognitive Career Theory

Social cognitive career theory (SCCT) was developed originally to connect an individual's career development with three core variables that focus on how basic academic and career interests are developed, how educational and career choices are made, and what factors affect academic and career performance and persistence [14]. SCCT was derived from Albert Bandura's [15] social cognitive theory which includes overlapping variables and processes of self-efficacy, outcome expectations, and contextual supports. Bandura [15] stated that self-efficacy is fostered by successes in related tasks, vicarious experiences, social persuasion, and physiological and emotional responses. He concluded that past successes in related tasks is the prevalent predictor of self-efficacy in future tasks. An individual's perceived self-efficacy is dynamic such that new cognitive, motivational, affective, and selection processes are subject to alter one's self-efficacy and alter one's future actions [16].

Lent et al. [17] developed a fourth model that explains the factors responsible for educational and occupational satisfaction and other aspects of positive adjustment to school and work contexts. This model focuses on the interconnectedness of cognitive, behavioral, contextual, and personality factors that impact the process of educational and occupational adjustment. The new model proposes that demographic and individual social identities, such as race/ethnicity, social class, gender, can interact with background and educational context to influence learning experiences that impact the forming on self-efficacy beliefs. Multiple studies have supported the basic interest, choice, and performance models for high school [18], and college students [19].

Lent, Brown et al, [17],[20] concluded that SCCT was able to account for the interest and major choice goals for racially diverse women and men in engineering. The interest, choice, performance, and satisfaction factors are interrelated and connected in the process of persisting in engineering programs. Both outcome expectancies and self-efficacy beliefs predict interests; and interests combined with self-efficacy beliefs and outcome expectations predict goals. This combination leads to behaviors that will lead an individual to practice and choose activities and therefore lead to performance attainments. For example, women are likely to become interested in engineering and choose to pursue an engineering career, and perform better at engineering coursework, if she has strong self-efficacy beliefs, necessary skills, and environmental supports to pursue an engineering degree.

SCCT affirms that career and academic pursuits are dynamic and can be affected by an individual's high school educational experiences that may be "inspirational, reinforcing, or preparatory" [4]. Due to the fluid nature of SCCT, a women's decision to persist in engineering as a major is directly related with post-secondary educational experiences that can influence persistence in degree attainment [4]. These educational and environmental experiences can strengthen or weaken a woman's resolve to continue in the field of engineering.

Social cognitive career theory provides a framework for this proposed research that will incorporate how and why young women author their identities through their secondary and post-secondary educational experiences. Previous studies have utilized SCCT to predict a student's intent on declaring a STEM major [4], a woman's interest and engineering major choice [17] interest and predicted academic satisfaction and intended persistence for engineering students [21].

Purpose of the Study

This pilot study aimed to add to literature on how women author their engineering identities by seeking to understand how secondary and post-secondary educational experiences nurture or create barriers in their pursuit of degree attainment. This study proposes to answer the following research question and sub-questions:

(1) How do women who have persisted in undergraduate engineering programs, at an urban university, build engineering identity through their educational experiences?
   a. How do women describe secondary educational experiences that contributed to their decision to major in engineering?
   b. How do women describe post-secondary educational experiences that contributed to their persistence in an engineering major?

Subjectivity Statement

For qualitative studies, it is necessary to describe how the position of the researcher could influence the data analysis and interpretation of the data [22], [23]. I am a White female who is an engineer and full-time lecturer in the College of Engineering at the university where the study will take place. The participants of this study have had me as an instructor or worked with me as a teaching assistant. Along with recruitment, having established rapport with both participants made the interview process more comfortable and open. Reflecting on the interviews, I believe that both participants did not hold back and were honest in their responses. However, this could also be due to the nature of the topic that we are discussing, since it is not necessarily an emotional topic and poses no risks to the students. This study did not include any of my current students.

