FACTORS IN ENGINEERING EDUCATIONAL PERSISTENCE

THE CORRELATION BETWEEN IDENTITY AND SELF-EFFICACY

by

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Abstract

Engineering educators seek to further understand why there is a shortage of engineers in the work force and a decline in student interest (National Center for Education Statistics, 2014). Understanding how one would define their identity as an engineer is of a critical nature. This study investigates the motivation for studying engineering, as well as the role of persistence in an engineering curriculum and engineering self-efficacy. Using an explanatory sequential mixed method design, this study examines the correlation between variables in two areas: student academic self-confidence and student engineering identity as well as a correlation between engineering student self-efficacy and student educational persistence. The key factors and experiences that relate to engineering student identity development and enhanced educational persistence are explored.

The purpose of this study is to analyze the relationship between the identity development of engineering students and their educational persistence in STEM programs. This study explores the following two primary findings relating to engineering identity in the context of emerging adulthood and social cognitive career theory.

(1) A list of key factors and experiences that relate to engineering student identity and educational persistence.

(2) An initial framework of social cognitive career theory in the context of emerging adulthood.

The following are the primary research questions for the current study:

(1) Is there a correlation between student academic self-confidence and their identity as an engineer?

(2) Is there a correlation between engineering student self-efficacy and their educational persistence?

(3) What are the key factors and experiences that relate to engineering student identity development and enhanced persistence?

The goal of this study was to look at the relationship between the identity development of engineering students and their educational persistence to continue in STEM programs. Initial studies that describe the development of the identity of engineers, parallel engineering development to existing human learning developmental stages (Learner, 1976). As we gain greater understanding of the multiple factors that influence the development of identity in post-secondary engineering students, we can begin to make connections to the pedagogical issues inherent in STEM education and the educational leadership required in support of student needs. After complete data analysis, findings show that the following exists:

1) A correlation between academic self-confidence and identity as an engineer
2) A correlation between student self-efficacy and educational persistence

Qualitative analysis reveals key factors and experiences that relate to engineering student identity development and enhanced persistence.

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CHAPTER 1 INTRODUCTION

1.1 Introduction

As the world has become increasingly advanced in many dimensions, an evaluation of the effectiveness of science, technology, engineering, and mathematics (STEM) education in the United States has become imperative (Honey, Pearson, & Schweingruber, 2014). STEM education will determine whether the United States will play a leadership role among the nations and to what extent we will be able to solve challenges in areas such as energy, health, environmental protection, and national security (National Science Board (NSB), 2012). Producing a capable, effective, and flexible workforce is critical to compete in the global marketplace (Business Higher Education Forum [BHEF], 2010). Generating scientists, technologists, engineers, and mathematicians is required to create new ideas, new products, and new industries for the 21st century. Technical skills and quantitative literacy will be critical skills to make informed choices in an increasingly technological world (President's Council of Advisor's on Science and Technology [PCAST], 2010; President's Council of Advisors on Science and Technology [PCAST], 2012). The economy, the power and the leadership of the United States is critically dependent on how we educate and motivate students into STEM professions.

Throughout the 20th century, the United States education system has driven our Nation's economic growth and prosperity by producing workers with higher levels of skill than previous generations. Scientific progress has become increasingly important as a driver of innovation-based growth. In the 21st century, the country is working toward becoming a world-leader in the STEM workforce as they make rapid advances in science, engineering and technology (National Research Council [NRC], 2007). Despite coherent actions taken by the government and various institutions, the US cannot ensure the production of a sufficient number of experts in STEM fields to meet its national and global needs (Hossain & Robinson, 2012, p. 442). Continued focus on educational standards in science and mathematics are required to aid in the process of attracting STEM candidates.

Shared standards for science and mathematics have been developed to help the educational system set and achieve goals to advance learning in STEM subjects for the next generation to succeed globally. Both the Common Core State Standards for Mathematics (CCSSM) and the Next Generation Science Standards (NGSS) have promised deeper connections in mathematics and science among the STEM subjects (Honey, Pearson, & Schweingruber, 2014). Revised standards and updated practices are the foundation for all changes that need to be made in a pursuit of student STEM identity development. Although content is a key factor in attracting students, the development of student identity is also required. The NGSS explicitly includes inquiry-based practices and core disciplinary ideas from engineering along with science, taught in an integrated manner. The expected outcomes include learning and achievement in the STEM related fields, the development of STEM identity; and the ability to transfer understanding across STEM disciplines (PCAST, 2012). The implementation of both the revised curriculum standards and classroom practices are the foundation for recommended changes necessary to increase future STEM students in higher education.

Adjustments to the secondary school learning environment have the goal of creating an influx of engineering and science students into higher education. The potential influence of the standard enhanced STEM education initiatives on college students include: learning and achievement, and interest and identity (PCAST, 2012). There are some indications that STEM experiences will support interest development in secondary schools, but the research studies are limited. Furthermore, there are very limited studies on student identity at the college level in the context of STEM educational experiences and are mostly qualitative in nature. The findings of these studies will be described in the literature review.

Additional cognitive factors need to be considered to reap the potential benefits and challenges of the STEM initiatives (Association of Higher Education [AHE], 2011; PCAST, 2010). Examining the topic from a cognitive psychology perspective may provide insight into factors that enhance the benefits and the development of a STEM identity. For many students there is a perceived barrier of complexity in taking STEM classes. The STEM changes may be effective because basic qualities of cognition favor connected concepts over unconnected concepts; thus making it easier for future retrieval and making meaning (Krogh & Anderson, 2013). Connected knowledge structures also support the learners' ability to transfer understanding and competencies to new or unfamiliar situations. Being able to represent the same concept within and across disciplines in multiple ways can facilitate learning. However integrated context can also impede learning as it can place excessive demands on resource-limited cognitive processes such as attention and working memory.

In addition to these cognitive factors, a socio-cultural aspect also influences student success in STEM learning. Social and cultural experiences require students to work together and actively engage in discussions, joint decision making and collaborative problem solving (Bybee, 2010). Each of these learning experiences is particularly important in integrated learning. Techniques such as scaffolding and peer collaboration can help students be successful with challenging tasks and move them beyond their current state of knowledge (Crippen & Archambault, 2012). The use of real-world situations can bring STEM fields alive for students and has the potential to deepen their learning. However, there is evidence that detailed concrete situations can prevent students from identifying the abstract structural characteristics that are needed to transfer their experiences to other settings (Tseng, Chang, Lou, & Chen, 2013). Constructing knowledge through teamwork and problem-solving with scientific methods does not ensure a student's choice in pursuing future careers. A better understanding of students' learning attitudes and motivations must also be examined to strengthen learning abilities and enhance self-efficacy in STEM fields. Will these revisions increase the number of students who can "see themselves" as future scientists, mathematicians, and engineers?

1.2 Statement of the Problem

Engineering, one of the main disciplines of STEM, represents a wide variety of concepts with varied interpretations based on the perspective of the individual. More importantly, understanding how one would define the identity as an engineer is of critical nature. This is a question of identity and is considered based on a psychosocial perspective: how do I identify myself, and how do others identify me? Engineering educators seek to further understand the answer to these questions as there is a shortage of engineers in the work force and a declining student interest (National Center for Education Statistics [NCES], 2014). To resolve this problem, it is necessary to understand the motivation for studying engineering, as well as the role of persistence in an engineering curriculum and engineering self-efficacy. Persistence in engineering has been linked to a sense of belonging to a greater community (Lent et al., 2003). This directly relates to identity and how well an individual perceives that they fit into the classification as an engineer (Hutchison, Follman, Sumpter, & Bodner, 2006). Engineering identity research has been predominantly qualitative and the studies have focused on the extent to which students see themselves as engineers and the factors that define classification. There is a strong need for quantitative studies with larger populations. This will allow for theoretical foundations from developmental psychology to articulate the developmental process of engineering identity and the correlation to self-efficacy (Loo & Choy, 2013).

1.3 Purpose Statement

The goal of this study is to look at the relationship between the identity development of engineering students and their educational persistence to continue in STEM programs. Initial studies that describe the development of the identity of engineer's parallel engineering development to existing human learning developmental stages (Learner, 1976). As we gain greater understanding of the multiple factors that influence the development of identity in post-secondary engineering students, we can begin to make connections to the pedagogical issues inherent in STEM education and the educational leadership required in support of student needs. The following are the primary research questions for the current study:

(1) Is there a correlation between student academic self-confidence and their identity as an engineer?

(2) Is there a correlation between engineering student self-efficacy and their educational persistence?

(3) What are the key factors and experiences that relate to engineering student identity development and enhanced persistence?

1.4 Conceptual Model / Theoretical Framework

The theoretical framework for the current study is Bandura's Social Cognitive Theory (Bandura, 1986) and Erikson's eight-stage theory of human development (Erikson, 1950). The conceptual model is a psychosocial perspective, a combination of self-efficacy and identity as the basis of the developmental process for engineering and STEM related fields. The conceptual model is introduced in this section and will be developed further in Chapter 2.

Bandura's Social Cognitive Theory was further developed by Lent, Brown and Hackett's (1994), as Social Cognitive Career Theory (SCCT) to understand vocational and academic predictors of interests, performance, and choice goals. SCCT has been applied to academic domains such as math, science and engineering. Lent et al. (1994) theorize that a person's self-efficacy, or confidence is related to outcome expectations and results in a particular behavior, ultimately influencing interest. Persistent interest is only developed when a person expects to be successful and anticipates a positive outcome (Lent et al., 1994). Performance, therefore, is predicted by behavior and a person's self-efficacy beliefs. Engineering education research requires the use of qualitative methods to answer well-designed studies built across theoretical perspectives, research questions and research methods to measure outcome expectations. Many factors that contribute to the development of interests and goals have been investigated; however very few articles have been published that correlate self-efficacy and interest in engineering (Koro-Ljungberg & Douglas, 2008; Lent, Brown, & Larkin, 1984). With the limiting contributions from qualitative studies, there is a call on researchers to expand their use of qualitative methods and to design studies with careful attention to epistemological consistency across theoretical perspectives (Koro-Ljungberg & Douglas, 2008, p. 163).

In Erickson's eight-stage theory, the stages of young adulthood are the focus, identity versus confusion and intimacy versus isolation (Erikson, 1968). Stage theory offers an understanding of the psychological development that takes place and applied to the educational development of students and their emerging identity through experiences with faculty, peers and the college community. Jeffrey Arnett's (2000) theory of emerging adulthood is a modern theory stemming from Erikson and focuses on a separate developmental stage of understanding of college students. Emerging adulthood, as defined by Arnett (2015), involves a longer and more widespread education, later entry to marriage and parenthood, and a prolonged and erratic transition to stable work (Arnett, 2015, p. 8). These changes are taking place worldwide over the past half century, and are true of developed countries across the globe, as well as developing countries. Whenever there are a substantial number of years between the time a young person reaches the end of adolescence and the time they enter stable adult roles in love and work, emerging adulthood is said to be present. Many possible paths through this stage exist for how emerging adults experience their education, work, beliefs, self-development and relationships (Arnett, 1994, 2000). Arnett's theory is applied in this study to identify factors that engineering students deem critical to being considered an engineer.

1.4 Definition of Terms

Conceptual Framework Terms

Educational Persistence:

Educational persistence is a student's postsecondary education continuation behavior that leads to graduation. Continued enrollment or degree completion at any higher education institution including one different from the institution of initial enrollment.

Emerging Adulthood:

Arnett has defined emerging adulthood as a time in life when little about the future has been decided and the scope of independent exploration of life's possibilities is greater than any other period. There are five factors commonly experienced during this time: identity exploration, instability, self-focused, feeling in-between and the age of possibilities (Arnett, 2004).

Interest:

Interest develops over time, beginning with the triggering of attention and extending to voluntary reengagement, often characterized in terms of curiosity, persistence, and resourcefulness (Honey, Pearson, & Schweingruber, 2014).

Interest is also related to outcomes that can influence learning such as self-efficacy, and individual's sense that he or she can be successful in a given domain. Once an interest begins to develop, it can be sustained through instruction and/or out of school experiences, during which the learner often comes to identify with those who represent and pursue the interest professionally (Honey, Pearson, & Schweingruber, 2014).

Identity:

Identity is a person's conception and expression of their own (self-identity) and others' individuality or group affiliations (such as national identity and cultural identity).

Identity generally refers to one who is or wants to be a particular kind of person, with particular interests, expertise, and ways of being in particular social contexts (Honey, Pearson, & Schweingruber, 2014).

Identity with respect to STEM has implications for how or why one might engage in classes, enroll in STEM course, or use ideas and practices from STEM disciplines outside the classroom (Honey, Pearson, & Schweingruber, 2014).

Self-efficacy:

Psychologist Albert Bandura (1977, 1982) has defined self-efficacy as one's belief in one's ability to succeed in specific situations.

Engineering / Higher Education

ABET:

ABET, Accreditation Board for Engineering and Technology, is a non-profit and non-governmental accrediting agency for academic programs in the disciplines of applied science, computing engineering and engineering technology. ABET is a recognized accreditor in the United States (U.S.) by the Council for Higher Education Accreditation (ABET, 2007-2008).

CDIO:

CDIO, short for conceive, design, implement and operate, is an international collaboration conceived by Massachusetts Institute of Technology in the late 1990's. CDIO is an innovative educational framework of curricular planning and outcome-based assessment for producing the next generation of engineers (Crawley, Malmqvist, Ostlund, & Brodeur, 2007).

1.5 Research Questions

(1) Is there a correlation between student academic self-confidence and their identity as an engineer?

(2) Is there a correlation between engineering student self-efficacy and their educational persistence?

(3) What are the key factors and experiences that relate to engineering student identity development and enhanced persistence?

1.6 Significance of the Study

The current study contributes two primary findings to a growing body of literature relating to engineering identity in the context of emerging adulthood and social cognitive career theory.

(1) A list of key factors and experiences that relate to engineering student identity and educational persistence for engineering students in the Northeast.

(2) An initial framework and understanding of social cognitive career theory in the context of emerging adulthood.

These findings contribute to the engineering educational community and through links to prior scholarly work and application of developmental psychology and sociology.

1.7 Delimitations

There are three primary limitations involved in the current study: the single-site design, the reliance on human subjects, and the study participants. The single-site design limits transferability to other dissimilar institutions. The research site is a small university and the results may not be generalizable to larger institutions. As the nature of the study involves human subjects, inherent uncertainties exist.

1.8 Summary

This paper includes five chapters in total. The first chapter serves as an introduction which outlines the objectives, problem statement, framework, significance, limitations and definitions. Chapter 2 is a review of the conceptual framework and synthesis of related literature on student interest and identity. Chapter 3 outlines the methods for both the quantitative and qualitative aspects of the study, to address the research questions. Chapter 4 presents the findings of the survey and the interviews. Key factors, experiences and emerging themes are presented from the student interviews. Chapter 5 presents the interpretation of these themes and recommendations for future study.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

The intent of this chapter is to highlight previous research and theories related to the topic of student identity and educational persistence in engineering and integrated STEM subjects. Aligned with this purpose, this chapter will focus on three components: 1) an overview of STEM Education (history and current STEM), 2) the literature in regards to the conceptual framework, and 3) finally the review of the literature on student academic self-confidence, engineering identity, engineering student self-efficacy and educational persistence. The review of the literature will provide information about what is currently known about student identity and educational persistence in STEM subjects and what defines or creates an effective STEM learning experience for students.

2.2 Historical Perspective of STEM Education

Scientific advancement dates back to the 1700’s when now famous scientists, theorists and mathematicians made critical discoveries during the Scientific Revolution. These pioneers created the foundation for major fields of modern science, including physics, chemistry, biology and astronomy; and created a path for STEM that has impacted education that is emerging over 200 years later in the fields of astrophysics, medicine, technology and environmental studies. Their innovation and passion for science and learning still influences how STEM education is conducted in classrooms to this day through the advancement of current day technology.

In 1896, John Dewey created a learning laboratory in the Dewey School where he tested his theories and began his work on school reform. His philosophies and research have influenced STEM education as well as pedagogy (Goodchild, 2012). In 1931, Dewey wrote a pamphlet, *The Way Out of Educational Confusion*, which described the importance of integrated learning; this paved the way to integrate curriculum into classrooms. Dewey recommended that the different disciplines should be taught together and brought to life through real-world applications (Dewey, 1931). In 1899, Thomas Huxley, another education pioneer, concluded that science education was essential for understanding the modern world (Association of Higher Education, 2011). He also, recommended that science be taught at an early age using physical real-world objects rather than books to master science topics.

In 1917, the Smith-Hughes Act promoted vocational-focused education so that individuals were prepared to enter the work force; and provided federal funds for these purposes. This Act provided federal and state funding for teacher training in secondary vocational educational settings (Scott & Sarkees-Wircenski, 1996). This Act provided the funding necessary to encourage innovative practices needed during that era and provided an impetus for future education funding.

The National Science Foundation (NSF) Act, signed by President Truman in 1950, initiated a significant movement toward the reform of science and math education (Appel, 2000). At that time, NSF began funding opportunities through grants to support innovation in science education. The demand on science and technology was further pronounced in reaction to the Soviet Union's launch of Sputnik in 1957, along with the Cold War (Thomas & Williams, 2010). The STEM acronym, referring to the academic disciplines of science, technology, engineering and mathematics, arose shortly after an interagency meeting on science education held at the National Science Foundation to address educational policy and curriculum choices in schools with the goal of improving competitiveness and increase qualified candidates in high-technology jobs (Gonzalez & Kuenzi, 2012, p. 5).

Congressional interest in STEM education heightened in 2007 when the National Academies published a report titled *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Gonzalez & Kuenzi, 2012, p. 6). This publication warned federal policymakers that perceived weaknesses in the existing U.S. education system threatened national prosperity and power. Although many disputed the report's assertions, the report helped focus the federal STEM education programs and lead to the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act (or America COMPETES Act), which in turn authorized STEM education programs at the National Science Foundation, National Oceanic and Atmospheric Administration, Department of Energy, and Department of Education.

In 1985, Project 2061 was initiated by the American Association of the Advancement of Science (1993). The purpose of the project was to enhance STEM education in the United States by focusing on curriculum, and professional development. In 1996, the National Research Council created the National Science Education Standards to promote and expand the importance of elementary and secondary science education (National Research Council [NRC], 2007). These standards are crucial as they guide science curriculum and the integration of science in general education.

The Next Generation Science Standards (NGSS) are based on the Framework K-12 Science Education that was created by the National Research Council, 2011. NGSS are part of a national effort to create new education standards that are rich in content and practice. They are arranged in a coherent manner across disciplines and grades to provide students an internationally benchmarked science education. The final draft of the standards was released in April 2013 and is currently being implemented today in many states.

In 2010, the President's Council of Advisors on Science and Technology wrote the report, Prepare and Inspire: K-12 STEM Education for America's Future. This report outlines initiatives in STEM education which are federally funded: 1) support the current state-led movement for shared standards in math and science; 2) recruit and train 100,000 teachers in the next decade to prepare and inspire students in STEM; 3) recognize the top five percent of the nation's STEM teachers; 4) use technology to drive innovation, by promoting advanced research projects for education; 5) create opportunities to inspire students through individual and group experiences outside of the classroom; 6) create one thousand new STEM-focused schools over the next decade; and 7) provide strong and strategic national leadership (President's Council of Advisors on Science and Technology, 2010). These federally funded programs provide a focus on critical areas that will help progress the STEM movement in the upcoming years.