My path to obtaining an engineering degree was not linear. From elementary to high school I had strong mathematics and science identities and was confident in my abilities with both subjects. I started as a freshman in pre-engineering program with the intent of transferring to a 4-year engineering college at the start of my junior year. Like many women pursing engineering degrees, I was the only woman in the four engineering specific classes that I completed in the program. While my instructors never said anything to make me feel unwelcome, I did not feel like I belonged in engineering. I could not see myself in my professors (who were older male, retired engineers) or my peers in the classroom. While I did well in the classes and enjoyed the course content, I decided that engineering was not for me and changed my major to mathematics. I graduated with a Bachelor of Science in Mathematics. Following graduation, I successfully completed a Master of Science in Engineering and worked as a forensic engineer for seven years before deciding to make a career change to teach in higher education.

I am currently a part-time PhD student in an Educational Research, Measurement, and Evaluation program and a full-time lecturer in the engineering college. My research interests include increasing the participation and retention of underrepresented students in undergraduate engineering programs.

Methodology

A descriptive qualitative case study was selected for the purpose of this research study. This paper serves as a pilot study for a larger study that is being conducted. The study aims to examine women's perspectives on their high school and university educational experiences to gain understanding of their motivations and determine educational factors that contributed to their engineering identity. Qualitative case study research are widely utilized throughout the field of education which have included research on students, programs, schools, teachers, and policies. Since the 1970s, case study research has effectively brought about a better understanding of educational practice. A defining characteristic of a case study is delimiting the object of the study, the case [24]. According to Merriam [24] a case can be a person such as a student, a program, a group of students that is bounded by a context or event. According to Olson in Hoaglin [25] descriptive case studies can illustrate the fact that many factors contributed to a situation, have the advantage of hindsight but maintain relevance in the present, and present information from different groups (in this case of this study different engineering majors).

The participants for this study included undergraduate, women who are on track to graduate from the College of Engineering a large, public university located in the southeast region of the United States during the 2019-2020 academic school year. The institution offers undergraduate engineering degrees including Bachelor of Science degrees in Civil, Environmental, Electrical, Computer, Mechanical, Systems, Engineering Technology, and Construction Management. According to the institution's fall 2019 census data, there were approximately 3,182 enrolled undergraduate students in the College of Engineering, 387 of which are women. All participants in this study were in their senior year of their respective undergraduate engineering program and were expected to have an established engineering identity.

Of these women, over 147 have completed enough credit hours to be considered seniors and the expected ages ranged from 21 to 24 years old. The students were selected based on class standing, major, and gender. Senior class standing will be utilized to show evidence of persistence in the women's pursuit of degree attainment. Due to the nature and time constraints of qualitative case studies, all graduating seniors were not included in the study. For confidentiality, the background information is grouped so that there are no clear identifying markers that can be associated with the participants, including pseudonyms.

For the pilot study and for this paper, a total of three women participated in the study and their ages ranged from 22 to 25. Data collection and analyses is ongoing for an additional nine women. The first participant, Ana, is pursuing dual degrees in physics and electrical engineering and is expecting to graduate with both degrees in spring 2020. Ana prefers female pronouns and gender identification and identifies as Latina. She is a first-generation student and took two years of classes at a local community college before transferring to the institution where the study took place. No members of Ana's family have any background in engineering-related professions. She started as a physics major and decided to add the electrical engineering major after she did research on starting salaries of physics majors and electrical engineering major. She also mentioned that she chose electrical engineering since she could have a professional degree after completion of her bachelors. She indicated that most physics majors continue on to graduate school and she currently does not want to attend graduate school. She has experience with being a teaching assistant for multiple courses in the physics department and the College of Engineering as well as research assistant.

The second participant, Ashley, is pursuing a degree in construction management and is expected to graduate with her undergraduate degree in spring 2020. She has been accepted for early entry into the construction and facilities management graduate degree. Ashley prefers female pronouns and gender identification and identifies as White. She is a second-generation student who took two years of classes at a state university before transferring to the institution where the study took place. Her father is an engineer and her mother works at a residential home building company. She started at enrolled in the community college in order to complete a 2 + 2 construction management program where two years of courses are completed at the community college and the junior and senior years are completed at a four-year institution. She has industry experience through a summer internship for a large, commercial construction firm and has experience being a teaching assistant for several course in the College of Engineering.

The third participant, Jessica, is pursuing a degree in construction management and is expected to graduate with her undergraduate degree in fall 2019. Jessica prefers female pronouns and gender identification and identifies as African American. She is a second-generation student who started at the institution her freshman year. Her mother is a mechanical engineer and has a job in project management. She has cooperative-learning experience at a construction management firm and expects to work for the same company following graduation.

She is an active member of multiple campus organizations for engineering and women in STEM-related fields.

Data was collected by conducting individual, face-to-face interviews that will range from 45 to 60 minutes. For convenience of the participants, the interview location was selected by the participants. A semi-structured interview guide was utilized and consisted of guided questions on the participant's secondary and post-secondary educational experiences. The ten to twelve open-ended questions focused on coursework, research experiences, Career and Technical Education, participation in STEM specific programs, mentorship, and perspectives on their interest of study. The interviews provided valuable data to gain insight on each woman's pursuit and perspectives on their path to obtaining an engineering degree.

The qualitative data collected was transcribed verbatim, with identifying markers removed. The transcripts were coded using descriptive and concept coding strategies. Descriptive coding summarizes data into a words or short phase and is typically the topic of the passage of qualitative data [26]. Key words and phrases were identified from the transcript and the description was noted. NVivo computer software was also utilized to code the transcripts and similar descriptions and codes were found. The codebook was exported to Excel and quotes were added that supported the codes. The codes and code description, as well as examples of the code can be found in the Appendix.

During the second cycle of coding, the transcript, primary codes, theoretical framework, and research questions were reviewed, and concept codes were developed. Concept coding lumps together data with the purpose of considering the bigger picture suggested by a concept and is appropriate for studies focused on theory [26]. The codes and code description, as well as examples of the code can be found in Appendix. The codes were reviewed for patterns by looking for repetition, similarities, and differences while considering the research questions and theoretical framework of SCCT. From the concept codes, three themes emerged from the data and are described in the Findings section of this paper.

The participant's risk for this study was expected to be minimal to none, and each participant was given the opportunity to review their transcripts and preliminary data analysis. Prior to the data collection, the author assumed that the questions and topics discussed posed little to no emotional or mental stress or risk. However, two of the participants became emotional when discussing family or when discussing a faculty member who challenged their resolve to pursue engineering. By participating in this study, the women were able to reflect on their educational pathway in their pursuit to degree attainment.

Peer debriefing was conducted to ensure the reliability of the findings. After the first cycle of coding, I met with my faculty mentor to discuss initial coding, the theoretical framework proposed for the study, and initial themes. Based on the conversation, I used concept coding for the second cycle. Additionally, a colleague with experience in qualitative research reviewed Ana's transcript and offered themes from the data without knowing my research questions or the results of my coding. The majority of the themes are similar to the themes that are presented in the following section. Overall, the feedback allowed the data analysis to proceed and reinforced the findings.

The participants, responsible faculty, and fellow peer mentors assisted in ensuring research quality, credibility, and trustworthiness [23]. Following the data analysis, the participants had an opportunity to review and discuss the findings of this study during a debriefing meeting. Peer researchers were consulted during the data analysis portion of the study to ensure quality in analysis of the data. Additionally, the responsible faculty, a professor from the Educational Leadership department, was consulted for guidance on data collection and analysis. The responsible faculty provided feedback on both the data collection and analysis and provided insights on coding strategies appropriate for this study.

Findings

After reviewing the data, connections were noted between the concept codes and social cognitive career theory. Three main themes emerged from the data: 1) *eagerness to learn science and engineering theory*, 2) *self-confidence in ability,* and 3) *significance of teacher interactions.* The themes address the overarching research question of how the participant's built their engineering identities through their educational experiences. Within each theme there was evidence that the participant's secondary educational experiences fostered their pursuit of an engineering degree and has supporting evidence that their post-secondary educational experiences both aided and created obstacles in their pursuits. Each of the main themes are congruent with social cognitive career theory and speak to the nature of why women persist in engineering programs and choose to pursue engineering as a profession.