The long history of STEM provides a basic framework that informs education and guides the research. The experiences of all those involved impact the improvement of STEM pedagogy and the leadership and interactions of teachers and students. For nearly two decades, the National Science Foundation has used STEM to refer to the four separate and distinct fields we know as science, technology, engineering, and /or mathematics (National Science Board [NSB], 2012). Each discipline is well established in their own sovereign territory. Only recently, there has been suggestion that STEM education implies interaction among these disciplines (PCAST, 2010). New integrative approaches have only recently emerged to explore teaching and learning between and among any two or more of the STEM subject areas. In this new realm, there exists purposeful design and inquiry as a component to the integrative STEM education. Over the past two decades of educational reform, technology education has focused on technological design, while science education has focused on inquiry tasks (PCAST, 2010). By combining technology and science education, the student envisions and develops solutions to a design challenge to test an idea about their scientific problem. This problem-based learning approach situates scientific inquiry and the application of mathematics in the context of technological designing and problem solving (Pan & Allison, 2010). Inquiry of this type rarely occurs in the science classroom or in the technology education lab, and the technological design rarely occurs in the science classroom. However, in this new integrated domain, technology design and scientific inquiry occur concurrently in the engineering of solutions to real-world problems.

2.3 Conceptual Model / Theoretical Framework

Engineering, as a STEM discipline, involves integrated inquiry-based learning and is grounded in constructivist learning theory. STEM disciplines incorporate a number of well-known theories: contextual learning (Dewey, 1931), cognitive development (Piaget, 1954), social cognitive learning (Vygotsky, 1978), sociocultural constructivism (Cobern, 1991), discovery learning (Bruner, 1971), social learning and self-efficacy (Bandura, 1977, 1997), and situated learning (Lave & Wenger, 1988).

2.3.1 Theoretical Influences

Dewey advised that meaningful learning occurred through real-world contexts, and the students' ability to use these concepts resulted in the creation of more complex representations which demonstrated deeper understanding of these concepts (Dewey, 1931). Similar to Dewey, Lave alleged that the situation in which learning occurred affected the learning; he referred to this as situated learning (Lave, 1988). The current term inquiry-based learning involves aspects of situated learning as the student solves contextual real-world problems using integrated techniques and procedures that they can apply to similar problems in different situations (Lave, 1988). This aligns with both Dewey and Lave's theory of how meaningful learning takes place.

Learning experiences that include debate, active reflection, collaboration, pre-existing knowledge, and the development of critical thinking skills, often have roots in the work of Jean Piaget (Piaget, 1954). Piaget proposed that the development of logical reasoning in children occurs in sets, and children accommodate what they know to incorporate new knowledge, or assimilate new knowledge into their pre-existing world (Piaget, 1954). Piaget proposed that when students collaborate with peers during their cognitive development, constructed knowledge through experiences and active reflection, leading to understanding. In contrast, providing students with information as in rote learning, will not lead to understanding (Piaget, 1954). Piaget's ideas are the basis for integrated learning as we know it today.

Similar to Piaget, Cobern (1991) believed that understanding was built on pre-existing knowledge and experiences, and influences inquiry-based learning. Cobern further recommended that the prior experiences and knowledge students bring with them to the classroom should be valued and incorporated in the lesson design (Cobern, 1991). During the course of integrated inquiry-based learning activities, the students' knowledge and experiences should be actively solicited and used to reinforce the lesson.

The work of Vygotsky (1978) also incorporated the use of collaboration and discourses as a means of constructing knowledge, and can be directly connected to models of inquiry-based learning. Vygotsky stated that students learn best through social interactions with knowledgeable peers and teachers, through scaffolding or support for the student's acquisition of more complex knowledge (Vygotsky, 1978).

Bruner (1971), recognized for his theory of discovery learning, recommended students be engaged actively through discovery of principles and discussion of ideas with peers and teachers. Similar to a reflective learning style, students become reflective learners and become personally engaged with the materials (Bruner, 1971). Bruner recommended students' questions be encouraged in the classroom and integrated in the instruction. Through the use of intellectual communities, Bruner believed that effective learning occurs through conversation and discussion between the more knowledgeable and the less knowledgeable. Bruner's emphasis was on critical thinking and knowledge construction through the collaborative nature of inquiry.

Bandura (1977, 1982) proposed a theoretical framework to explain and predict behavior change and suggested that these changes are mediated by a common cognitive mechanism. Self-efficacy is the belief that one's ability to successfully perform a given task or behavior determines whether coping behavior is commenced, how much effort will be expended, and how long effort will be sustained in the face of obstacles and aversive experiences (Lent, Brown, & Larkin, 1984). According to self-efficacy theory (Bandura, 1977), self-efficacy beliefs determine performance accomplishments and persistence in pursuing a difficult course of action. In the extension of this model to career behavior, Hackett and Betz (1981) have hypothesized that efficacy expectations are related to degree of persistence and success in the selection of college major and career choices.

Bandura's theory proposed that students will observe and imitate the actions and behaviors of those they perceive as the same or higher status (Bandura, 1986). Through collaboration and dialogue with peers, teachers and experts on authentic problems, the student is able to learn, adopt and demonstrate the skills and behaviors of more competent members of the environment.

Wenger's work promoted inquiry-based learning through the belief that learning occurs between everyone in a community of practice (Wenger, McDermott & Snyder, 2002). Through collaborative community practice, the students and practitioners engage in meaningful dialogue, sharing ideas and deepening their knowledge and expertise. When students join a community of practice, they adopt the attributes and language modeled by that community of practice. They become more confident and competent, moving toward the role of expert for those who are just entering that community (Wenger et al., 2002).

2.3.2 Social Cognitive Career Theory

Social Cognitive Career Theory, SCCT, provides a model that relates self-efficacy, outcome expectations, interests and choice goals (Lent et al., 1994). This framework has been extensively explored by Lent et al. (2006) and has provided the information for instruments to measure components of this model. Specific to research questions are personal motivation constructs (interest and self-efficacy) and outcome expectations (career choice goals). This model takes into consideration influencing factors such as background, learning experiences, and supports and barriers. This model also considers how one's choices and actions are influenced by their expectations, goals and environmental influences. SCCT was derived mainly from Bandura's social cognitive theory (Bandura, 1986). Bandura's theory states that, "people act on their judgments of what they can do, as well as on their beliefs about the likely effects of various actions" (Bandura, 1986, p. 249). In a similar fashion, SCCT is focused on understanding the processes during which individuals form interests, makes choices, and attain achievements in occupational and academic pursuits. The main advantage of using the SCCT framework is the ability to link a student's interest and self-efficacy of their current curriculum to their outcome expectations and goals. Self-efficacy relates to a person's belief in their ability to accomplish actions required for a particular activity and varies depending on the task, also known as task-specific self-efficacy. Within SCCT, task specific and coping efficacy has been studied as predictors of choice goals and persistence. While an interest refers to a person's likes and dislikes about an activity, an outcome expectation is the belief about the implication of performing a behavior. Goals are the intention or aspiration to engage in a study to obtain a specific outcome (Lent et al., 1994, Lent & Brown, 2006).

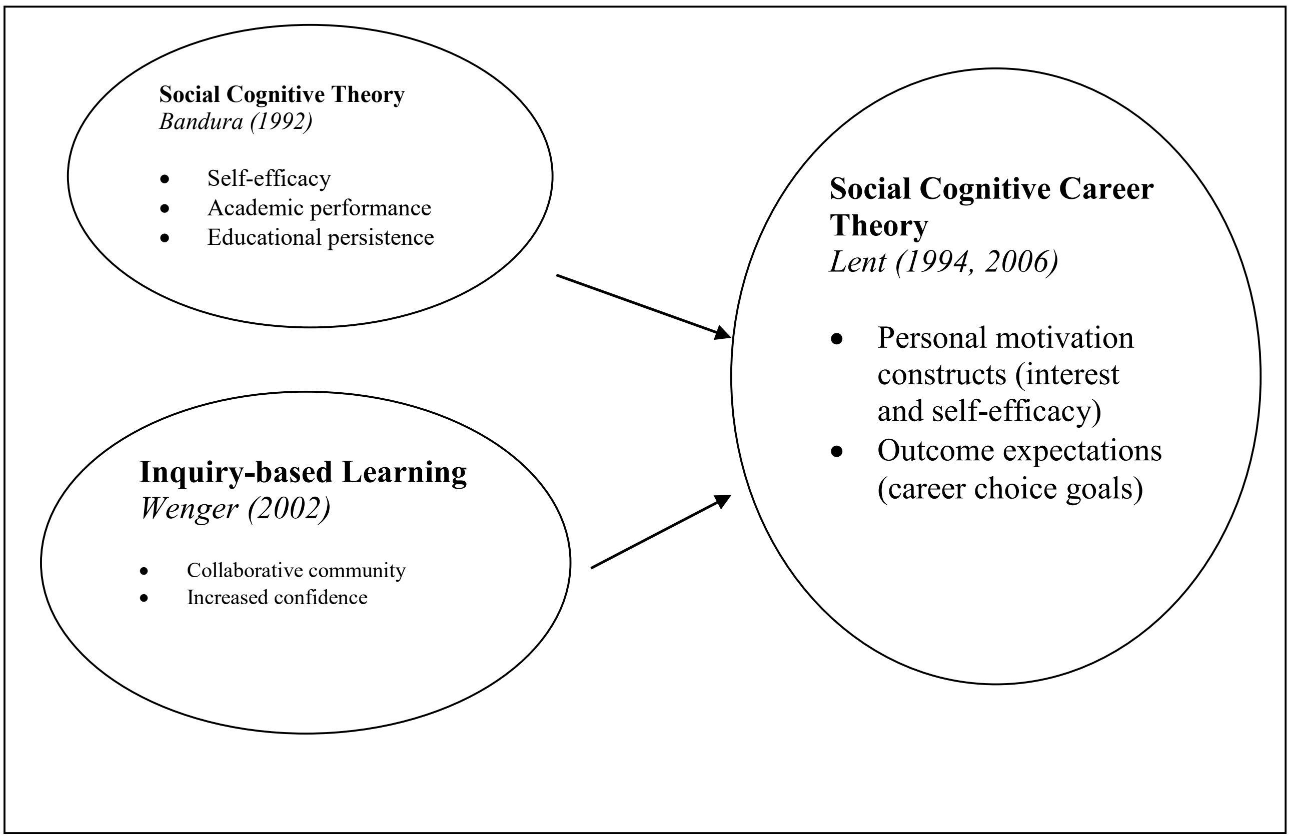


Figure 2.1 Conceptual Framework: Social Cognitive Career Theory

2.2.3 Identity Stage Theory

Identity formation is central to adolescence (Erikson, 1950) and extends from adolescence into college during the time period of emerging adulthood (Arnett, 2000). During the 1950's, theories of adolescent identity were proposed and viewed as credible as they reflected the conditions of the time (Erikson, 1950). However, these theories could not encompass the technological changes and social evolution that have since occurred. Criteria for adult status can no longer be measured by traditional criteria. Adolescent identity and career exploration is more difficult in a technological society. Additional ways to improve student readiness need to be explored as more education is needed to qualify for jobs.

According to Erikson, adolescents must resolve two internal life crises during this developmental stage. The first crisis occurs in middle adolescence and is referred to as identity versus identity confusion. The struggle involves finding the balance between developing a unique, individual identity while still being accepted. Erikson believed that when an adolescent successfully navigates through this stage they emerge with a clear understanding of their own identity; and can easily share themselves with others without deviating through persuasion. The second crisis occurs between late adolescence and young adulthood; and is the crisis of intimacy versus isolation. This struggle resolves the reciprocal nature of intimacy; to achieve a mutual balance between giving love and support. Erikson believed that when youth successfully navigate this crisis they emerge with the ability to form honest, reciprocal relationships with others and have the capacity to form bonds with others to achieve common goals. While Erikson's theory remains influential, it has been revised over time as the developmental process is considered less concrete and more flexible than first thought.

2.3.4 Arnett's Theory of Emerging Adulthood

According to Arnett (2000), emerging adulthood is a distinct developmental period from late teens through the twenties, specifically ages 18-25. The focus during emerging adulthood is on exploring one's own identity. Changes over the past century have altered the nature of development in the late teens and early twenties. Because marriage and parenthood are delayed until the mid to late twenties, it is no longer typical for late teens and early twenties to be settling into long-term adult roles. Emerging adulthood is distinguished by relative independence from social roles and normative expectations. During this time, many different directions remain possible and very little about the future has been decided for certain. Independent exploration of life's possibilities is greater than it will be at any other period of their life. It is only in the transition from emerging adulthood to young adulthood in the late twenties that the diversity narrows and the instability eases as choices in work and love are made.

The distinctiveness of emerging adulthood focuses on demographics, subjective perceptions, and identity exploration. There is evidence available suggesting risk behavior to be another distinct aspect of this phase, with a connection to identity exploration. Arnett states that emerging adults pursue novel and intense experiences more freely before settling down into roles and responsibilities of adult life. "Explorations in work sometimes result in a failure to achieve an occupation most desired or in an inability to find work that is satisfying and fulfilling" (Arnett, 2015, p. 169). To a large extent, emerging adults pursue their identity explorations on their own, without family of origin or their family to be. Emerging adults spend more of their leisure time alone than any persons except the elderly and spend more of their time in productive activities such as school or work.

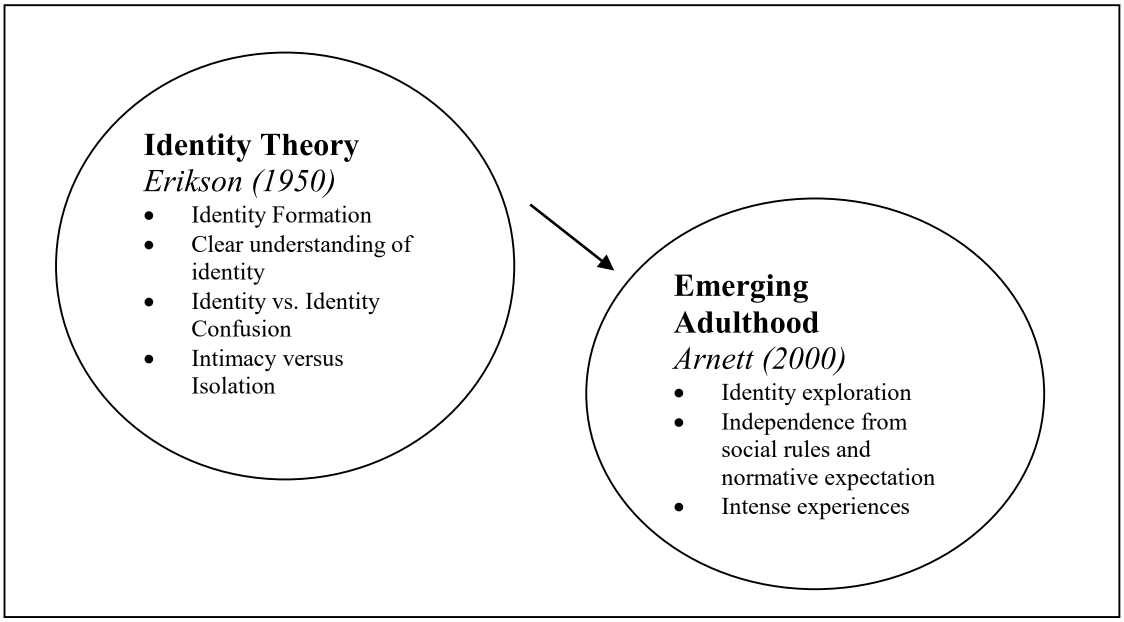


Figure 2.2 Conceptual Framework: Emerging Adulthood

2.3.5 Additional Perspectives on Emerging Adulthood

Emerging adulthood is defined by Arnett as a separate stage from Erickson's stages of adolescence and of young adulthood (Arnett, 2000). Erikson defined adolescence as the ages 12 to 18 and young adulthood as the ages 19 – 40. Due to biological and social changes, it makes sense in our time to define adolescent development as ages 10 – 18. There are also a number of reasons why young adulthood is unsatisfactory as a designation for ages 18 – 25. The majority of people ages 18 – 25 are still in the process of obtaining education for a long-term adult occupation, where people in their thirties have settled into a more stable occupational path (Arnett, 2000). The transition from emerging adulthood to young adulthood is much less definite with respect to age, intensifies in the late twenties, and is typically reached by age 30 in most respects. Emerging adulthood is most found in cultures that postpone the entry into adult roles and responsibilities until well past the late teens. Countries that require a high level of education and training for entry into information-based professions, leave most young people in school into their early to mid-twenties. Emerging adulthood is therefore found in countries that are highly industrialized or post-industrial and characterizes a distinct period of life for young people. The career exploration aspect of emerging adulthood merits scholarly attention as a distinct period of life course in industrialized societies. As countries around the world reach higher points of economic development, prolonged periods of career exploration during emerging adulthood will become normative in society.

Social Cognitive Career Theory (SCCT) provides the conceptual framework used in this research. Lent and Brown demonstrated that the SCCT model provides the personal and motivation constructs (interest and self-efficacy), along with outcome expectations of a career choice goal. In addition to this model, identity as describe by Arnett (2000) constructs should be considered as a factor for engineering educational persistence. A clear understanding of identity and the processes involved in formation may add to this conceptual framework to determine if there is an impact of engineering educational persistence. Exploring the correlation of the key experiences as described in emerging adulthood by Arnett (2000) to the constructs found in social cognitive career theory, will be the basis for the conceptual framework of this study.

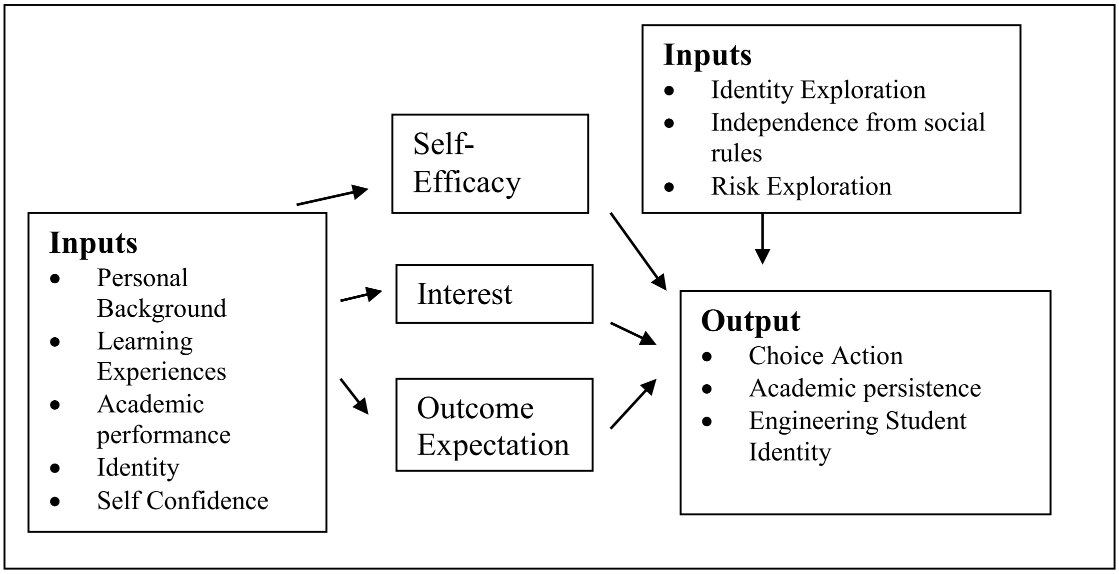


Figure 2.3 Proposed Conceptual Framework

2.4 Literature Review

This section includes a review of the literature on student academic self-confidence, engineering identity, engineering student self-efficacy and educational persistence. The review provides information about what is currently known about student identity and educational persistence in STEM subjects and what defines or creates an effective STEM learning experience for students.

Lucas, Cooper, Ward and Cave (2009) stated that self-efficacy in engineering education, is becoming more the appropriate basis of study because of the growing importance of experiential learning. In their study, Lucas et al. (2009) declare that a steady expansion of experiential forms reach into all the years of engineering education as a basis of the ABET (Accreditation Board for Engineering and Technology) requirements. In the work by Pan & Allison (2010), and Scheibe, Mennecke, & Luse (2007), the authors state that active learning and problem-based learning is expected to make material more interesting and engaging, and increase the understanding of material because students find information for themselves and then actively use their skills to complete tasks. Today, universities use the CDIO (Conceive – Design – Implement – Operate) Syllabus to stress the importance of hands on experience in carrying out engineering tasks as the process has considerable value to the educational experience (Crawley, Malmqvist, Ostlund, & Brodeur, 2007). The self-efficacy construct can be used to determine whether the students see themselves as having greater capability and a more authentic experience as a result of the "design-implementation" experience. Most importantly, enhanced self-efficacy increases the ability for the student to develop their skills further and apply themselves in the engineering field as a lifelong career. Understanding the studies in engineering self-efficacy provides direction for the current study.

2.4.1 Engineering Student Self-Efficacy

Self-efficacy studies have been focused on the relationship between self-efficacy and work-related behaviors and career pursuit. The literature included in this section reveals that there is a correlation between self-efficacy and both behavior and performance. However, the effects between self-efficacy and performance for complex tasks such as engineering are lagging due to the lack of effective strategies to cope with the intricate demands of the complex tasks. Self-efficacy influences vocational choice and career pursuits; however more specific questions by career field need to be examined to determine the exact relationship.

The self-efficacy concept has been examined by Sadri and Robertson (1993) to show the predictive power relating to effective work behavior. This study is a meta-analysis of the findings on the relationship between self-efficacy and work-related behaviors. Relevant samples were defined as adult members of the population who were currently engaged in an occupation or about to enter the work force. Results of the meta-analysis support the view that self-efficacy is related to both performance and behavior choice.

Stajkovic and Luthans (1998) also performed a meta-analysis that examined the relationship between self-efficacy and work-related performance. The results of this study indicated a significant weighted average correlation between self-efficacy and work-related performance and a significant within-group heterogeneity of individual correlations. To account for this variation, the authors conducted a 2-level theory-driven moderator analysis by partitioning the samples first by according to the type of study setting. The lagged effects between self-efficacy and performance for the different levels of task complexity may be due to the development of effective strategies to cope with the intricate demands of the complex tasks. These authors concluded that although there have been numerous reviews of self-efficacy literature, the relationship between self- efficacy and work-related performance is lacking. Although self-efficacy has been demonstrated to influence vocational choice and career pursuits, additional factors need to be considered. Instead of looking at whether self-efficacy is related to performance which has been clearly answered, more specific questions regarding the nature and underlying mechanisms by career field need to be examined to determine the exact relationship between self-efficacy and work-related performance. This understanding would clarify the contribution of efficacy beliefs to human action in career domains.

Early work by Betz and Hackett (1983) examined the relationship between vocational self-efficacy and occupations for men and women. In this study, the authors explored differences in self-efficacy regarding educational requirements for traditional and non-traditional careers. Traditional careers were defined as occupations in which at least 70% were women and non-traditional careers were defined as occupations in which at least 30% were not women. Engineering and STEM related careers were categorized as non-traditional careers for women. Using a mathematics self-efficacy scale, an adapted version of the Fennema-Sherman

Mathematics Attitudes Scales and a questionnaire concerning their college major choices, 153 female and 109 male undergraduates were surveyed. Results indicated that mathematics self-efficacy expectations were significantly related to the extent to which students selected science-based college majors. The math-related self-efficacy expectations of college males were significantly stronger than were those of college females. Their research confirmed that there were significant differences in reported self-efficacy in gender traditional and non-traditional careers. The authors also found a connection between self-efficacy beliefs and perceived career options for men and women for non-traditional occupations.

In 1994, Lent, Brown, and Hackett (1977, 1982, and 1986) studied Bandura's social cognitive theory as it applies to career and academic outcomes. In their initial study, they developed a model using social cognitive concepts to explain why people become interested in different academic and vocational domains. They further developed this model in later studies to include particular academic or career behaviors. Although this model was similar to Bandura's theory, the author's stated that social cognitive career theory describes self-efficacy as predicted by the same four sources: mastery, modeling, social persuasion and anxiety, and that self-efficacy influences outcomes and eventually predicts behaviors. These authors further stated that self-efficacy and outcome expectations predict interests; and interests, self-efficacy and outcome expectations directly predict goals and actions which influence performance of a task.

Lent, Brown, and Hackett (1994) studied vocational interests as patterns of likes, dislikes and indifferences regarding career-relevant activities (Lent et al., 1994, p. 88). Through experiences and activities, successes and failures, rewards and punishments, an individual uses this information to develop self-efficacy and outcome expectations and to form their interests. One is more likely to form an enduring interest in activities that were successful. While career paths are explored through experiences, social cognitive career theory states that people tend to develop a relatively stable pattern of performance which develops into their interests.

Initial interest in a career domain has been correlated to having confidence to perform the tasks required to pursue an occupation (Lent, Brown, & Hackett, 1994). Furthermore, the measurement of self-efficacy as related to a set of specific tasks in a well-defined domain, such as the CDIO syllabus, can be particularly useful in engineering educational program development.

2.4.2 Engineering Student Identity Development

Engineering identity studies have focused on the first year student experience and the factors relating to engineering identity. The literature included in this section reveals that the concept of identity development is not new to the curriculum but it is very difficult to identify. The major contribution from the literature involves the investigation of identity development during internships as this experience provides authentic engineering challenges.

Engineering identity is believed to relate to educational persistence and a student's sense of belonging to the engineering community (Meyers, Ohland, Pawley, & Silliman, 2012). The concept of students' identity development is not a new element in the higher engineering curriculum, but identity development is difficult to identify and sometimes overlooked (Dehing, Jochems, & Baartman, 2012, p. 1). As a result, the process of engineering identity development has not been well investigated. Research has found that students develop their engineering identity during internships in industry because these situations provide authentic engineering challenges. It was also found that professional role models and the interaction with these professionals create a forum for experimentation with the students own professional role behavior (Dehing et al., 2012, p. 6). Internships in industry for most disciplines are positioned the first semester of the third year of the four-year curriculum.

An in-depth study on the factors relating to engineering identity was conducted by Meyers et al. (2012). The primary research questions in this study were: 1) which students self-identify as engineers? and 2) what are the key factors that relate to self-identification? The study was based on the belief that student's sense of belonging to the engineering community is a critical path to the development of engineering identity and that engineering identity is believed to relate to educational and professional persistence. To address the research questions, a cross-sectional study of all undergraduate engineering students at a medium sized Midwestern private university was conducted in the spring of 2009. The majority of the engineering students did self-identify as engineers with educational progression and future career plans as significant attributes. The factors that student identified as being necessary to be considered an engineer included: making competent design decision, working with others to share ideas and accepting responsibility. The study concluded that student's self-identification as engineers can be linked to a sense of belonging to the engineering college.

Meyer et al. (2010) conducted a survey focused on the impressions of the first-year engineering experiences motivated by a new mentoring program. The focus of the study was the introduction of a mentoring program at the University of Notre Dame in which upper class engineering students serve as a resource to first-year students. A retrospective survey was administered to classes of sophomores and juniors to address research questions relating to student's comfort approaching faculty and upper class students. The findings indicate that students are more comfortable approaching upper class students than faculty for advice in many situations. It was also concluded that no measurable student benefit could be concluded as a result of the introduction of the mentor program. Gender differences existed in terms of a student's comfort with their decision to stay in engineering and that gender was not a statistically significant factor in predicting the adjustment to engineering.

Educational projects also aid in engineering identity development through exploration of engineering roles and learning mechanisms for role behavior (Dehing et al., 2012, p. 6). Teachers have further reported that increasing authenticity and complexity of engineering tasks maintain identity development. In this study, Dehing et al. (2012) conducted an exploratory study among teachers to find out whether the development of engineering identity can be understood using the theoretical models of Ibarra (1999) and Sullivan (2004). The results showed that the development of engineering identity boosted during the internship in industry in the third year. The theoretical models were recognized in the findings and four interaction types in internships could be identified. Each of these interactions had different effects on identity development. The four types of interactions were identified in two dimensions: industry supervisors' perception of students, and the professional responsibility awarded. The research recommended the introduction of projects into the curriculum that could stimulate identity development from the start.

Due to the diverse areas of engineering that engineers serve, articulating a distinct professional identity for engineers is a challenge (Downey & Lucena, 2004, p. 400). This article stated that to account for such diversity, epistemological values of engineering knowledge need to be linked to the wider social values of engineering work. It is possible however to consider areas that influence the engineering identity, such as a value for mathematics or the importance of practical knowledge. Populations of engineers may respond to similar configurations of challenges in somewhat predictable ways based on such values. Efforts to change engineering identities involves building a new identity by reformulating labels for engineers and engineering knowledge and then convincing others to use them (Downey & Lucena, 2004, p. 401). This task involves identifying dominant challenges for engineers at particular times and places, and then follows how different engineers respond to challenges and interactions. Once the challenges and interactions are understood, forms of knowledge and identities can be formed for subsequent generation of engineers. Historically, the identity of engineers has evolved in this manner both domestically and internationally (Downey & Lucena, 2004, p. 413).

Studies of engineering students' professional identity development recognize the importance of articulating engineering identity for student retention in engineering (Eliot & Turns, 2011). This study was designed to explicitly investigate identity related impact during portfolio commission to identify themselves as budding engineers and as future professionals. Engineering undergraduate students attended four weekly workshops where they wrote a professional statement and selected artifacts that demonstrated their engineering abilities. Online surveys were given at each workshop asking participants about their ongoing experiences of creating their portfolios. Analysis of the survey responses revealed that participants had two primary frames of reference for the construction of professional identity. The authors stated that there were two frames of reference: 1) an external frame of reference focused on the students' understanding of the expectations of potential employers and 2) an internal frame of reference focused on students' emerging realizations of their own values and interests as professional engineers. The internal frame of reference accounted for twice as many responses as the external frame of reference. Identity development is a key aspect of student learning in engineering disciplines. The process of developing professional identity involves negotiation between societal and institutional expectations related to a specific professional role and the needs, wants, and aptitude of the individual preparing for that role (Eliot & Turns, 2011, p. 631).

Ibarra (2004) has identified that the development of professional identity if a result of three basic processes:

1. Acquiring skills and knowledge through the engagement with professional activities
2. Gaining access to domain knowledge and role reinforcement by developing social networks
3. Understanding the demands and opportunities of the professional role through self-discovery and solidification of personal and professional goals.

Engineering education programs offer opportunities for students to engage in the first two processes. However, the third process is more elusive. Students rarely have the opportunity through curriculum to make sense of their educational experience and derive their own understanding of themselves, their skills and their interests as engineers. Professional identity has been identified as a key factor in engagement, retention and adaptation to the workplace (Ibarra & Barbulescu, 2010). Understanding the professional identity development process requires an understanding of the current generation sense-making processes. Eliot (2007) has explored the definition of self through an internal and external frame of reference. This definition of self as an engineer has also led to an increase in self-efficacy, with participants repeatedly reporting positive perceptions about their own skills as both engineers and as job applicants. Furthermore, self-efficacy beliefs have been shown to ease the school to work transition and are associated with increased job satisfaction (Pinquart, Juang, & Silbereisen, 2003).

The literature reviewed in this section focuses on the development of the engineering student identity. While the concept of identity development is included in the engineering curriculum, the major contributions involve identity development during internships and professional experiences. A minimal amount of studies has been conducted to determine the factors that contribute to identity development. Student's self-identification as engineers were linked to a sense of belong to the engineering college. Exploration of engineering roles and learning mechanism are in the early stages; with an emphasis on internships in industry. Most importantly, studies of engineering students' professional identity are directly connected to student retention in engineering. Identity development is a key aspect of student learning for engineering disciplines.

2.4.3 Student's Interest and Attitude in STEM

Studies that have examined student influences on STEM interest find that personal interest is the most important aspect when choosing a major. The literature included in this section reveals that student self-efficacy is directly connected to interest and attitude to STEM careers. When students show interest in a career path in high school, it is important to provide them with information that allows them to envision a future in the career and information about daily responsibilities and salary. At the high school level, student self-efficacy is the main reason for interest and intent to pursue a career. When selecting a college major, low self-efficacy has been found to be the largest influence on career indecision. Self-efficacy beliefs form as early as elementary school and are a critical developmental factor during the middle and high school years. Influences on self-efficacy development at the college level is an important area of research.

Positive learning experiences, especially in mathematics and science have been shown to build self-efficacy and increase interest in those subjects (Lent, Brown, & Hackett, 1994). Lent, Brown, Schmidt, Brenner, Lyons, and Treistman (2003) tested the predictions of social cognitive career theory and general social cognitive theory. In this study, 328 students in an introductory engineering course completed measures of SCCT's person (self-efficacy, coping efficacy, outcome expectations, interests, academic goals) and contextual variables (environmental supports and barriers) related to the pursuit of engineering majors. Findings in this study indicated good support for a model that includes contextual supports and barriers as connected to choice goals and actions (i.e., persistence in engineering). Positive learning experiences and support from family, teachers, peers and role models mediate interest in STEM careers. Interventions, such as role models, increase students' engagement, interest, and perceptions of STEM. Role play and peer video documentaries have also helped middle school students relate to STEM fields and to connect students to professional communities while increasing classroom engagement, motivation and a sense of ownership.

In a study conducted by Fouad, Smith, and Zao (2002), the authors investigated the academic subject matter domain of the social cognitive choice model. The relationships between self-efficacy, goals, outcome expectations, and interests were examined across the subject areas of art, social science, math, science and English to see if the predicted relationships hold for subject domains other than math/science. Previously validated scales in each of the subject domains were used in an undergraduate survey in introductory psychology classes at 2 Midwestern universities. The results indicated support for the social-cognitive career model relationships in each of the four subject areas and revealed that these relationships are similar across subject areas.

Masnick, Valenti, Cox, and Osman (2010) performed a study to investigate student's implicit and explicit attitudes towards scientific professions. In this study, they asked high school and college students to rate the similarity of pairs of occupations. They investigated factors that included whether the student could identify with a practitioner in science fields, whether the student was the investigative personality type; and social factors such as parent and teacher science knowledge or encouragement, and the availability and commitment of mentors. The authors then used multidimensional scaling to create a spatial representation of occupational similarity. The study found that participants across age and sex considered scientific professions to be less creative and less people-oriented than other popular career choices. They also concluded that students may be lead away from STEM careers by common misperception that science is a difficult, uncreative, and socially isolating pursuit.

In a study by Tseng et al. (2011), the authors examined student's attitudes towards integrated science, technology, engineering and mathematics learning to further understand that the claim that STEM project-based learning (PjBL) activity would increase the effectiveness, generate meaningful learning and influence student attitudes in future career pursuits. The study sent out questionnaires and conducted semi-structured interviews to five institutes of technology in Taiwan to examine student's attitudes towards STEM before and after the PjBL activity. The results of the survey showed that students' attitudes to the subject of engineering changed significantly. In the interviews, the students recognized the importance of STEM in science and engineering disciplines and stated that the possession of professional science knowledge is useful to their future career. The authors concluded that combining PjBL with STEM can increase effectiveness, generate meaningful learning and influence student attitudes in STEM careers.

Du (2006) examined the learning experiences of engineering student of both genders in a problem based and project-organized learning environment at a Danish university. This study relates an amalgam of theories on learning and gender to the context of engineering education. A qualitative study of electrical and electronics engineering programs revealed that studying engineering in a PjBL environment involves not only the mastery of technological knowledge but also an engineering identity development process. However, the association of an engineering identity with masculinity led to different learning experiences for male and female students. The study reported that the nature of engineering subjects, based on male interests, enabled men and acted as a barrier to women; therefore, the culture of engineering communities of practice require more effort in identity management for women students than their male peers.

The literature reviewed in this section provides an overview of influences on student interest and attitude to STEM careers. Positive learning experiences relate to increased self-efficacy and an increase in STEM interest. Some studies have been conducted to understand factors that influence student's implicit and explicit attitudes towards scientific profession. Studies have also been conducted to understand the learning experiences in the project based learning environment that aide in the development of engineering identity.

2.4.4 STEM Student's Identity

The literature reveals that studies that student identity development has a social and individual dimension. Studies on the process of students' identity development, as included in higher education curriculum in preparation for their profession, have been conducted. Initial studies have been conducted on attrition and retention as the enrollment rate in STEM is much lower.

The concept of students' identity development is not a new element in higher education curriculum, however the process of identity development, especially in the area of STEM fields has not been well investigated (Dehing, Jochems, & Baartman, 2012). Professional identity has a social and individual dimension. The social dimension is made up of the requirements associated with the profession; while the individual dimension is the identification with the profession. The process of professional identity development has been successful if someone meets the requirements of the social role and the individual identifies themselves with this role (Tonso, 2006).

In higher education curriculum, the process of students' identity development is supported by the preparation for professional practice. As students grow more mature, they become more responsible for their decisions and actions. This results in them becoming more self-directed in their learning and less dependent on their teachers (Plemmons, 2006). Models and guidelines for the development of identity are needed to help students through the process.

When models on identity development are placed in the context of higher education, a few variables should be considered. Students develop their professional identity as a result of curricular learning and teaching activities and extra-curricular experiences in social life. The students' perceptions of these activities are decisive for the learning result, which in turn develops the student's orientation on becoming a professional. The curriculum design and its implementation, influenced by the beliefs of teachers, are two additional important conditions. Several variables influence the process of identity development. They are categorized by variables related to the students' orientation on learning, the curriculum design and the teachers' beliefs on teaching (Dehing et al., 2012). When the students are learning-oriented, the exam at the end of the year is the main reason for acquiring knowledge. However, students with a professional-orientation, learn better by performing projects and participating in internships. Curriculum design plays an important role in student identity development. Curriculum design, when focused on discipline-oriented curriculum limit identity development, while professional-orientation enhance identity development as students perform professional roles in projects. Furthermore, professional identity is mostly developed in terms of professional standards as well as professional values. A better understanding of each of these variables will enhance interest in STEM fields.

As the student transitions to higher education, attrition in STEM career fields continues. Although one-third of freshman express interest in STEM majors before starting college, the actual STEM enrollment rate is much lower (National Science Board (NSB), 2012). For a variety of reasons, a significant proportion of students who initially intend to study STEM fields abandon them several years later. A study found that a total of 56 percent of postsecondary students who declared STEM majors in their freshman year left these fields over the next 6 years (Chen & Ho, 2009). Attrition rates of similar magnitude were also reported in other studies (Goulden, Frasch, & Mason, 2009).

Studies on STEM student's identity are discussed in this section. It is recognized that the student identity has two dimension: social and individual. The processes for student identity development are currently included in higher education curriculum. However, studies show that enrollment and retention are on a decline.

2.4.5 Engineering Student Educational Persistence

The literature on student educational persistence reveals the connection to student self-efficacy. Studies reveal that students with higher grades persisted longer in technical and scientific majors than those with low self-efficacy. Initial studies on the mechanism for the relationship that connect self-efficacy as related to performance have been done. A better understanding of the student experiences that connects directly to building self-efficacy needed for educational persistence and student retention is needed.