The first theme, *eagerness to learn science and engineering theory*, describes the participants' experiences of identifying the vast capabilities of science and engineering theories and yearning to learn more. The theme is supported by the possibilities of material, desire for knowledge, and cognitive challenge concept codes. For example, it was through Ana's AP Physics course in high school that she first discovered what this subject matter could offer to her and she was excited by the opportunity. She commented, "I feel like there were a lot of possibilities [in physics] and so much that I could learn and, you know, it was like a whole world opened up for me." It was only through the challenging course content of AP Physics that she began to consider science, technology, engineering, and mathematics (STEM) as a career opportunity. Before this transformative experience, going to college after graduating high school had not been a consideration to Ana.

When asked to describe their favorite engineering courses, the women's first thought was not about instructors, peers, assignments or projects in the course, but about the engineering content of itself. Ashley described her love for concrete and explained why her advanced concrete materials class was her favorite, she said, "obviously [advanced construction materials] is my favorite [class] ever. We learn about all the micro-structure and chemistry of concrete, which is nice… I love concrete." Moreover, learning about new engineering theories and application created a sense of wonderment for some of the participants. Ana described her amazement of the capabilities of the electrical components that she learned about in her electronics class: "the transistors and just all the things you can make with these little transistors. Like it is so cool and there's so much possibilities and there's growth every year [in transistor capabilities]."

When an engineering topic sparks the women's interest, learning about it in class is not enough for them. The participants sought out to gain more knowledge and to improve their understanding of how engineering topics can be applied in real life. Ana stated, "when I'm interested, I go the extra step and I definitely always like to go above where they teach me. So, if they're going to teach me something, I want to know how I can use it." Ashley spoke about her experience of taking construction management courses in her junior year after taking two years of general education courses, "I was excited to actually be in a classroom learning the stuff that I want to be learning. The classes are interesting. Like I'm never bored." The women's fascination and interest in engineering materials has been instrumental in their persistence in their respective engineering programs.

The second theme, *self-confidence in ability,* describes the women's resolute confidence in their academic abilities both in mathematics, science, or engineering topics. This theme is supported by the experiential application of theory, focused certainty, and socializing with like minds concept codes. The women's self-confidence and efficacy in science and mathematics classes in high school were instrumental in their decision to pursue an engineering degree. For example, Jessica stated, "I'm really good in math, so definitely engineering is what I want to do. Math and science have always been like a part of my life growing up. Like math is like second nature." This idea of mathematics, science and engineering problem solving being an inherent ability was echoed by Ashley: "I feel like I use problem-solving when I'm not even thinking about it. When you're just walking around or when I'm trying to help my parents do something, I feel like it's second nature at this point."

Despite the financial barriers, lack of support from Ana's immediate family, and the added challenge of being a first-generation student, Ana knew that she wanted more out of her life. She stated, "I just kinda knew that I didn't want to have like a regular job like other people do. And I wanted to have like a cool, meaningful job where I feel like I'm contributing to society with the way I think." This self-confidence is what drives Ana in her pursuit of physics and electrical engineering degrees. This unwavering self-confidence was also directly influenced the women's resolve to attend college after high school. Jessica did not doubt her ability to be successful in college, "I never doubted myself going to college, I just always knew I could get through it."

Additionally, the women's self-confidence is apparent by their selectiveness in who they study with and in how they describe their research or internship experience. When studying, the women prefer to not waste time studying with peers who do not perform at the same level as them. Ana stated, "it just depends if they're on the same track as I am because I don't want to try to study with somebody and they're going to be asking me calculus questions, like we already took that class. I'll find students that are on the same track as me and we study together, we're fine, get similar grades." Ashley described her preference in studying alone: "I don't really like to work in groups that much unless someone understands something better than me. I like to teach myself things alone." Analogously, when asked about to describe the environment in the engineering department, Ana speaks about her research experience, "when you're with your colleagues and with people that you are working with, it's great. Everybody's always working and, so it's nice."

The third theme, *significance of teacher interactions,* describes the varying impact that teacher interactions have had on the women's educational pursuits. The theme is supported by need for encouragement and inspiring role models concept codes. All of the women described interactions with high school teachers or engineering faculty that either provided support or became an obstacle in their pursuits in engineering. In high school, Ana was unable to identify a role model and stated that high school teachers "were very good at judging people by their covers." Specifically, her mathematics and English teachers had the biggest impact on her. She stated, "Math teachers, they were very critical in just like, they weren't encouraging enough. English teachers, they wanted you to get your feelings out so bad. They were encouraging."

The women also described specific faculty interactions in their respective engineering programs that made them question staying in their majors and their ability. Jessica spoke of an engineering professor from her junior year that damaged her self-confidence and made her consider changing her major. Jessica questioned his motivate for treating her differently: "it made me question my presence in his classroom- if it was wanted, if it mattered. It had me question like if my gender played a preference and like how he treated me and even my skin color in how he treated me." Subsequently, Jessica took a semester off to participate in a cooperative learning (co-op) where she built her self-confidence back up to continue in her construction management program.

Similarly, despite having a father who is an engineer, a mother who works in the construction industry, a strong mathematics identity, and a sustained interest in pursuing a construction management degree, one engineering professor made Ashley reconsider her major and questioned her ability. Ashley stated, "I straight up had a professor telling me that I should not be in engineering. I was devastated. I think it had a lot to do with like how the professor spoke to us. She was like very, very intelligent and made it seem that like we were not at her caliber understanding and knowing." This encounter had a lasting impact on Ashley as she mentioned this professor several times throughout the interview. It was only through the support of her parents and her faculty advisor that Ashley continued in the program.

The importance of faculty relationships also supported and nurtured the women's pursuit to their respective engineering degrees. While in her undergraduate programs, Ana identified multiple professors that were role models to her. Professors that were engaging and were passionate about course content were particularly important to Ana. She stated, "I just love the way their face lights up when they start talking about their subject. Like it's great. It's my favorite thing." Their enthusiasm in engineering topics had a direct effect on Ana's engagement with the material. In fact, one professor encouraged Ana to start a research assistantship based on her engagement in the classroom: "Dr. J, he was like my favorite professor ever. Like he's amazing. And he liked how much I liked the class. So, he started encouraging me to get into research." Based on his encouragement Ana applied and was selected for a research assistantship at Clemson University and within the electrical engineering department.

Both Jessica and Ashley mentioned high school teachers or engineering faculty that they still contact to keep them updated on their educational accomplishments. Ashley described one professor that was instrumental in Ashley's decision to persist in engineering after being told that she should not be in engineering: “Dr. R was probably the reason why I didn't give up after that other professor told me to stop being an engineer. She let me cry in her office a lot. But I emailed her after my first semester here because I got on the Dean's list and told her. She was so happy.” Similarly, a high school teacher that taught an introductory engineering course made an impact on Jessica and her decision to pursue an engineering-related degree. She said, “he gave me that opportunity to look at different aspects of engineering. He gave me an opportunity to try to see what I liked and what I didn't liked. In that class I was the only girl and so even being like a female, he was open to me and I really appreciated as a male, him coming to me. Like knowing that he saw what I wanted to do for a living and where I was headed after high school.”

Discussion

This pilot study examined the educational pathways and experiences of women who are on track to graduate from their respective undergraduate engineering programs during the 2019-2020 academic year. The study sought to determine how the women’s high school experiences aided in creating a foundation for their engineering identity and to explore how their post-secondary educational experiences contributed to their persistence in engineering; and provide a framework for a larger study that include 9 additional women. For this study, the women constructed their engineering identities through their interest and desire to learn more about engineering theory, self-confidence in their academic ability, and through positive interactions with their high school teachers and post-secondary engineering faculty. The findings from this study are congruent to existing literature on social cognitive career theory that conclude that interest, choice, performance, and satisfaction factors are interrelated and connected in the process of persisting in engineering programs [21]. Both outcome expectancies and self-efficacy beliefs are connected to interest; and interest combined with self-efficacy beliefs and outcome expectations can predict goals. These combinations lead to behaviors that lead the women to practice and choose engineering activities and therefore lead to degree attainment. Additionally, the finding of this study also show the dynamic nature of how educational and environmental experiences can strengthen or weaken a woman’s resolve to continue in the field of engineering.

Limitations

There are several limitations to the study. First, the findings are based on one- 45 to 60-minute interview from three participants. Future studies should expand on this work by increasing the number of participants and conducting follow-up interviews with the participants to increase the richness of the data. Second, only two engineering majors were explored in this study. Future studies should include women who are majoring in other engineering programs such as civil, mechanical, computer, and systems. Continued research on how social cognitive career theory explains how women develop their engineering identities and persist in engineering is necessary to increase the retention and persistence of women pursing undergraduate engineering degrees.