The relationship between self-efficacy and educational or academic persistence was studied by Lent and Larkin (1984). In this study, 42 students participated in a 10-week career-planning course on science and engineering fields. The participants then completed survey questions related to the measure of self-efficacy. The questions involved their perceived ability to fulfill educational requirements for a variety of technical and scientific occupations. The findings from this study indicated that the subjects reporting high self-efficacy for educational requirements achieved higher grades and persisted longer in technical and scientific majors than those with low self-efficacy. Furthermore, Stajkovic and Luthans (1998) performed a meta-analysis and examined the relationship between self-efficacy and work-related performance. The findings of this study indicated a significant weighted average correlation between self-efficacy and work-related performance. This study concluded that the focus the general question of whether self-efficacy is related to performance, to more specific questions regarding the nature and underlying mechanism for the relationship between self-efficacy and work-related performance, or more broadly stated as the contribution of efficacy beliefs to human action.

Carrico and Tendhar (2012) studied Social Cognitive Career Theory as a predictor of engineering students' motivation in a program called PRODUCED. PRODUCED is an outreach program from University of Virginia School of Engineering and Applied Science and was initially established to help fill in the gap in engineers in the state of Virginia. This study measured the expectations of the engineering students using Lent and Brown's Social Cognitive Career Theory model. A quantitative survey was sent to students at five community colleges in the state of Virginia. The purpose of the study was to test the predictive relationship amongst self-efficacy, outcome expectations, interests and goals, with the goal of measuring participants' motivation to pursue engineering degrees and careers. The data from 68 responses were analyzed using descriptive statistics, correlations, factor analyses, and multiple regression. Cronbach's alpha of four variables ranged from 0.75 to 0.91. Three regression models were used to measure the predictive relationship among the four variables. The assumptions of regression analysis were reasonably met; however, outcome expectations were not a good predictor of goals. This study provided valuable information as a first step in knowing how to measure student motivation to persist and to determine further research necessary to understand student motivation.

Crosthwaite and Kavanagh (2012) performed a qualitative and quantitative study on the first year attrition, academic success and retention the student experience, and student engagement to determine the efficacy of a first year engineering program at the University of Queensland, Australia. In this study, the researchers evaluated the student experience and student engagement of the implementation of a program of curricular and extracurricular activities based on accepted principles of good practice and research. This includes small group 'design and build' projects beginning with an Orientation to Engineering Project Day, a comprehensive program of pre-arrival academic advising, and online diagnostic testing of pre-requisite knowledge and skills. The program also includes a dedicated physical Engineering Learning Centre and a virtual first year hub learning space. This study provided the information from evaluations and feedback on individual initiatives and the outcomes of the first year cohort performance and overall experience. The study reported that the students felt that the first year was well structured and well-resourced and that the first year courses were really well organized. However, the students stated that as you get to later years the resources and support, as well as the quality of organization decreased. This study also reported that the first year engineering cohort has more than doubled in the past 10 years. The success of the program was attributed to the strategic deployment of resources such as people and processes to effectively engage with new students in ways to recognize and address their interest, uncertainties and insecurities.

In “Conceptions of mathematics and student identity: implications for engineering students”, Craig (2013) studied a cohort of students who engaged in their first year of tertiary engineering studies (civil, electrical, chemical, and mechanical). As part of an ongoing longitudinal research, the author studied how a cohort of students choosing to study engineering exhibits a view of mathematics as conceptual skill and as problem solving, which is coherent with an understanding of the role of mathematics in engineering. In this study, cohort students completed a biographical questionnaire to establish home, school and community social condition as well as social habits. They were then asked to complete an open-ended questionnaire about their history of studying language and mathematics. The third and final data source was an interview that investigated how students were negotiating the school-university transition. Sfard and Prusak’s narrative theory of identity (Sfard et al, 2005) suggested that students had not yet developed an ‘engineering identity’ for completing engineering studies, yet they had a mature conception of mathematics as problem-solving. Allie et al., (2009) and Stevens, O’Connor, Garrison, Jocuns, & Amos (2008) stated that engineering identity is desirable for completing engineering studies. Cobb, Gresalfi, and Hodge (2009) concluded that students who identify with their program of study will experience greater affiliation with the subjects they study, be more motivated to study, be engaged in active meaning-making and have a greater chance of succeeding. Craig (2013) posed the question if students consider themselves to be engineers or in some way identify with the profession of engineering, they stand a greater chance of graduating than if they cannot claim such an identity. Through this study, the author concluded that exhibiting the conception of mathematics is arguably naturally associated with engineering identity however it does not in general display signs of engineering identity despite great motivation to succeed.

The literature review provided in this section reveals that student educational persistence is directly connected to student self-efficacy. The mechanisms for the relationship that connect self-efficacy as related to performance are in preliminary study. A better understanding of the student experiences that connects directly to building self-efficacy needed for educational persistence and student retention is needed.

2.4.6 Factors Influencing Engineering Student Self-Efficacy Beliefs

The literature reviewed in this section include studies in regards to the factors that influence self-efficacy beliefs. Hutchinson, Follman, Sumpter, and Bodner (2006) performed a study to determine the factors influencing self-efficacy beliefs of first-year engineering students. In this study, the authors administered a qualitative survey of student self-efficacy beliefs to 1,387 engineering students enrolled in ENGR 106, *Engineering Problem-Solving and Computer Tools,* at Purdue University. This survey was designed to identify factors related to students' self-efficacy beliefs, and their beliefs about their capabilities to perform the task necessary to achieve a desired outcome. Through open-ended questions, the students listed and ranked factors affecting their confidence in their ability to succeed in the course. Gender trends emerged in student responses to factors that affect confidence in success. The influential factors included: understanding/learning, drive and motivation, teaming, computing abilities, help or support, working assignments, problem-solving abilities, interest or satisfaction, and grades. This study examined these factors in light of Bandura's social cognitive theory and identified Bandura's four sources of self-efficacy beliefs. The categories of influential factors included: mastery experiences, vicarious experiences, social persuasions, physiological states, and drive and motivation. This study reported that this is a first step in gaining an understanding of the sources of student self-efficacy beliefs and that more work needs to be done to provide a description of cognitive processes that lead up to the formation of these beliefs. This study concluded that there was not significant gender variation in how students identified and ranked the factors influencing self-efficacy beliefs. The author's stated that the knowledge found in this study will allow for the creation of learning environments designed to promote students' self-efficacy beliefs and thereby increase their confidence, success, and retention.

A study performed by Loo and Choy (2013) examined the correlation of the four sources of self-efficacy (mastery experience, vicarious experience, social persuasion, emotional arousal) with academic performance, and the prediction of the main source of self-efficacy that affects academic performance. A 40-item survey measuring sources of mathematics self-efficacy was administered to 178 third-year engineering students. Academic performance, including mathematics and grade point average scores were collated. The results of this study showed that self-efficacy sources were correlated with mathematics achievement scores as well as cumulative GPA. More importantly, mastery experience was found to be the main predictor for academic achievements of mathematics and related engineering modules.

Research conducted by Lucas and Barge (2010) explores the value of project-based learning (PjBL) in strengthening aspects of student confidence in their engineering skills (self-efficacy) and their subsequent decisions to major in engineering. Using measures of teaming and technology self-efficacy, the researchers assessed the effects of optional freshman PjBL courses offered at MIT in 2007-2008 and 2008-2009. The results show that these PjBL courses increased student self-efficacy both for working in team and for using technology. In addition, the authors concluded that MIT students had heightened technology self-efficacy and were more likely to pursue a degree in engineering.

The studies reviewed in this section highlight the factors that influence self-efficacy beliefs. Self-efficacy studies utilize surveys based on Social Cognitive Career Theory to identify factors related to students' self-efficacy beliefs, and their beliefs about their capabilities to complete a task. Studies that explore the value of project-based learning further explore the factors that build student confidence in engineering skills (self-efficacy) and their decision to pursue their engineering degree.

2.5 Summary

In summary, this chapter focuses on the three main components as related to student interest and identity in engineering and integrated STEM subjects. An overview of STEM Education and history is provided. The literature relating to the conceptual framework of social cognitive career theory and identity theory is included. Finally, a review of the literature is presented on student interest and identity. Self-efficacy studies focus on the relationship between self-efficacy, work-related behaviors and career pursuits. Engineering identity studies focus on the concept of identity development and how difficult it is to identify. Student self-efficacy is directly connected to interest and attitude to STEM careers. Student identity development has a direct connection to attrition and retention in STEM fields of study. Educational persistence is directly connected to student self-efficacy. Finally, studies are presented that reveal the factors that influence self-efficacy beliefs. The review of the literature provides information about what is currently known about student self-efficacy, interest, identity and educational persistence in STEM subjects and what is currently known about effective STEM learning experience for students.

CHAPTER 3 RESEARCH METHODOLOGY

This chapter presents the rationale for the research design, and describes the procedures for collecting, analyzing, interpreting, and reporting data associated with the research questions in the current study. The research problem called for an explanatory sequential mixed methods approach that is based on the theoretical framework of the study. The methods for both the qualitative and quantitative portions of the study are addressed as they relate to answering the targeted research questions. Prior to my decision to use this approach I spent time considering my identity as a researcher.

3.1 Researcher's Identity

A year prior to data collection, I began the examination of my identity as a researcher by keeping a journal to capture my attitudes, preconceptions, and biases that might influence my ability to listen and to understand the stories told by participants. I used this information to remain aware of my experiences that had the potential to influence my analysis of data.

I began with a self-analysis of my beliefs about my role as a researcher. I used, as a starting point, my experiences at Boston College, Department of Chemistry where I received my Master's degree in Experimental Physical Chemistry. My research involved the gas phase kinetics of Boron atoms with the halomethane gases. This highly quantitative experiment required extensive data collection and analysis of atomic absorption spectra to determine the impact of the halomethane gases on the ozone layer. This reflection leads me to view my role as an objective outside researcher in my current study. My identity evolved from this reflection.

My research interest originates from my personal experiences in the development and implementation of highly technical systems in a variety of sectors including highly classified government projects, the airline industry and the cell phone industry. I realized that I wanted to step out of my role as a program director as an authority figure and listen from a researcher's perspective to the engineering students. With a more defined intention, I continued my introspection.

My next step was to study the beliefs that guide in my role as an educator in the field of mathematics and science. While I was at Simmons College and Boston College, I was a private tutor in mathematics and worked with students who struggled with basic math concepts. I believed that if I could help them master the basic concepts, that they would also share the passion I had for mathematics. At the time, I did not understand other social factors that may influence their preference for math and science. Later in my career, while my own children were in grade school, I returned back to educating students in mathematics and science as a First Lego League coach. These younger students, ages 9 to 14, when given a current engineering challenge, were enthusiastic to learn advanced concepts and demonstrate their innovative solution to judges in a team competition. I recognized that these students now had the advantage of technology to assist in their learning. In addition, by working together in small team, these students were able trouble shoot difficult problems to ultimately demonstrate their solution in a robotic competition. Based on these experiences, I reflected on my role as an objective researcher in my study.

I continued to explore my researcher's identity by reflecting my experiences as a college professor in mathematics and science. Over the past 10 years, I have taught college level mathematics and science to every level of college student and in a variety of current teaching formats. I realized that the age of college student's today range from young to old, and that the advantage of technology was assisting their learning. Many of these students had a prior negative experience in learning mathematics and as result had a fear that they would not be able to pass a college level math course. I reflected on my role as a college professor and realized while I had the advantage of technology to teach these concepts, these students were not enthusiastic about mathematics. Based on my personal experiences and observations as an educator over the past 10 years, I realized that my role as an educator continues to evolve. I reflected on my role as an objective researcher in my current study.

3.2 Rationale for Design

An explanatory sequential mixed method design (Creswell, 2014) was used to address the research questions and associated hypotheses. The mixed methods approach assumes that both forms of data provide different types of information for the study. The explanatory mixed methods approach is a design in mixed method that involves a two-phase project in which the researcher collects quantitative data in the first phase, analyzes the results, and then uses the results to plan the second, qualitative phase (Creswell, 2014, p. 224) The overall intent in this type of research design is to have the qualitative data help explain in more detail the initial quantitative results. The procedure involved collecting survey data in the first phase, analyzing the data, and then following up with qualitative interviews to help explain the survey responses.

This method was selected as existing research has not clearly answered the proposed research questions in regards to the self-efficacy, identity and educational persistence for engineering students as well as the development of identity for STEM students. Quantitative data was collected and analyzed, followed up with qualitative data collection, analysis and interpretation. Two distinct phases were conducted to determine the critical factors that relate to engineering student identity development. This design started with the collection and analysis of quantitative data to determine if a correlation exists between variables in two areas: student academic self-confidence and student engineering identity as well as a correlation between engineering student self-efficacy and student educational persistence. Administering a survey offered the advantages of larger sample sizes and advanced statistical analysis to identify trends within data (Patton, 2002). The second, qualitative phase of the study was designed so that it builds on the findings of the initial survey phase. Interpretation of the qualitative results helped to explain and provide data to clarify and add depth to the third research question: What are the key factors and experiences that relate to engineering student identity development and enhanced educational persistence?

The factors and experiences that relate to the development of identity in engineering students and enhanced educational persistence were explored through in-depth semi-structured interviews with students who have been identified during the initial phase. These methods were implemented sequentially, starting with the quantitative data collection and analysis in phase one and followed by qualitative data collection and analysis in phase two that builds on phase one. The purpose of this interactive design was based on the need to explain and explore the quantitative results in more depth. The quantitative results in phase one were used to make decisions about the qualitative research questions in phase two. Interpretation of both phase one and two provided insight into the key factors for engineering identity development for students who have academic self-confidence and student identity as well as self-efficacy and student educational persistence.

3.3 Research Design

There are three primary research questions as well as multiple sub-questions that were addressed through this mixed-methods study. Table 3.1 summarizes the questions and the primary method used to answer the questions. Appendix B: Survey information contains the complete survey used in survey phase of the study. Appendix C: Interview questions contains the complete set of interview questions used as a guide during the interviews. The primary method used for the first and second question is quantitative, while the primary method for the third question is qualitative.

Table 3.1 Summary of Research Questions

Primary Question	Survey Questions
Is there a correlation between student academic self-confidence and their identity as an engineer?	Quantitative survey question Academic self-confidence: 17, 18, 20, 21, 23, 24, 39, 103, 105, and 111 Engineering Identity: 8, 10, 12, 14, 42, 43, 44, 45, 47, 49, and 62
Is there a correlation between engineering student self- efficacy and their educational persistence?	Quantitative Survey question Engineering self-efficacy: 25, 26, 32, 33, 57, 58, 60, 70, 73, and 88 Educational persistence: 27, 28, 29, 30, 31, 34, 35, 38, 40, 63, and 108
What are the key factors and experiences that relate to engineering student identity development and enhanced persistence?	Interview students who have a correlation from questions one and two (i.e., students who have high academic self-confidence and engineering identity and/or who have high engineering student self-efficacy and educational persistence).

3.3.1 Research Setting

The study was conducted at a privately owned college in New England with a well-developed engineering program. The majors in the engineering program include aeronautical, mechanical, electrical and computer engineering.

This program is nationally accredited and is over 50 years old. The Electrical and Computer Engineering program prepares students for professional careers in the design, development, and use of electronic and computer equipment in a wide range of industries, including telecommunications and networking, computer hardware, aerospace, automotive and medical instrumentation. The engineering curriculums is based on the Conceive, Design, Implement and Operate educational framework (CDIO) and Accreditation Board for Engineering and Technology standards (ABET) and includes a three-semester design sequence within which students work in teams applying theories learned in the classroom to develop projects from concept to operation. This can help students to develop confidence and competence in solving engineering design problems and to learn effective teamwork skills. Students apply creative and strategic thinking to economic and technical issues involved in typical engineering projects. They also learn to generate briefings and reports and present them to their peers and faculty. These two central aspects of the program (working in teams and developing communication skills) help students prepare for the engineering profession. Because of the attributes of this engineering program, this college made a suitable research setting.

3.3.2 Research Sample

The current undergraduate students from the aeronautical and mechanical engineering program were invited to participate in phase one: online survey. The students included in the study were currently enrolled in the spring 2015 engineering course sequence. The target population was 100 students and assuming a response rate of 50-60%, a sample size of approximately 50 students was expected. However, to determine the adequate sample size to achieve the minimum power of 0.80, a priori power analysis was conducted using G*Power at alpha level of 0.05 with moderate effect size level. The sample size determined using this method was 38.

Interview candidates were selected from the survey candidates to provide rich data sets that can provide insight to the minds, meanings and experiences of engineering students that could not be captured in a survey alone (Patton, 2002, Seidman, 2006). Based on the quantitative survey response, the selected students were asked to participate in interviews to further explore the factors and experiences that relate to student identity development and enhanced persistence. Individual interviews of a subset of purposefully sampled students were conducted to probe the underlying factors of identity as a sense of belonging to the field of study. Students, who felt that they belong to the College of Engineering, or persisters, were interviewed to further understand underlying factors that develop engineering identity and enhance persistence.

3.3.3 Operational Definition of Variables

The variables for this study include academic self-confidence, identity as an engineer, engineering self-efficacy and educational persistence. Each of these variables are operationally defined below:

Academic self-confidence was measured by calculating a composite score of items on the student's survey responses in regards to science and math outcome expectations and goals, and to the responses in regards to sources of academic self- efficacy. Academic self-confidence was calculated as a composite score of the following items from the survey: 17, 18, 20, 21, 23, 24, 39, 103, 105, and 111. Each item is measure on a scale of 0 to 6, with 0 indicating low levels of self-confidence and 6 indicating high levels of academic self-confidence.

Identity was measured by calculating a composite score of items on the student's survey responses in regards to engineering experiences, science and math goals, and career commitment. Identity as an engineer was calculated as a composite score of the following items from the survey: 8, 10, 12, 14, 42, 43, 44, 45, 47, 49, and 62. Each item is measure on a scale of 0 to 6, with the value of 0 indicating low levels of being an engineer and 6 indicating high levels of being an engineer.

Engineering self-efficacy was measured by the student's survey responses to science and math self-efficacy. It was calculated as a composite score of the following items from the survey 25, 26, 32, 33, 57, 58, 60, 70, 73, and 88. Each item is measured on a scale of 0 to 6 with 0 indicating low self-efficacy scores and 6 indicating high self-efficacy scores.

Educational persistence was measured by the student's survey response in regards to career commitment, career decidedness and educational aspiration. It was calculated as a composite score of the following items from the survey: 27, 28, 29, 30, 31, 34, 35, 38, 40, 63, and 108. This variable will be measured on a scale of 0 to 6 with 0 indicating less persistence and 6 indicating high persistence.

3.3.4 Data Collection Tools

The primary tools for data collection was: (1) a survey assessment tool and (2) individual interviews. The survey assessment tool (Mills, 2009) was adapted from an instrument originally developed by Fouad et al. (2002) that investigated the relationships between self-efficacy, goals, outcome expectations and interests across the subject areas of art, social science, math/science, and English. The primary instruments used in this study were 16 scales designed to measure self-efficacy, outcome expectations, intentions and goals, and interests in each of the four subject matter domains. Participants responded that they very strongly disagreed (1) to very strongly agreed (6) with 41 statements assessing their confidence in performing tasks related to the four subject areas. Using the same 6-point scale, respondents also indicated their agreement with 36 statements assessing outcome expectancies in the four areas. Respondents indicated their intentions to continue in those four areas also using the same 6-point Likert scale on 34 items. And finally, participants indicated how interested they were in 47 activities representing the four areas (e.g., doing research to understand revolutions, participating in a science fair, reading a biography, dancing) (Fouad et al., (2002). These scales are described in more detail in Smith and Fouad (1999), along with information related to their reliability and validity. The number of items and their reliability data, Cronbach's alpha, for each of the math/science scales were reported as: self-efficacy – 7 items, 0.85 reliability, outcome expectations – 9 items, 0.81 reliability, intentions and goals – 7 items, 0.87 reliability, and interests – 17 items, 0.94 reliability.

The results of Fouad's study indicated support for the fit of the social – cognitive career model relationships in each of the 4 subject areas and also revealed that the relationships are similar across subject areas. Specifically, the study examined whether the relationships among self-efficacy, outcome expectancy, interest and intentions found in previous research on math and science would also be found for other subject matters (Fouad & Smith, 1996, Lent, Brown, & Hackett, 1991).

The Sources of Social Self-Efficacy Expectations was created by Anderson and Betz (2001) to assess people's experience with these four sources in social situations and modified in 2008 by Mills to measure student's sources of academic self-efficacy. The survey instrument for this portion of the study is the Sources of Academic Self-Efficacy Expectations (SASE) which adapted from the Sources of Social Self-Efficacy of an individual's sources of academic self-efficacy. This 40-item measure includes four subscales: mastery experiences (ten items), modeling (nine items), anxiety (nine items), and social persuasion (nine items) and utilizes four equal subscales on a six-point Likert scale ranging from 1 (very strongly disagree) to 6 (very strongly agree).

The web survey was designed with a respondent-friendly design that takes into account both the logic of how computer browsers operation and the logic of how people expect questionnaires to operate (Dillman, 2007, Dillman, Tortora, & Bowker, 1999). The amount of time to complete a survey and survey length are related to response rates (Deutskens, Ruyter, Wetzels, & Oosterveld, 2004). Care was given to limit the number of items on the survey to approximately 100 questions (Couper, Traugott, & Lamias, 2001). A graphical representation of the percentage complete or a progress indicator was displayed, as it is desirable for users as a motivation to continue to complete a survey (Couper et al., 2001, Dillman et al., 1999).

The web survey was designed with a respondent friendly design that takes into account the logical flow of the survey. A graphical representation of the percentage completion or progress indicator was displayed for users as a motivation to continue the survey. Google surveys was used to administer the survey. The amount of time to complete the survey was under 30 minutes and survey length was less than 100 questions.

Case study is the framework for this portion of the research study (Creswell, 2007) and is used as the technique for analysis (Patton, 2002). This form of inquiry investigates the contemporary phenomenon within its real-life context (Yin, 1994). Individual cases were analyzed both within and across cases within the context of undergraduate engineering students during the spring of 2015. Multiple sources of data included survey, individual interviews and background information (Creswell, 2007). The qualitative research questions were general and open-ended.

3.3.5 Data Collection Timeline

Upon receipt of IRB approval at Southern New Hampshire University and at the university where the study was conducted, pre-notification was sent to the engineering students via email to inform them about the study and about the process for signing informed consent forms. Within one week from the first email, a follow-up email was sent with a link to the survey. One week following the second email, a follow-up email was again sent as a reminder to complete the survey.

Upon completion of the online surveys, two weeks were dedicated to calculating the correlation of self-efficacy and educational persistence, and student academic self-confidence and engineering identity and determining the selected students to be interviewed. Selected candidates were notified by email and were requested to accept the invitation within a one-week timeframe. Upon confirmation, interviews were scheduled and conducted over a three-week timeframe.

Table 3.2 Data Collection Timeline

Week	Task
1	Initial email informing the students about the study and process for signing informed consent forms
2 – 4	Phase One: Survey Data Collection - Collect informed consent forms - Follow-up email with survey link
5 – 7	Phase One: Survey Data Analysis - Select candidates for phase two. - Email informing requesting interviews
8	Schedule Interviews
9 – 12	Phase Two: Interview Data Collection - Conduct Interviews
13 – 15	Phase Two: Interview Data Analysis Additional interviews as needed based on data analysis

3.4 Data Collection

The explanatory sequential mixed methods approach used in this study involved a two-phase approach. The results of the survey phase were analyzed and used to build on the students selected for the interview phase. The survey phase results were used to inform the types of participants to purposefully select for the interview phase and the types of questions that were asked for the participants. The intent of this design was to have the qualitative data help explain the detail the initial quantitative results.

The data collection was done in two distinct phases with quantitative sampling in the first phase and with purposeful sampling in the second qualitative phase. The qualitative data collection built directly on the quantitative results. Follow-up qualitatively grouped respondents in the quantitative phase based on two factors: (1) the correlation between student academic self-confidence and their identity, and (2) the correlation between self-efficacy and their educational persistence.

The quantitative sums for engineering student identity and enhanced educational persistence from this phase were then used to select interview candidates for phase two, the interview phase of this study. Survey respondents who scored the highest in engineering student identity and engineering educational persistence were invited to individually be surveyed.

3.4.1 Phase One: Survey Phase

An email with a link to the survey was sent to all undergraduate engineering students in the engineering program each of the universities during the spring 2015 semester. Students from engineering courses were asked to participate in a survey to learn more about engineering majors' self-efficacy and educational goals. The students were given an informed consent sheet (see Appendix A) including permission to access a survey containing a subset of questions from the following measures: Sources of Academic Self-Efficacy Expectations (SASE), Fouad-Smith Scales For Subject Matter Specific Social-Cognitive Constructs (FSS subscales, including math self-efficacy and outcome expectations, and science goals, science interests, math goals, and math interests), the Social Provisions Scale (SPS-S) (Cutrona, 1989), an emotional intelligence scale (Wong & Law, 2002), and a career commitment scale (Carson & Bedeian, 1994). See Appendix B for measures.

The survey was advertised by three different methods: (1) pre-notification sent through email, (2) an email invitation, and (3) a follow-up email. Email invitations were the primary method for directing and inviting participation in the web survey, and were sent from a credible source, namely an email address for the School of Education at SNHU. Pre-notification for the survey was delivered two days prior to the email invitation. One week after the initial email, a follow-up email was sent to any potential participants who have not yet responded, reminding them of the survey.

3.4.2 Phase Two: Interview Phase

Engineering students were purposefully selected as the participants by analysis of the similarity and differences in the sampling groups according to grade level and response to the SASE survey. Ten invitations were sent through email, with upper-division students as the priority followed by interviewing lower-division students as a second selection. A mixture of engineering disciplines and genders at the research site were selected, although student schedules and willingness to participate determined the exact distribution. Six students responded to the email invitation and agreed to the invitation to participate in the interview.

The qualitative portion of the study required purposeful selection of interview participants. The goal of the participant selection was to include a distribution of students who scored the highest scores in engineering student identity and educational persistence. Average scores for engineering identity and educational persistence were calculated for all survey participants. Average engineering identity scores ranged from 3.7 to 5.5. Average educational persistence scores ranged from 3.4 to 5.1. Survey participants who had a combined scored for average engineering identity and educational persistence of 9.0 to 10.6 were invited to be interviewed to explore key factors and experiences that relate to the development of engineering student identity and enhanced educational persistence. Of the thirty-five survey responses, 10 students were invited to be interviewed and 6 of these students were interviewed. Of the six students interviewed, one was female and five were male; two were sophomores, one was a junior and three were seniors. All six had declared their major as mechanical and/or aeronautical engineering and plan to complete a post graduate degree in engineering. None of the students interviewed had military experience.

The first student interviewed was Maxwell, a 20-21 year old Caucasian male in his senior year. He is a traditional college student majoring in mechanical engineering and will complete his degree in five years. Maxwell completed an internship last summer and plans to go on to graduate school after working for a while in the field of mechanical engineering.

The second student interviewed was David, a 20-21 year old non-Caucasian male in his senior year. David is a traditional college student in the five-year program double majoring in aeronautical and mechanical engineering. He completed an internship last year and is now employed part-time by the same company. David also plans to go on to graduate school after working for a while in the field of aeronautical engineering.

The third student interviewed was Grace, a 26-27 year old Caucasian female completing her senior year. Grace attended a non-engineering college for three years and worked for two years prior to attending her current university. She is majoring in mechanical engineering and minoring in business management. She is highly involved in the clubs on campus and the engineering affiliations nationwide. She plans to get her graduate degree in physics after graduation and she aspires to be an astronaut and work in the space industry.

The next student interviewed was Steve, a 26-27 year old Caucasian male in his sophomore year. After high school, he graduated from automotive school but was unable to find steady employment. Steve then signed up for the United States Marine Corps when he had a tragic accident and lost the lower half of his leg. After many months of recovery and vocational rehabilitation, Steve discovered his interest in manufacturing technology and engineering. He attended a local community college for manufacturing technology and is now completing his bachelor's degree in mechanical engineering.

The next interview was with Mark, an 18-19 year old Caucasian male in his sophomore year. Mark was very involved in team sports and robotics in high school. He is majoring in mechanical engineering and plans to attend graduate school after graduation. Mark is a team player, is highly competitive and enjoys working with others.

The last interview was with John, a 24-25 year old Caucasian male in his junior year. He attended another university for aeronautical engineering for a year, however he did not apply himself and separated from the university. After working a few years fueling planes, John decided to go to his current university to study aeronautical engineering to become an astronaut in the space program. He is highly driven to complete his degree in the next few years so that he can join the Air Force before turning 27 ½. His goal is to join the Air Force after graduation, to become interplanetary and explore the universe.

The following table provides on overview of the six students interviewed.

Table 3.3 Summary of Interview Participants

Pseudo name	Male or Female	Age Group	Race / ethnicity	Military Exp.	Attended any other college or university prior to current university	Decided on a major	Declared a major	Current level in college	Post grad degree
Maxwell	Male	20-21	Caucasian	No	No	Yes	Yes	Senior	Yes
David	Male	20-21	Other	No	No	Yes	Yes	Senior	Yes
Grace	Female	26-27	Caucasian	No	Yes	Yes	Yes	Senior	Yes
Mark	Male	18-19	Caucasian	No	Yes	Yes	Yes	Sophomore	Yes
Steve	Male	26-27	Caucasian	No	No	Yes	Yes	Sophomore	Yes
John	Male	24-25	Caucasian	No	Yes	Yes	Yes	Junior	Yes

Interviews were conducted one-on-one, face-to-face in a conference room in the engineering building at the student's university. The location was private, free from people passing by, interruptions and other distractions. All interviews were digitally recorded and notes during the interview will be transcribed immediately following each interview.

Interviews were semi-structured and about 30-45 minutes in duration. The protocol for the individual interviews were developed related to survey responses and the progression and feedback gained during the interview. The primary questions were related to the student's sense of belonging to the Engineering department at their University. At the start of the interview, the interviewer explained the purpose of the interview, who is gathering the information, how it will be used, what will be asked, and how responses will be handled (Patton, 2002).

The interview protocol was as follows:

(1) In your time at your University, can you describe a time that you felt you really felt a part of a group? What about this experience made you feel you were a part of that group?

(2) To contrast this experience, can you describe a time since being at your University that you felt that you did not belong to a group? Specifically, what about this experience made you feel like you did not belong?

(3) As an engineering student, can you think of a time where you really felt you belonged? Are there any activities, programs, or specific experiences that help to make you feel a part of the College of Engineering?

(4) Can you think of a time, as an engineering student, where you did not feel you belonged? Is there anything that would help you to feel you belonged?

(5) Can you think of the first time you "felt like an engineer?"

(6) Is there a certain experience that made you feel like you weren't an engineer?

The outlined protocol served as a guide to begin the conversation, but the interview was semi-structured to allow follow-up questions and a comfortable conversational discussion. See Appendix C for complete interview questions. Follow-up interviews were conducted with individual students based on initial interviews and the qualitative analysis results.

3.5 Data Analysis

3.5.1 Phase One: Survey Analysis

The quantitative and the qualitative databases were analyzed separately in the explanatory sequential mixed approach. Responses in the quantitative database were analyzed for a correlation between student academic self-confidence and their identity as an engineer by correlating the operational variables of academic self-confidence and identity as an engineer. Responses in the quantitative database were analyzed for a correlation between student self-efficacy and educational persistence by correlating the operational variables of student self-efficacy and educational persistence. The quantitative correlation analysis informed the sampling and types of qualitative questions to ask participants.

Quantitative data were analyzed using the statistical software package for social sciences, SPSS version 21. Data was screened for outliers and missing values. Any survey responses that are incomplete were dropped from the analysis. The main analysis involved running bivariate regression analysis to determine if engineering identity is related to, and can be predicted from academic self-confidence and if educational persistence is related to, and can be predicted from student self-efficacy. The advantage of running bivariate regression analysis is it provided information on the relationship between variables, as providing the ability to predict one variable from the other. The quantitative results were used to plan the qualitative follow-up. The quantitative results informed the sampling procedure toward the types of qualitative questions to ask participants in the second phase.

3.5.2 Phase Two: Interview Analysis

Qualitative data analysis involved the systematic search for meaning in the interview data collected. Using the procedures of theme development, the researcher analyzed the qualitative data. Each interview was transcribed, and a formal coding and analysis process was conducted using ATLAS.ti v7.5.7. The researcher used deductive coding scheme as a starting point. The codes were based on the categories originally introduced in Arnett's study (Arnett, 1994). A primary code and a secondary code were part of the within-case analysis (Creswell, 2007; Huberman & Miles, 2002). The answers from the qualitative portion were analyzed using Atlas TI v7.5.7.

3.5.3 Reliability and Trustworthiness

Reliability is a consistency measure of data collection in the quantitative phase of this study. For the qualitative phase, reliability is a measure of the ability to replicate the results from the same case (Yin, 1994). The interview protocol for the interviews were documented and the transcription was recorded. This offers the exact wording, question order, and a record any non-standard questions that were asked of each participant so that the case could be replicated. The transcription record was used during the interview phase and the coding identification process.

3.5.4 Limitations and Ethical Considerations

The risks associated with this study are believed to be minor as this study does not seek to tell individual stories of students; however, there is always a risk with interviews of emotional discomfort. The researcher was conscious of this risk and careful not to probe issues that students define as being beyond their comfort zone. In addition, since the researcher teaches first year engineering students at the research site, the higher level students interviewed were not current students of the researcher and there was no power or influence to respond as related to course grades.

Due to the research design of the study, there are three primary limitations involved in the research. First, the single-site design limits the transferability to other dissimilar institutions. As research site is a small university, the results from the study may not be generalizable. Second, the nature of a study involving human subjects has inherent uncertainties. And finally, the study is not a longitudinal study as the students will only be interviewed one time. This will provide a snapshot in time for the current student body of engineers. Furthermore, the study includes surveys and interview of students who have persisted in engineering to determine factors and experiences that relate to engineering student identity development.

All of these limitations and ethical concerns were thoroughly discussed in a pre-interview risk assessment with each participant prior to their formal interview. The survey and interview procedures as described in my proposal, accepted by the Southern New Hampshire University IRB (Number: 2015-018), were adhered to so as to protect the confidentiality of participants and not produce any negative effects on the participants of this study.

3.6 Summary

An explanatory mixed-methods study addressed the research questions and associated hypotheses. The hypotheses of the questions are considered primarily through quantitative methods. Qualitative methods were utilized to inform the data collected by survey and to expand the knowledge of student identity as related to self-efficacy and self-confidence. The instrument developed for this study was created from previous studies relating to self-efficacy and the transition to adulthood.

The primary methods for data collection were: (1) a survey assessment tool and (2) individual interviews. Surveys offered the advantage of larger sample sizes and statistical analysis allows the ability to identify clear trends within the data. Interviews, on the other hand, provided the ability explore and determine the experiences of the students that could not be captured in a survey alone. Follow up questions allowed the interviewer the ability to explore in directions that may have not been initially anticipated. These methods when used in conjunction with each other support and strengthen the findings through triangulation.

A cross-sectional study of engineering students at the research university were invited to participate through an on-line survey. Those students, with high scores in academic self-confidence and in identity as an engineer, as well as in self-efficacy and in educational persistence, were asked to be a part of an individual interview. The individual interviews of a subset of purposefully sampled students were conducted to probe at determining the factors and experiences that relate to engineering student identity and enhance persistence.

CHAPTER 4 FINDINGS

This study looked at the relationship between the identity development of engineering students and their educational persistence to continue in STEM programs. Phase one of this study calculated the correlation between student academic self-confidence and their identity as an engineer; and the correlation between engineering student self-efficacy and their educational persistence. In phase two of this study, key factors and experiences that relate engineering student identity development and enhanced educational persistence were determined from information gathered in student interviews.

4.1 Phase One: Survey Findings

The quantitative data gathered through the survey assessment tool was assessed to determine if a correlation exists between variables in two areas: (1) student academic self-confidence and student engineering identity, and (2) engineering student self-efficacy and student educational persistence. Individual survey question responses were grouped by academic self-confidence, engineering identity, engineering self-efficacy, and educational persistence as described in Table 3.1 Summary of Research Questions. The entire survey can be found in Appendix B: Survey information. The totals in each of these categories were calculated for each survey response and were statistically analyzed using SPSS Version 21 software to determine if a relationship exists between academic self-confidence and identity as an engineer, and between engineering student self-efficacy and educational persistence. To achieve this, bivariate regression analysis was conducted to answer the research question, "Is there a correlation between student academic self-confidence and their identity as an engineer?" and, "Is there a correlation between engineering student self-efficacy and their educational persistence?" The results are reported below, organized according to the research questions.

4.1.1 Research Results Question 1

Research Question 1 examines if there is a linear correlation between student academic self-confidence and their identity as an engineer. To answer this question, bivariate regression analysis was conducted between academic self-confidence as the independent variable, and engineering identity as the dependent variable. Results in Table 4.1 below indicated that the linear regression, is significant, $R = 0.37$ and $R^2 = 0.13$. The R-value of 0.37 suggests moderate linear correlation exists between student academic self-confidence and identity as an engineer. The R^2 value of 0.133 reveals that 13% of the proportion of the total variation in the response variable, engineering identity, is explained by academic self-confidence. The p-value is 0.031, which is less than the level of significance, $\alpha = 0.05$, this means that engineering identity can meaningfully be predicted by academic self-confidence. This is also supported by results in Table 4.1 of the regression coefficients, beta = 0.37, $t = 2.249$, and $p = 0.031$ or $p < 0.05$. The beta value measures the strength of the relationship between academic self-confidence and engineering identity and this relationship. Both the beta and the t values were determined to be significant. Therefore, the null hypothesis for Research Question 1 is rejected and concludes that a relationship exists between student academic self-confidence and engineering identity.