Implications

The findings of this study will provide insight on student academic development and help educational institutions gain understanding on how women decide on their engineering career choice. At the secondary level, schools can use these findings to enhance current STEM educational strategies and create a more integrated approach to appealing to female students. Current strategies fail to consider how women, from a social cognitive career prospective, process engineering learning opportunities and build their engineering identity [16]. Post-secondary educational institutions can utilize the results to aid in retaining women in engineering programs. Additionally, the institution where the study will take place may use the results to enhance current practices, through curriculum and mentorship, to nurture the development of women's engineering identities.

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Appendix

Concept Code	Primary Code	Code Description	#	Quotes
Possibilities of material	COE Favorite Class	Participant's description of their favorite engineering course	5	Ana "the transistors and just like all the things you can make with these little transistors. Like if this is so cool and there's so much possibilities and there's growth every year" Ashley "I liked cost estimating because it was interesting. It was nothing like I had ever learned before and I, it intrigued me."
Desire for knowledge	Student Characteristics	Personal characteristics of participant	11	Ana "when I'm interested, I go the extra step and I definitely, um, I always like to go above where they teach me. So, if they're going to teach me something, I want to know like how I can use it or how I can be done better or why we do things." Jessica "I was like kicked butt in engineering classes. Like I had like 16 probably credit hours with like 1201 being included like my freshman year here."
Cognitive challenge	Coursework	Engineering classes	3	Jessica "So definitely math and science has always been like a part of my life growing up. Like math is like second nature." Ana "I feel like there were a lot of possibilities and so much that I could like learn and, you know, it was like a whole world opened up for me"
Focus certainty	Changing major	Answer for if participant has ever considered changing to a major outside of engineering	5	Ana "No, definitely not. Electrical engineering is definitely where I want to be."
Experiential App. of theory	Research or Internships	Participant's description of their involvement in research on campus or engineering internship	17	Ashley "And I'm a fast-paced learner, so I picked everything up really quickly. And at that point, like I was helping to teach him stuff, which like I felt bad cause he'd been there longer than me, but at the time, like he was very appreciative of the fact that like I could do the stuff and help him with it before I left. It was like gratifying, I guess, like know that you were helping someone not to." Jessica "I did the co op for one term, so I did it last fall. And then they asked me to continue working part time in the spring. I continued working and instead of doing my second term in the summer, they extended an offer to me in March of that spring semester."
Socializing with like minds	Studying with Peers	Study habits	7	Ana "it just depends if they're on the same track as I am because I don't want to like try to study with somebody and they're going to be asking me algebra questions and like calculus questions, like we already took that class."
Need for encouragement	HS Teachers	Reflection on high school teacher interactions	21	I've always liked my English teachers. There were always my favorite teachers and my least favorite teachers were always my math teachers.
	HS Teachers Inspire	Participant's description of how teachers inspire their students	4	Ana "they wanted it to like inspire everybody to be into their field, which is I think my favorite, um, aspect of a teacher when they, when they want to like encourage their students and be like that"
Inspiring role models	COE Faculty	Interactions with faculty inside classroom, research, and TA	21	Ana "I just love like the way their face lights up when they start talking about their subject. Like it's great. My favorite thing" Jessica "my engineering professor would probably be my favorite teacher just because he gave me that opportunity to look at different aspects of engineering."
Engineering Application	College experience	College experience, in classroom, with faculty, with peers, with curriculum	7	Ashley "The classes are interesting. Like I'm never bored really."
	COE environment	How participant describes climate in their respective engineering discipline on campus	7	Jessica "I think your presence really plays a lot cause you give like the women that I do see like just from me as a woman, just looking from the outside like, Oh there's another woman. Like thank God I can come talk to her, this lady like thank God.
Applied career	Engineer	Participant's description of what an engineer is/does	1	Ana "I feel like as an engineer, yes it's important to do math, but it's a lot more important to be able to put things together and make them work, if that makes sense."