Table 4.1 SPSS Bivariate Regression Analysis Output for Question 1: Academic self-confidence versus engineering identity

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.365[a]	.133	.107	11.86190

a. Predictors: (Constant), ASC

b. Dependent Variable: EI

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	711.485	1	711.485	5.057	.031[b]
	Residual	4643.257	33	140.705		
	Total	5354.743	34			

a. Dependent Variable: EI

b. Predictors: (Constant), ASC

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	66.357	16.191		4.098	.000
	ASC	.460	.205	.365	2.249	.031

a. Dependent Variable: EI

4.1.2 Research Results Question 2

Research Question 2 examines if there is a linear correlation between engineering self-efficacy and educational persistence. To answer this question, bivariate regression analysis was conducted, utilizing the engineering self-efficacy as the independent variable, and their educational persistence as the dependent variable. Results in Table 4.2 below indicated that the linear regression, is significant, R = 0.53 and R^2 = 0.28. The R-value of 0.53 suggests moderate linear correlation exists between engineering self-efficacy and educational persistence. The R^2 value of 0.28 reveals that 28% of the proportion of the total variation in the response variable, educational persistence, is explained by engineering self-efficacy. The p-value is 0.001, which is less than the level of significance, $\alpha = 0.05$, meaning that educational persistence can meaningfully be predicted by engineering self-efficacy. This is also supported by results in Table 4.2 of the regression coefficients, beta = 0.53, $t = 3.586$, and $p = 0.001$ or $p < 0.05$. The beta value measures the strength of the relationship between engineering self-efficacy and educational persistence, confirmed to be significant because the t value is significant. Therefore, the null hypothesis for research question two is rejected and it is concluded that a relationship exists between engineering self-efficacy and educational persistence.

Table 4.2 SPSS Bivariate Regression Analysis Output for Question 2: Engineering self-efficacy versus educational persistence.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.530[a]	.280	.259	8.97361

a. Predictors: (Constant), ESE

b. Dependent Variable: EP

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	1035.336	1	1035.336	12.857	.001[b]
1	Residual	2657.350	33	80.526		
	Total	3692.686	34			

a. Dependent Variable: EP

b. Predictors: (Constant), ESE

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	45.593	15.876		2.872	.007
	ESE	.643	.179	.530	3.586	.001

a. Dependent Variable: EP

The SPSS results for both questions in this study revealed that a linear relationship does exist for both academic self-confidence and engineering identity, and engineering self-efficacy and educational persistence. However, the R-value for engineering self-efficacy and educational persistence, $R = 0.530$, was greater than the R-value for academic self-confidence and engineering identity, $R= 0.365$. Therefore, the linear correlation is stronger between engineering self-efficacy and educational persistence, than academic self-confidence and engineering identity. At $\alpha = 0.05$, the level of uncertainty, the p-values for both correlations were less than 0.05, which reveals that for both correlations, a linear relationship exists.

The quantitative sums for engineering student identity and enhanced educational persistence from this phase were then used to select interview candidates for Phase two, the interview phase of this study. Survey respondents who scored the highest in engineering student identity and engineering educational persistence were invited to be surveyed individually. The findings of the survey results are presented below.

4.2 Phase Two: Interview Findings

The qualitative data gathered through individual interviews was interpreted to determine the key factors and experiences that relate to engineering student identity development and enhanced educational persistence. This section describes the six interview participants selected and the factors and experiences that relate to engineering identity development and educational persistence. In several cases, direct student quotes are introduced as evidence. As the results are presented, brief comments explaining the relevance of the data are introduced with a complete discussion following in Chapter 5.

4.2.1 Emerging Themes

Each interview was first coded by the 14 questions asked during the student interviews. Questions were grouped into three categories: decision to be an engineer, inspiration and encouragement, and other people's perception and sense of belonging. Responses were documented as memos in each of these categories in ATLAS.ti V7.5.7 and compared to the proposed conceptual framework. Codes were created from these memos and themes emerged. In-vivo codes included: academic performance, challenge and engagement, identity development, leadership, learning experiences, mentorship, personal experiences, personal background and relationships, self-confidence, teams and competitions. Major themes that emerged from the interview data include the following six themes:

1. Working in and accepting the collaborative nature of inquiry.
2. The ability to make a real contribution to society.
3. Challenging coursework and affirmation from mentors, which increase the desire to achieve.
4. Unique and intense experiences, which increase the desire to persist.
5. Decision-making independent of social rules and norms.
6. Goal-driven achievement.

4.2.2 Factor One: Collaborative Nature of Inquiry

Working in and accepting the collaborative nature of inquiry are experiences that develop engineering identity. Peer collaboration can help students to be successful with challenging engineering tasks and move the students beyond their current state of knowledge (Crippen & Archambault, 2012). Engaging students to think like an engineer is indicative of the nature of scientific inquiry and is a key component of STEM education. Inquiry-based instruction provides the opportunity to address timely and critical issues that bears success on student learning. All interviewed students acknowledged that working in the collaborative nature of inquiry is a key component of mastering engineering and as a result feeling like an engineer. There was evidence that some of the students preferred to work in a team with trusted peers who have similar work ethics; while other students preferred to work independently and then incorporate peer work to ensure the quality of the outcome. Through the following interview quotes, a depiction of these two perspectives is portrayed. Working in small teams to solve problems is part of the development of the engineering student's identity.

Mark spoke about how working in small teams to solve problems influenced his decision to go into engineering. He reflected back to his high school experiences: working with other students as a team and solving engineering problems. Mark discussed his experiences working with his high school robotics team.

> "When I got into high school, I joined the robotics team, which was a lot more hands on experience and asking kind of the things you would do as an engineer. Actually talking to engineers and seeing what it is. And I just really wanted to do that. And I found it to be very interesting."

Mark went on to explain that he was a very competitive person and liked winning. "I found the competitions to be very fun and I'm a very competitive person. I was like, let's try our best to win and do our best. And like let's try to win it." Mark clarified that winning the competition was just part of the experience and that he really enjoyed working with the team. "What it came down to was, I think, it was nice to just have team work and work with other people who had the same passion of wanting to build something. That is really incredible to do a task." Mark clearly enjoyed the experience of working in a collaborative sense with a team.

Throughout his interview, Mark emphasized that a team working as a cohesive group was important, regardless of whether the team succeeds or fails.

> "We are a team. You either fall as a team or you rise as a team. You know, and that's what it came down to and we tried to work our best together. Even if we didn't like each other. It's for the team. We want to win."

Mark then explained how important it was to him to learn and brainstorm with others.

> "I feel that team work improves you more than anything else, because you get that feedback from people. You get other people's ideas in what they think is the solution and it may be better than what you think. And I think it's always important to look back and reflect on all the angles of something. And working with other people is such a good way to do that."

He described that the individuals on the team could not be forced to work together and had to want to work together as a team. "I really like working with a team of people. I need to work with a team of people who want to work as a team. Not by themselves who are forced to work as a team." Mark valued the collaborative nature of working with a team and accepted that cohesive teams do not always form.

John also discussed how working with a team is an important factor in his education. He explained how he reaches the level of quality in his work, regardless of who is on his team.

> "Well I just kept up, I had to do a lot of the work myself. And other than that, how I got the quality I wanted I did, I would do the part of the project that I knew I couldn't compromise on and I would give them the parts of the projects that they could live up to their expectations on. But on this portion I am not going to let that slide."

John had explained how he was able to navigate with existing team members without compromising on the level of quality he wanted in his work.

Steven, an older, non-traditional sophomore, also discussed working in the collaborative sense with a team. When asked do you remember a time when he felt a part of a group, Steven described his experiences in projects. “In our group projects. And being around some of the other engineers and how we work together really made me feel part of a group.” Steven, however, discussed that he had worked in teams that were not cohesive.

> “So in my class last semester I single-handedly designed the machine full project by myself. Because I knew that I knew how it needed to be built. And with the younger crowd, they don’t have any experience seeing a product to say. In a way other stuff has been structured. So I kind of took the lead with that.”

Steven went on to explain in his freshman experiences how the team behaved. “Other people on the group didn’t even want to learn how to do machine and straight out told me that so I was perfectly fine with that.” Although Steven spoke about the value of teamwork, he did not have a team that produced quality work. He felt it was necessary to complete the project on his own to ensure quality work. Steven valued the collaborative nature of working with a team however his experiences resulted in independent work to increase the quality of the project.

David, a traditional sophomore student, also spoke about his experience working in collaborative teams. He explained the sense of belonging in an engineering group that resulted from the team in his freshman year.

> “I would say at this school, every group project, I have felt like I belonged. We have been able to choose our groups since freshman year. They made a survey that was pretty good

> at putting people with similar schedules and interests together. So, everyone was able to get good group mates."

He then went on to describe the experiences and friendships he had in the following years. "I made my friends, my close knit friends pretty fast. I would say. It helped that we had to work with each other on a project. But we also talked about things we have in common." David felt a sense of belonging to the community and valued these experiences. By collaborating with peers, David had a greater experience that moved him beyond his current state of knowledge.

From peer collaboration, students succeeded at more challenging tasks and as a result grew beyond their current state of knowledge producing a quality product. David explained that through his experiences with teams he felt that trust was a key part of the group he belonged to now.

> "I think a part of it is that we all get along with each other and that we all, I don't want to say that the other students aren't as competent. But we don't know what kind of work they can produce. So we don't immediately trust them. But these people we know so we don't have to go back and check what they are doing and we can just trust them to get it done."

When asked to describe specific activities that made him feel like a part of this group, David described the attributes of his current team.

> "The same type of work ethic and quality of work, I guess it's kind of like work ethic. But even if it gets down to the last night and it's late, we are not going to just rush to go to bed. We are going to get it done."

He went on to explain the working behavior of his current group.

"I know a lot of the group things, they have told us to pick a group leader, and we have never done that. We just lay out the work that we have to do. Like we don't need somebody to boss somebody around. And say you better do this. Everybody just picks something that they know they can do. And then we just all get it done."

David's experiences with this team included a high level of trust that each student would provide a quality product.

Mark also experienced personal growth from working with a team. Mark explained in his interview that the value of being a part of the team and the personal improvement that came from their interaction.

"I feel that team work improves you more than anything else, because you get that feedback from people. Or you get other people's ideas in what they think is the solution and it may be better than what you think. And I think it's always important to look back and reflect on all the angles of something. And working with other people is such a good way to do that."

Mark described the need to share ideas in engineering and discuss options with the team.

"Yeah, without teamwork, you fall apart. And engineering, you have to get used to working with people and you should work with people. Because if you come up with an idea, you want to have a few friends or people that you know in the field look at it. And be like, oh maybe you should do it this way or this way."

Mark described his positive experiences working with teams to solve problems and recognized the value of this experience.

Through Mark's interview, he spoke about peer collaboration and how it helped him be successful in different engineering tasks. Mark continued to include comments on working with a team. "I guess I really grew up with that kind of mentally always that team work always being essential." Mark went on to explain that he likes working with a team to get tasks done.

> "Again, I am not afraid to work by myself. That's fine. But I will probably look ask other people who are doing the same thing, what their opinion is of it. I've always liked to work with other people. I find it to be more interesting and the task gets done with better quality with other people."

He reiterated the importance of teamwork while solving engineering problems through robotics competitions.

> "Let's say it's a robotics competition then it's really understanding what the competition is asking of you. What you can do as a team? What you can build? So you have to understand your limits, really. And when you fail, you can't be if afraid to redesign things ever. So, I always remember one year that my team did terrible in one competition. And then we went to another competition that was a week later. And we came back last place in the first one. And the week before hand we rebuilt our whole machine from the ground up we took it 100% apart and rebuilt it. And we came in middle of the pack. My teacher (laughing) was very frustrated with us. But was very proud that we did okay as a team."

Mark's positive outlook was essential in his team experiences and the development of his identity as an engineer. Furthermore, Mark's personality elevated his team's ability to produce a high quality revised product.

Mark's team continued to use this process to refine their solution and compete in future robotics competitions.

> "So when we took it back. We made like a bubble chart almost like a flowchart, I guess, I what the machine did and then be recorded why it failed at the competition. So if it was

electrical we made sure to include that. If it was mechanical. And then we pointed out flaws that we knew were there. So, we didn't like the way it drove so we train the way it drove. We changed the whole mechanism that drives the object. So it was just reflecting on what you do, and how we can improve it. And that's exactly what we did."

The process his team used was further explained in great detail.

> "We were given a challenge and then after the competition you see how other teams have built their robot. And we like to go to a few competitions. After every single one, we would stop and we write down in our notebook. What were the problems with our machine? Why didn't it function as well? And we looked at other team's machines. And we videotaped them. We made specific notes about them. Things that we liked. Things that we didn't like. And things that we were inspired to take and put into our new redesign. And bring that into our next competition."

Mark's process for project improvement and team development influenced his team immensely. This peer collaboration moved the students well beyond their current state of knowledge and provided highly valued team development experiences.

The quotes presented in this section reveal that working in and accepting the collaborative nature of inquiry are experiences that are important in engineering identity. Peer collaboration engages students to think like engineers and is indicative of the nature of scientific inquiry. Inquiry-based instruction provides the opportunity to address timely and critical issues that increases student learning. Furthermore, all interviewed students acknowledged that working in the collaborative nature of inquiry is a key component of mastering engineering. Some of the students preferred to work in a team with trusted peers with similar work ethics; other students preferred to work independently and then incorporate peer work to ensure the quality of the outcome. Working in small teams to solve problems is a key experience in the development of the engineering student's identity as they moved beyond their current state of knowledge in their field.

4.2.3 Factor Two: Real Contribution to Society

The ability to make a real contribution to society is a factor that influences engineering educational persistence. When students solve real-world problems using integrated techniques that they can apply to similar problems in society, meaningful learning takes place (Dewey, 1931, Lave, 1988). Engineering students in this study indicated that they aspire to make a real contribution to society and to improve the quality of life for others. There was evidence in the interviews that the students wanted to be a part of changes that need to be made to improve lives and this became a driving force in completing their engineering degree.

When Mark was asked what influenced his decision to go into engineering, he explained his desire to contribute to change.

> "If I had to go back and say my first time when I was like, man this is what I really want to do, it would be my freshman year in robotics when I saw this giant robot on the table and I was like man I would love to be doing that."

Mark went on to explain how he felt about his decision.

> "I went into it more. I would like to see how this evolves into other things. Rather than just robots. I knew I never wanted to do robotics as a career but like to work on other things like cars. You know things in society that we need."

Mark continued to speak through the interview about the need for change and how he would like to be a part of it.

When Mark was asked what inspires him to complete his degree, he spoke about his view of the world.

> "What inspires me to continue for engineering is that there is always flaws in the world and wanting to find a better way at looking at things and to fix the flaws in the world. I am always fascinated in things that people make and I think well how I could make that in a better way."

Mark continued to refer to the flaws in the world and the multitude of things he saw that could be modified or fixed to improve the quality of life for many. He was fascinated with working towards resolving these challenges with proficient high functioning team.

When John was asked what experiences made him decide to go into engineering, he reflected on a life event that had occurred.

> "Looking back on my life, when I am older, if there was one thing that I would regret not trying for and that was the same answer I got when I asked myself, "What would I do if there were no limitations?" Getting the same answer for both questions really spoke a lot to me. Okay, I have to try for. Otherwise I will never achieve my full potential for happiness."

John further explained how he developed this point of view and how he arrived at it, by explaining his philosophy.

> "I think most of it comes from my determination to reach the goals that I have set for myself. But my attitude in high school isn't the same as it is now. Just that and also, intellectual growth I have had in the meanwhile. The two years I took off I wasn't just working. I was reading a lot. I was trying to figure out what my beliefs were. Because I

> didn't have anything, really, so I wanted to find a comprehensive integrated philosophy to apply to my life. So I found that."

John explained how this changed his point of view on contributing to society. "Because I found a philosophy, on which to guide my life." He spoke about how this created a great understanding of his view of the world. "Not all people have a conscious understanding of their view of the world. For me, it's a conscious understanding because I formed it myself. Having studied all that. And decided that this is how I view life." John then went on to reveal that he is interested in becoming an astronaut and participating in the space program.

> "Because that is the future of mankind. To become interplanetary and explore the universe and I want to be a part of that. And plus I want to be up there and look down at the earth where I came from and feel weightlessness and I just want to experience all of that."

During the interview with John, he explained how his philosophy and view of the world motivates him during his studies, like a compelling force that continues to move him towards his goal and to complete his engineering degree.

When Grace was asked what influenced her decision to go into engineering, she explained her experience.

> " The space program influenced me to go into engineering." She went on to explain. "I really got interested in the actual space station. In particular, there was a particular astronaut, Nicole Scott, was on the international space station at that time. And she just seemed really awesome. And I looked at her resume and she was actually an engineer. And I looked into what engineering was."

Grace had attended a private high school and completed three years of theology school before she found her true passion in engineering.

> "The thing is that when I was going to school before, I was kind of bored because there was no math involved and I knew I really liked math. I knew that I would be really bored doing something with my life that didn't involve math or science."

Grace had struggled to complete high school in a traditional manner and ended up taking General Educational Development tests to provide certification of her high school-level academic skills. She was bored in high school and lacked incentive to attend class. Without clear direction, Grace then attended theology school, but found herself, again, unchallenged. It wasn't until she found her role model, Nicole Scott that she began to challenge herself academically. Grace explained that she would love to be an astronaut someday.

> "I would like to work as an engineer. Well, I love engineering but I think that after a few years I would realize that my favorite part is the why the things work and not how to make them work."

Grace had found a motivating force, her desire to become an astronaut, to apply herself in the engineering program and to complete her engineering degree.

When Maxwell was asked about experiences that influenced his decision to go into engineering, he revealed his need to utilize mathematics. "I shadowed an architect in high school. It was cool. I liked the thought of it. But it was very artsy. There was no math, no interest behind it. There's no why does it work." Maxwell then explained specifically his decision to become an engineer.

> "Junior and senior year I researched every bit of engineering that I could. I learned that mechanical is super broad. Aeronautical engineering is a subdivision of aerospace. After

> researching everything I wanted, I said alright maybe civil engineering. And I looked into it, it also wasn't fun. It was boring. Everything stands still."

After his research was complete, Maxwell made a decision.

> "But what influenced me is the fact that with after having so much knowledge about everything knowing what it took to be an engineer, it's going to be a hard road. I still took it because I knew I could be smart enough."

Maxwell was challenged by the level of knowledge attained in the engineering program. He explained how vital it would be to apply this knowledge in society. This aspiration provided Maxwell the inspiration to complete his engineering degree.

David's decision to go into engineering was influenced by a glider lesson at the age of 15. When asked, "What are some things that influenced you to go into the field of engineering?" David spoke about his glider lesson.

> "It probably started when I turned 15. I got a glider lesson and that is what peaked my interest in aviation and aeronautics. I originally wanted to be a pilot but then I realized I was interested in how things work. So I decided to do aeronautical engineering."

He went on to explain his interest in how things work as a factor in his decision making process and how he arrived at his final decision.

> "I really liked flying so I wanted to be a pilot. But I did research on the cost of that, and it was way more expensive. And then I also was more interested in how things flew instead of doing it."

David explained that he questioned his desire to be a pilot based on the cost of the pilot training. He went on to describe his experiences as a child.

> "So, I guess even when I was a kid, I liked to take things apart and put them back together. I have always been interested in science and math and generally working on things and understanding how they work."

David went on to describe the types of engineering projects he is currently working and their potential to contribute to society. David's aspiration to make a real contribution to society provided him educational persistence to complete his engineering degree.

When Steve was asked what influenced his decision to go into engineering, he spoke about his experiences prior to entering engineering school.

> " Ever since I graduated from my automotive school, I always have been fascinated with how things work and how the technology got to where it was for whatever I'm working on. And I like fabricating and working with my hands and puzzles."

Steve's had attended a high school that focused more on trade experiences than academic experiences. These experiences encouraged him to learn more about the world around him and how things work together. Steve also explained that this motivated him to understand automotive technology to a level where he could make a real contribution to society.

The quotes included in this section reveal that the ability to make a real contribution to society is a factor that enhance educational persistence for engineers. Solving real-world problems using integrated techniques provides students with meaningful learning. Engineering students in this study indicated that they aspire to make a real contribution to society and to improve the quality of life for others. There was evidence in the interviews that the students wanted to be a part of changes that need to be made to improve lives by completing their engineering degree.

4.2.4 Factor Three: Challenging Coursework and Affirmation from Mentors

Challenging coursework and affirmation from mentors which increase the desire to achieve are experiences that influenced persistence. The Next Generation Science Standards were created as part of the Framework K-12 Science Education to create new education standards that are rich in content and practice (NRC, 2011). These standards are organized in a coherent manner across disciplines and grades to provide students an enriched and challenging academic experience. Engineering students in this study revealed that they desired to academically achieve in their field of study through challenging coursework and projects. Many of the students explained that they felt it necessary to maintain a positive outlook and to seek affirmation from mentors, supervisors and professors while they increased their depth of understanding. In the interviews, the desire to solve problems by being challenged and by applying mathematics to solve problems was brought up by all of the students.

Mark discussed how challenging coursework and projects increased his desire to achieve. When was asked to explain more about the experiences that made him feel like he belonged at the college, he spoke about his course challenges and his interactions with his professors. “When you first get here as a freshman, the Dean of Engineering teaches you right off the bat in your first engineering class. Right off the bat you are behind 99% of the time.” Mark revealed that he was motivated by this challenge and worked very hard to keep up.

> “He moves so fast that if you don’t keep up with him, you’re behind. So I got to a point where I was super behind and I stayed at school until 11 o’clock and got everything in that I needed to do.”

Mark felt accomplished when he was caught up and able to stay on track. “I got to the point where I could keep up with his pace and I was faster so it felt cool to be able to keep up with him. So that was nice." Mark was then asked how he was able to get through the materials. "Encouraging yourself to do better and when you see yourself do it, it makes you feel good." He explained another experience he had in studying gas dynamics.

> "I want to go into propulsion. And I didn't know that until I got to gas dynamics. And we touched on everything there is to know about fluid flowing through a turbine. And that was the coolest thing I ever saw."

Mark explained that as he reached new levels of learning, he desired to learn more and challenged himself. "So when I was doing the calculations on it, I didn't get the best grade all the time. But when I got those 90's, it felt good that I knew everything there is to know about it." Mark's educational persistence had reached a new level, which helped him to master the upper level courses in engineering

Maxwell discussed how important it is to have affirmation from mentors and professors. When he was asked about the first time he really felt like an engineer, he described his experiences during his first engineering internship. "With the prototype I was working on, my boss asked me to design a differential equation for it and luckily I just went through differential equations the semester before that. And I said I can do this." Maxwell was glad to be able to apply what he had learned in his studies in his internship. He explained the process he used during that time. "I designed the three differential equations that were needed for the prototype that they are probably still using right now." Maxwell went on to explain how that made him feel.

> "So when I was doing that I was fantastic. It felt really good and with one of my things was quality of control for this to the sensors and I had to test the sensors and both worked, but the one that was older happened to be better. So the new system that they

wanted to use, the one that they thought was so cool, wasn't as good as they thought it was. Because it wasn't what they were looking for."

Maxwell described how his interactions with the president of the company built his confidence.

"So the president of the company, I had to present every Wednesday what my findings were and he looks at me and says what do you think? And I said I think the older sensor, it's a two-piece sensor, but it works, it's better and it seems to work perfectly every time as long as it's calibrated. And he looked at me and said that's what we're using. He didn't even ask. He didn't even question my decision. And that felt awesome. I felt like I was part of an engineering team and I actually knew what I was supposed to do."

The positive affirmation that the president had given him made Maxwell's identify as an engineer and was a factor in Maxwell continuing to pursue his degree.

Maxwell went on to explain that he had a similar experience that provided confirmation in his decision to pursue engineering. When he told the Dean of Engineering that he wanted to be an engineer, he received positive affirmation.

"So when I told the Dean, he's like cool and he smiled. And you can tell the joy in his face when we want to push ourselves and it's nice to know that we can go to him with stuff like that. And when I say, I want to be an engineer and he says, you should do it and become an engineer, you can tell he wants you to succeed."

For Maxwell, this was a very important interaction that solidified his desire to continue in engineering. Maxwell then spoke of his interaction with career services when he received an internship.

"Before I left to the interview she said, I just wanted to let you know that the Dean was just here and what he said. He said that I will give a recommendation to anybody that hires you because he wants me to succeed and I feel very comfortable with having Maxwell as one of the engineers or interns at any department or at any company. So that was very nice to hear, especially from the Dean."

Each of these interactions that Maxwell had experienced, strengthened his identity as an engineer and motivated him to persist in his engineering studies.

David also discussed the importance of challenging coursework and projects. When asked what inspired him and encouraged him to continue as an engineer, he explained how he enjoyed his classes and learning.

"I generally enjoy the classes and learning, so it never feels like a bother. Class may feel like a lot of work. I have learned that more homework is almost better because when it comes to the test, I actually know what I am doing."

David then continued to explain what inspires him and encourages him to continue as an engineering student. "I guess it's the fact that I am doing well in my classes inspires me to keep going. Like if I started failing all my classes, I would feel discourage. The fact that I can keep doing it." For David, his success in his classes helped him to persist in the engineering program. He was motivated by the challenge he experienced in class and by his educational achievement.

John also discussed how he was challenged in his studies. Some of his experiences started before college. John was asked to explain what influenced his decision to go into engineering. "Probably just how good I was, to be honest. I just always figured out new ways to solve math problems and enjoyed doing and the chemistry labs and all of that." John was also motivated by his own educational success. He went on to describe his mentorship from his grandfather, who was a physicist. "When I was a kid, he always would describe physics stuff to me. Like stuff he had worked on in the past or phenomenon about the universe or work on trig problems trying to derive trig problems." For John, these factors worked together to encourage him in his engineering studies, especially during challenging times.

The quotes included in this section indicate that challenging coursework and projects, and affirmation from mentors increase the desire to achieve in school. These are experiences that influence educational persistence for engineering students. The Next Generation Science Standards included in the Framework K-12 Science Education create rich education standards for learning practices. These standards are organized in a coherent manner across disciplines and grades to provide students an enriched and challenging academic experience. Engineering students in this study expressed their desired to academically achieve in their field of study through challenging coursework and projects, while maintaining a positive outlook and affirmation from professors as they increased their depth of understanding.

4.2.5 Factor Four: Unique and Intense Experiences

Unique and intense experiences are factors that influence educational persistence for engineering students. Emerging adults have shifted their focus to intense experiences connected to identity exploration (Arnett, 2000). These experiences sometimes resulted in failure to achieve or an inability to find satisfying or fulfilling work (Arnett, 2000). When asked what influenced their decision to go into engineering, all of the engineering students spoke about their family's educational experiences and financial challenges. They spoke about the education and careers of parents, grandparents, aunts and uncles, brothers and sisters. In many cases, the family experienced financial instability and uncertainty based on the parents' educational decisions or career paths. Although each of their stories were distinct, the students were motivated by their experiences and driven to persist in their education.

Maxwell discussed his family's financial instability as a motivating factor that encourages him to continue his education. When asked, "What encourages you and inspires you to continue as an engineering student?" he spoke admirably about his aunt and uncle. "My uncle went to college and my aunt is an R.N. So they went to school and they got intelligent." He then spoke about how his parents were not as fortunate and did not get a college education. "My mom and dad never went. No one else in my family ever went to college. I'm the third person in the family and I want to finish. Not only for family reasons but I want to have a better future than my mom and dad." Maxwell recognized that his college education would provide a better future for him and his parents. He went on to explain his family's financial situation. "My dad, he works whenever he can with the job that he has. He is struggling with money and I don't want to be there. I don't want to be struggling with money." Maxwell clearly could see that his dad had difficulty finding a consistent, stable job. When further probed why he chose engineering, Maxwell explained that how he feels about engineering and the potential for a stable income. "I do it because I love it at the same time I know that it pays well. When those matchup, it's fantastic. Knowing that makes me feel better." Maxwell also shared that his sister did not get the opportunity to go to college, as his family could not afford it. "My sister didn't go because my family doesn't make enough that we could have two children in school at the same time. So my sister couldn't go. But she didn't know what she wanted to do yet." Maxwell also explained that his sister did not know what she wanted to study and that may have influenced her educational decisions. Maxwell's family's financial situation motivated him to persist in his engineering education and to complete his degree.

In a similar manner, David also spoke about his family's financial instability and college education. He explained his mother and father's college education and career experiences.

> "My dad has a masters and he didn't really end up liking his career in social work. He just got depressed with it. Because he was dealing with a lot of problem kids. And he was like eventually, like I don't want to work with that anymore."

David went on to explain how his parents changed their career paths.

> "Now they own their own business. They did like a gallery and picture frames. But they retired from that when I graduated from high school. Now my dad helps out at a senior center cooking. My mom does personal care for a guy with Parkinson's disease."

David admired his parent's persistence to find work that interests them; but was concerned for them financially. He recognized that completing his college education would provide financial stability while enjoying an engineering career.

David went on to explain how his Aunt and Uncle have encouraged him as they went to college for engineering.

> "Both my aunt and uncle are both computer engineers and they live well. I guess the fact that they were really successful really helped. Because it showed me that it was a good career to get into. You can get pretty good job security if you know what you are doing."

David admired his aunt and uncle and spoke fondly of them. "My uncle went to small university and my aunt to a large university. And then they both were computer engineers and it was just kind of cool. Like I looked up to them." David's family's financial struggles have motivated him to find a career in what interests him, engineering and to complete his college degree.

Grace's family experiences have also motivated her to academically persist and complete her degree. Her parents had the opportunity to attend college; however, she did not feel like it influenced her educational decisions. "My dad is an engineer. But I don't think that was much of an influence for me. Because he is a software engineer. But he never talked to me about engineering." Grace went on to speak about her mother's career. "My mom was a stay at home mom, the majority of my life but now she's been working in infant care for the past five or six years." Grace also admired that her mother was taking classes and educating herself. "She went to culinary school with my dad for about a year and then my mom has been taking some classes for infant care recently." Grace also revealed that her dad didn't finish college. "And then my dad he didn't graduate from college either. He got hired when he was in his early 20's. And then worked programming mostly on-the-job and then they sent him to school for some classes. But he doesn't have a degree." Grace didn't provide any indication that her mother wasn't happy in her career or that she had regretted her decision to be a stay-at-home mom. Grace's family experiences have motivated her to complete her education in an interesting and challenging field, engineering.

John's unique family experience and financial instability also influenced his decision to complete his degree. When asking John about his parent's education, he spoke briefly about his mother's career. "Well, Mom went to school. She got a liberal arts degree and she works now at a retail store." He didn't indicate what she had studied or what she did at her current job. He also spoke briefly about his father. "And dad I don't know what he is doing right now, he moved to Texas a few years ago. I haven't heard from him in a few years." John had grown distant from his dad in recent years. When asking him what encourages him and inspires him to complete his degree, he reflected back on his parent's financial situation. "I just wanted a better life than what they had." John's family instability and financial struggles have motivated him to complete his degree and pursue his engineering degree.

Of the six students interviewed, four of them had struggled to overcome academic failure and personal instability. These four individuals had intense experiences that molded them into the individuals they are today. Grace explained her high school experience and her inability to succeed within the formal high school structure. “No, not really because if I could learn from reading the book or writing a paper and get an A on a paper without even having to attend class, it didn’t make any sense to go to class.” She struggled with the daily structure in high school and was bored with her courses. “So, I went to ceramics every day, because it was fun. And I always went to my plant science classes, because they were classes I wanted to go to.” For the classes she enjoyed, Grace attended the classes on a regular basis. “And then English class or health class or even math class, if I could do all the work and get the grades and not have to sit in class, then that’s what I wanted to do.” Grace felt strongly that if she could do the work on her own that she shouldn’t have to attend the classes. She was in a big private high school and it was difficult for the administration to enforce attendance. “And honestly, nobody made me go to school. And the school so big that they he didn’t really reinforce it so like they just failed me to the point where it wasn’t worth going anymore. So I got my GED.” Grace was discouraged in high school; however, she still had the persistence to complete her GED. She even went back for a fifth year to again try to graduate in the normal high school setting. “I actually went back for a fifth year because maybe I could graduate and then I only did half of that year and then I stopped.” Grace explained how many times she attempted to pass junior English. “They told me that if I failed Junior English three times, I was not allowed to take it again; so when I failed Junior English for the third time, I just dropped out.” Grace’s failures in the ability to complete high school in a traditional manner, motivates her today to complete her engineering degree.

Grace continued to have unique experience and difficult decisions to continue her education after getting her GED. “I actually went to school for theology for three years and then

I had to take two years off to work." She recollected her decision to go into theology school and why she had to stop.

> "I went to a bible school in New York so I studied there for two years and then I was doing my third year online with another bible university. And then I would have finished with that university, but I ran out of money. So, that's why I had to stop."

Grace's financial struggles during this time in her life moved her to find out what really interested her academically. Grace described her thoughts during the time immediately after leaving theology school. "And it was just like it gave me time to think about how I was bored and stuff." Grace reflected on her thoughts during that time.

> "The thing is that when I was going to school before, I was kind of bored because there was no math involved. I knew that I really liked math and I knew that I would be really bored doing something with my life that didn't involve math or science. So, when I started researching mechanical engineering and what they do and how much math is involved, I just kind of was pretty much it. Just kind of decided that was for me."

Grace's experiences of instability and adversity throughout her life are factors that are influencing her to persist in completing her engineering degree.

Steve also struggled academically in high school; however, he also experienced intense personal challenges that changed his course and direction. He was popular in high school and enjoyed the social atmosphere. He developed a poor attitude that did not help him succeed academically.

> "I had a lot of friends. I was decently popular. That was probably why I came up with that attitude because during high school with them was when I wanted to be Mr. Popularity. And that's where I had bad grades from my bad decisions. I can actually say

> that's when my worst decisions in life were made. And I didn't pay attention to school, I didn't like school and my best GPA was 1.9 in high school."

Steve did not speak proudly of his behavior in high school and recognized how it kept him from succeeding academically. "I went to [local] high school. I did one year of [local] school of technology, a technical school or trade school. And I hated it. I was allowed to take lower technology in order to fill in blocks." Steve liked the trade school but now recognizes his lack of maturity. "Most of the teachers in the school said I had a bad attitude back in the day. I was 16 or 17 years old." It wasn't until Steve's senior year that he began to enjoy his high school classes; then his life changed when his mother became ill. "And I took intro to engineering my senior year. My mother had cancer at the time. So it didn't go too well because I was always out trying to help her. And taking care of her." Steve had responsibilities at home, caring for a terminally ill parent and financially supporting his family. He was forced to mature as he took care of his terminally ill mother, his life experiences changed him and focused him academically. Upon her death, he completed automotive school, but unfortunately he continued to struggle.

> "And then I went to automotive school in a school of technology. I came out just in time for a crappy economy and most of the job offers I got start as a tech with $7 - $10 per hour and that's not acceptable after having a state job that pays $8 - $12. I just couldn't take a pay cut so I stayed with the state job."

Steve had to be responsible for himself financially after his mother had passed away. He explained his work experiences during the interview.

> "After a couple of years or working with the state, where they cut my hours down. And I went for technology and got placed into another fulltime job working in an automatic

transmission remanufacture company. I stayed there nine months and they actually fired me. It wasn't my fault this time. I just got put in the wrong place at the wrong time."

Steve continued to experience adversity in his work.

"I starting working with a friend to try something new. I was single and I wanted to travel. I actually signed up for the United States Marine Corps. I wanted to go to school and that's when I signed up. Aviation mechanic after I passed my ABFABS and went to MEPS. And lost some weight. And then I lost my leg prior to going to boot camp."

Steve explained that he felt he was on the right path by selecting the Marine Corps however again he was involved in a serious accident. It wasn't until Steve again experienced tragedy that he had complete clarity of his goal.

Late one Saturday evening, when Steve was walking home from a party at a friend's house, Steve was hit by a drunk driver and lost his lower right leg.

"There was a party at a friend's house. I went on to go to another friend's house. From what I know, last thing I remember was I got in a fight with my brother and sister-in-law. And my girlfriend took her sister home, and me and her boyfriend were walking up the street. Another friend was on his bike hammered. And hit me. He was on a motorcycle while I was walking."

Steve reflected on this tragic accident and the inability to join the US Marine Corps.

"It was two years ago. I was 24. I blacked out at a certain point and then I woke up two days later in the ICU. My right leg right below the knee was amputated on impact. And the US Marine Corps came to a screeching halt."

Steve spent the next six months recovering from the accident and selecting a new career path. Through the process of rehabilitation, Steve was given the opportunity to explore different career paths. Proficiency and aptitude tests revealed engineering to be a field where he could apply his skills and desires. At that point, Steve applied to engineering school and is now completing his sophomore year. Steve's intense experiences where again changing his life.

> "After that I recovered. I went back to work after six months. Getting my prosthetic leg and then decided to try to get a full-time job with the state. I applied for positions after six months. Didn't get the positions. And then I decided to go back to school. I figured that it would be more beneficial."

Steve attended vocational rehabilitation and decided to go to college for engineering. He explained how he made this decision.

> "In vocational rehabilitation, they pinpointed all my likes and dislikes for me and showed me a couple of different classes at different schools. One was manufacturing technology at the community college which was a pre-engineering class and then after that I came here. I figured I'd go for a straight course for the bachelors."

Steve's intense life experiences eliminated options for him; however, through his experiences he attained the persistence in his education that he has today.

John also had intense experiences and many difficulties when he first attended college right after high school. "For the first couple of years, I was at a local university and I didn't do too well." He went on to explain why he did not do well for the early years and the impact for not having a clear focus and defined goals.

> "Because I didn't apply myself and I didn't focus. Probably because I didn't have clearly defined goals like I do now. I was just kind of get in there and get my degree and make some money. And then I was separated from the university and then I took a couple of years off and worked."

John described his thoughts during the time he worked after his first college experience. “And I decided after that, that I had to make some decisions about my life, so I thought.”   He recapped his work experience at the airport and how that provided him the direction he needed to continue with his education.

> “I just worked at a gas station for a couple of years. And then I started working fueling jets at the airport. And I like being in that atmosphere, the aviation atmosphere so that was probably why I chose aeronautical engineering.”

John explained how he recognized his career goals through his work experiences at the airport.

> “I am interested not in just aviation but in the space program. Because that is the future of mankind. To become interplanetary and explore the universe and I want to me a part of that.”

John’s intense experiences and difficulties focused him to define and set goals. These goals today influence his persistence to complete his engineering degree and become an astronaut.

The quotes included in this section indicate that students have had unique experiences of instability, adversity and intensity, and these experiences influence persistence. These experiences reflect that emerging adults have shifted their focus to intense experiences which is connected to identity exploration. As stated by Arnett (2000), “The developmental focus in emerging adulthood has shifted to intense experiences connected to identity exploration.” These experiences sometimes resulted in intense failure to achieve or an inability to find satisfying or fulfilling work. These students spoke about their personal failures, their family’s educational challenges and financial instability, and how it has inspired them to continue and persist in their education pursuit.

4.2.6 Factor Five: Decision-Making Independent of Social Rules and Norms

Decision-making independent of social rules and norms is a dispositional factor that influences engineering identity and persistence. Emerging adulthood focuses on identity exploration and is distinguished by relative independence from social roles and normative expectations (Arnett, 2000). Interviewed students expressed that peer and family views, if obtainable, provided their view about them becoming an engineer. However, students were very clear that they ultimately made their own decision on the direction of their education independent of outside views. As stated by Social Cognitive Career Theory, a person's belief in their ability to accomplish a task depends on their self-efficacy; and self-efficacy, as guided by social rules and norms, is highly influenced by peer and family beliefs and opinions. From the quotes included in this section, peer and family perception, as indicators of social rules and norms, were not a major factor in their decision to become an engineer and in building their self-efficacy.

Maxwell spoke about how the views from peers and family were part of his decision process. When Maxwell was asked how peers perceived him when he decided to become an engineer, he explained the differences in his high school friendships and college communities.

> "I didn't have a lot of friends in high school so I branched out more here than in high school. One of my friends he looks at me like I have three heads when I tell them I'm going into engineering and I'm finishing my fourth year. I talked to him and he says I couldn't do it."

Maxwell spoke about the differences in his college community. "It's a small community here so it might be a little different because there are so many engineers. So you're all the same." Maxwell however did express that what his family thought was important; however, it would not alter his decision to be an engineer.

> ” Mom loved the idea because Mom’s dad loved the idea so she liked the idea. My Dad said it doesn’t matter whatever you choose, just make sure you do the best you can. So that was nice to hear that.”

Maxwell respected his high parent’s opinion about his career choice; however, it wasn’t a deciding factor in choosing engineering as a career. Maxwell had developed stronger friendships and relationships in his college community with similar interests and desires; however, there was not any indication that peer opinion would change his decision about his career path.

David also had similar experiences as Maxwell when he told friends and family about his decision to become an engineer. David respected and valued his family and peer opinion; however, their voice wouldn’t have changed his decision to study engineering.

> “All my close friends and my parents thought that is generally what I should have gone for. Because they sort of knew based on my interests and saw what I excelled at high school that it would fit me. And then, my friends, they are excited, because they like the idea of it. But they said that they couldn’t do it. But it’s definitely interesting.”

David went on to explain how his college peers reacted to him being an engineering major.

> “Well, I mean, that generally people really feel bad because everyone has heard that it’s a lot of work. Oh yeah, you must get a lot of work. I don’t know. People don’t generally judge about a major here not with engineering.”

David had described the same peer experiences as Maxwell. Opinions of his peers did not really influence his decision to study engineering.

When Grace described how peers and family perceived her decision to become an engineering, she vividly described her Aunt’s reaction.

> "Ummm [long pause], it's umm [short laugh]. I don't know. I guess the only one I can think of is my aunt because when I told my aunt, I remember I was sitting with my family at dinner just in the middle of summer. And my aunt was there because I told my aunt, I was going to go to school for mechanical engineering."

Grace described her Aunt's disbelief. "And her response was I'll believe it when I see it. (laughing). And I was like well you'll see it okay, you will see it (boldly)." Grace's aunt's unsupportive attitude about her ability to succeed in engineering did not turn Grace away from her educational pursuit. Grace did not recall anyone who provided her any influencing voice about her engineering degree. "I don't remember anyone really having any positive or negative reactions. More like, okay you're going to do whatever you're going to do." Many of Grace's friends and family recognized her independence in decision-making. Grace did express that her parents were glad she had chosen engineering as a major. "They're pumped about it. I mean like, they have five kids so they can only support each kid so much." While Grace had respect and cared about what her parents thought, it would not have influenced her career and educational decision.

Steve was also a very independent thinker when it came to career and educational decisions. When Steve was asked about how his friends and family perceived his decision to become an engineer, he explained that he felt support due to his accident; however, it really didn't impact his pursuit. Due to his accident, many friends and family didn't question Steve's decisions and wished the best for him. "If this is what you like, do it. No one questioned me. My fiancée was blown away that I was able to turn around and go back to school." Steve had impressed his friends and family with his ability to move forward in his career after his accident. "My ability to just change when I wanted to change. If I am not happy, make a change. When people are unhappy, they just stick with it. It drives me nuts." Steve went on to explain that he doesn't really care what others think about his decision. "I always feel different but I just don't care. It's just my attitude. I really don't care what people think about me. I do what I have to do and get it done." Steve explained that his life experiences had put him into a position where he didn't worry about what other people thought.

> "Life experiences have made me stop dealing with what other people are saying and I just worry about myself. And treat others the way you want to be treated. It's one thing that was burned into my head growing up. Never give up. Don't be afraid to try anything new. Don't give up. Make sure you are always happy."

Steve was clearly an independent thinker and made his own educational and career decisions. Because he had such intense experiences in his life, social rules and norms as projected by peer and family opinions did not influence his decisions.

Steve's persistence to complete his engineering degree was not influenced by a sense of belonging or peer acceptance. Steve explained his persistence and attitude when he was asked about a time when in the engineering group that he felt like he didn't belong. "I always feel different but I just don't care it's just my attitude. I really don't care what people think about me. I do what I have to do and get it done." Decision-making for Steve was clearly independent of social norms as expressed by other people's opinions.

Steve further clarified his interactions with peers at college. He expressed that he likes being a part of a group and working others; this is in contrast to needing other people's opinion or support to succeed in engineering.

"Because I knew how it needed to be built. And with the younger crowd they don't have experience seeing a product to say. In a way other stuff has to be structured. So I kind of took the lead with that."

Steve was an older student with a great amount of outside experience. He found that the younger students lacked maturity to complete the work; and because of this perspective, he did not value his peers' opinions.

"Because it's more of the young freshman not 25-year-old adults coming into a college. I just felt like frustrated. The immaturity and its okay to procrastinate. I don't know how else to explain it. My ambitions were a hell of a lot higher than theirs were."

Steve went on to explain how he dealt with his peers to get the projects done correctly.

"Yes, we all had our own jobs but I did the open machining because of my experience. Other people on the group didn't even want to learn how to do machine and straight out told me that so I was perfectly fine with that."

Steve's educational decisions were clearly independent of social rules and norms. Coupled with his personal experiences, Steve knew exactly what he wanted from his education and has a strong desire to complete his degree.

Although Mark didn't have the intense personal experiences that Steve had, he also expressed a similar point of view when asked about how he was perceived by peers. He stated that other people's opinions would not change his decisions. Any type of social rule or norm did not have any influence on what he wanted to achieve. "I don't really know what other people think. Because I'm not other people, so I don't go into their mind and think about it." Mark did say that he didn't get any negative feedback from friends and family in regards to his engineering education and career. He also stated that it just didn't influence his decision. "No one gave me negative feedback. I got some positive feedback. People were like you're going to do great in the field. But I was telling other people that as well." Mark was not influenced by social rules or norms, as indicated by other people's opinions about his career or education. Mark explained his family's response to his decision to be an engineer is important because he respected his family.

> "So they knew that I wanted to do engineering. And I expressed interest in it because in my school, I took engineering classes and things like that. So they knew I wanted to do engineering and they were perfectly fine with that."

Mark felt his families support in his career choice.

> "We hope you do a good job in it. And we hope that you have fun doing it. And they always tell me to do my best and get the best grades that I can get. Even if they are not perfect. Do the best that you can in whatever you do."

Mark's family was highly supportive of his decisions regardless of whether he was pursuing an engineering education. He did express that his decisions were not influenced by social rules or norms, as indicated by his family's opinion in regards to a pursuing his engineering degree.

John also had similar experiences when telling peers and family of about his decision to be an engineer. His family was supportive and proud of their son's decisions regardless of the outcome and they did not influence his decision to return to school. He recalled his mother's response when he decided to go back to school the second time. "She was proud I suppose. She really didn't have any say. I have always been kind of do my own thing. It doesn't matter." I then asked if it's because he is older. "No it's not just that. It doesn't really matter what people think other than me." John's decisions were made independent of any social rule or norm. He was clearly making his own career and educational decisions. I then probed further to determine if there were interactions with teachers that influenced his decision to continue in engineering.

> "I told him that I was looking for a pilots spot in the military. He mentioned that there had been a few students who had graduated in the engineering program who had gotten pilot slots. So that was encouraging that he knew the people who had graduated and ended up getting a pilot's slot."

John was positively influenced by other student's success stories in similar careers; however, his decisions remained independent. I then asked if there were any other teachers who had any influence on his decision. "Influence on what exactly? On being an engineer? No just my high school teacher. But the decision wasn't based on his suggestion. It was based entirely on me." John's decision making for his education and career was clearly independent of any type of social influence, rule or norm. He was clearly on a pursuit to achieve his personal goal.

The quotes in this section reveal that students made decisions independent of social rules and norms, as indicated by other people's opinions, and that this dispositional factor influences their engineering identity and persistence. Emerging adulthood focuses on identity exploration and is distinguished by relative independence from social roles and normative expectations (Arnett, 2000). All of the interview candidates expressed that how their peers and family perceived them did not alter their decision to become an engineer. Many of them stated that peers, family and teachers had stated their opinions about their educational choices; however, each student's decision was independent of outside opinions. Social rules and norms were not a major factor in their decision to become an engineer.

4.2.7 Factor Six: Goal Driven Achievement

Goal driven achievement is a factor that influences engineering educational persistence. Personal motivation constructs (interest and self-efficacy) and outcome expectations (career choice goals) are key influencing factors in Social Cognitive Career Theory (Lent et al., 1994, 2006). This theory takes into consideration factors such as background, learning experiences and supports and barriers as personal motivation constructs to achievement (Bandura, 1986). All students included that they had career goals and were driven by these goals to focus on achieving high grades and completing their degree. As a result of having career goals, many of the students set course goals as well with the goal of maintaining their grade point average. Knowing that they were smart enough to complete their engineering courses was imperative as an indicator that they were on track to achieve their overall goal. Achieving their individual goals was a primary reason they continued to persevere with their educational studies and achieve their career goal.

Goal driven achievement through class performance motivated Maxwell to continue pursuing his engineering degree. When he was asked to describe his decision to become an engineer, he spoke about having mastered the knowledge required to perform as an engineer.

> "But what influenced me is that fact that with after having so much knowledge about everything knowing what it took to be an engineer. It's going to be a hard road; I still took it because I knew I could be smart enough."

Maxwell reflected on his grade point average at the end of his freshman year. "When I got here, I got a 3.9 my first year so I kind of kept going." Maxwell continued to describe how his confidence grew as he maintained his GPA and kept up with his coursework.

> "But I got to a point where you could keep up with his pace and you were faster so it felt cool to be a will to keep up with him so that was nice. Encouraging yourself to do better and when you see yourself do it. It makes you feel good."

By succeeding in mastering the difficult concepts in his engineering courses, Maxwell was confident that he could complete his engineering degree. These learning experiences and achievements are critical factors for educational persistence.

David spoke on his decision to double major in aeronautical and mechanical engineering and reflected about reaching goals in the sequence of courses. He first spoke about his learning experiences in difficult engineering courses in his sophomore year and how passing these courses increased his confidence to succeed.

> "The hard classes sophomore year, the first semester sophomore year is when it really got hard. So it's like once you get past that you knew that you had what it took to get the degree. And if you were struggling then, you realized that you may want to switch."

He went on to describe his experiences in his junior and senior year and how achieving in these courses also increased his determination to complete his degree and reach his career goal. He realized that if he was willing to put the time into his studies that he could keep his good grades. It was no longer a question of whether he could or couldn't learn the difficult course content.

> "Like they were harder but it was like, it was like to me, it's not about how hard it is. It's about whether you are willing to put the time into it. Like I get deans and presidents list every semester and I haven't really struggled with the classes."

David's confidence to complete his engineering degree had increased based on his academic success and reaching higher course levels.

Grace also focused on the goals that she set and academic success she has achieved. She was inspired and encouraged to continue as an engineer based on her academic success. Grace clearly stated that because she was older, she felt the maturity required to achieve her set goals which drove her educational persistence. "I think a big part of why I am a much better student now than I would've been is because I'm older. I think just the maturity now and with engineering I really want it." Grace now having the maturity to understand her career choice goal of engineering influenced her to engineering educational persistence.

Grace then discussed what is different about her college experience versus her high school experience. "So nobody wants to go to high school. You don't get to pick what classes you go to or anything. So it's like I chose my degree. I chose my school. And so and now it's like, I'm doing it because it's what I want to do." Grace continued to reflect on her grades in the more difficult classes. "I get better grades in his class than anybody else's class because I work so much harder. It's like rare that I don't get an A in one of his classes. Because I work so hard." As a college student, Graces had matured and set goals that clearly motivate her differently in her college courses as compared to her high school courses.

Steve had clearly defined goals that have driven his achievement in his engineering courses. When asked what inspires and encourages him as an engineering student, he spoke about how poor his family was when he was young.

> "If I wanted it, I had to get it myself. Sometimes, growing up, we were poorer than normal. And basically got that aspect from my mother, because she did the same thing. I want to give you guys everything I couldn't have growing up."

Steve went on to describe how his upbringing has focused his educational goals. "I would love to get my masters. I also want to go to school for machining and welding. I have a lot of wants. Materialistic male. I want a lot of things. I have a lot of goals." Steve's ability to achieve in his engineering courses is based on the fact that he has set goals for the quality of his life and the things he would like to have.

John spoke about how his goals have inspired him and encouraged him to complete his engineering degree. He spoke clearly and confidently about his goals and how he is driven to achieve them. "What drives me towards any goal that I would chose for myself that would have been the driving force behind choosing the force and sticking with it." He went on to describe that once a goal is chosen, the goal motivates him to achieve it.

> "But as far as once that goal is chosen, it's kind of the goal itself is the motivating force. Actually achieving it. Especially it's so difficult. Like having achieved. Like once I kind of envision myself once I get there. The satisfaction I will have when I reach that goal."

John was further driven with the desire to do something that no one has done before with adventure and excitement. His desire to achieve the goal that has never been done invigorates him to work harder.

> "I picked engineering because I wanted greater existence. I need something different, I need excitement, I need adventure, and I need exploration. So I figured if I were living back in 1400's or 1500's, I would probably be on Columbus' ship. Or like on the Mayflower with the pilgrims because that's my personality. And now there is nowhere else to explore in the world so let's go out there."

In this quote, John stated that his personality is that of an explorer to go where no one has gone before. He went on to explain and to state his goals clearly and with confidence.

> "Because that is the future of mankind. To become interplanetary and explore the universe and I want to be a part of that. And plus I want to be up there and look down at the earth where I came from and feel weightlessness and I just want to experience all of that."

John spoke with self-assurance and determination about his reasons for achieving this goal. His personal motivation to complete these goals drive him as he reflects in the future on his life's achievements

> "There I was looking back on my life when I am older. If there was one thing that I would regret not trying for and that was the same answer I got when I asked myself what I would do if there were no limitations. Getting the same answer for both questions really spoke a lot to me. Okay, I have to try for. Otherwise I will never achieve my full potential for happiness."

John went on to describe how his goals are on a strict timeline, clearly mapped out so that he achieves them.

> "Absolutely even more so due to the age restrictions. The process that I decided to go through, through the military pilot program, that's the one I am going to try for anyways. That's probably the quickest route to become an astronaut. That's the only way I can see becoming a commander of a spacecraft. A mission specialist can be an engineer or a scientist and they do not need any experience with jet propulsion systems. The guys who actually command the ship they need experience with jet aircraft."

John's career goals focus him on the individual achievement steps along the way. In contrast to his first college experience, these goals influence John to persist at his engineering education to meet his career goal of mission specialist.

The quotes in this section reveal that goal-driven achievement is a factor that influences engineering and persistence. Goals can be expressed in terms of career goals and then broken down into academic achievement. Having the goal constructed is the initial step and then mapping out the milestones along the way help the student to persist in their educational endeavor. In Social Cognitive Career Theory, personal motivation constructs (interest and self-efficacy) and outcome expectations (career choice goals) are key influencing factors to achievement (Lent et al., 1994, 2006). All interviewed students included that they had goals and were driven by these goals to focus on achieving high grades and completing their degree. The milestone of knowing that they were smart enough to complete their engineering and to achieve their individual goals influenced them to persevere with their studies.

4.3 Summary

The findings in this study for the relationship between the identity development of engineering students and their educational persistence to continue in STEM programs are fully explored in this chapter. The correlation between student academic self-confidence and their identity as an engineer, and the correlation between engineering student self-efficacy and their educational persistence were calculated. From the correlation calculations, it was determined that engineering identity can meaningfully be predicted by academic self-confidence and that a relationship exists between engineering self-efficacy and educational persistence. The key factors and experiences that relate engineering student identity development and enhanced educational persistence were determined from student interviews. The six emerging themes discussed in this chapter provide experiences and factors that develop and influence engineering identity and increase the desire to achieve and influence persistence. Interpretation of these themes and recommendations for future study are discussed in Chapter 5.

CHAPTER 5 INTERPRETATION AND RECOMMENDATIONS

The purpose of this study is to contribute to the literature relating to engineering identity in the context of emerging adulthood and social cognitive career theory. The findings include a list of key factors and experiences relating engineering student identity and educational persistence for engineering students in the Northeast. These findings contribute to the engineering educational community and through links to prior scholarly work and application of developmental psychology and sociology. An initial framework and understanding of these findings in terms of social cognitive career theory in the context of emerging adulthood is developed.

The research questions for this study included:

(1) Is there a correlation between student academic self-confidence and their identity as an engineer?

(2) Is there a correlation between engineering student self-efficacy and their educational persistence?

(3) What are the key factors and experiences that relate to engineering student identity development and enhanced persistence?

5.1 Major Findings / Discussion

This study looked at the relationship between the identity development of engineering students and their educational persistence to continue in STEM programs. The theoretical framework in this study explores how identity development as described in emerging adulthood theory (Arnett, 2000), impacts self-efficacy beliefs which determine performance, accomplishments and persistence in pursuing a difficult course of action (Bandura, 1986). Inquiry-based learning (Wenger, 2002) also adds to self-efficacy theory and promotes that inquiry-based learning through collaborative community practice, deepens student confidence and competency. Exploring the correlation of the key experiences as described in emerging adulthood by Arnett (2000) to the constructs found in social cognitive career theory is the basis for the conceptual framework of this study. The literature states that self-efficacy in engineering education is becoming the appropriate basis of study because of the growing importance of experiential learning. A steady expansion of experiential forms reach into all the years of engineering education as a basis of the ABET (Accreditation Board for Engineering and Technology) requirements. Enhanced self-efficacy increases the ability for students to develop their skills further and apply themselves in the engineering field. The literature implied that the process of engineering identity development has not been well investigated (Dehing, Jochems, & Baartman, 2012), with very few studies looking into the factors and experiences that relate to engineering students' self-efficacy beliefs. According to the 37 participants surveyed in this study, a moderate linear correlation exists between engineering student self-confidence and their identity as an engineer; and between self-efficacy and educational persistence. According to the six participants interviewed in this study, key factors and experiences exist that relate to the development of engineering student identity and enhanced educational persistence.

5.2 Phase One: Findings and Interpretation

Research question 1 examined if there is a linear correlation exists between student academic self-confidence and their identity as an engineer. Bivariate regression analysis of survey data revealed that a moderate linear correlation between academic self-confidence and their identity as an engineer exists and that 13% of the proportion of the total variation in the response variable, engineering identity, is explained by academic self-confidence. Through this analysis, it was also determined that engineering identity can meaningfully be predicted by academic self-confidence.

Research question 2 examined if there is a relationship between engineering self-efficacy and educational persistence. Bivariate regression analysis of engineering self-efficacy and educational persistence indicated that a moderate linear correlation exists and that 28% of the proportion of their educational persistence can be explained by engineering self-efficacy. Through this part of the analysis, it was determined that educational persistence can be predicted by engineering self-efficacy.

5.3 Phase Two: Findings and Interpretation

Research question 3 asks what the key factors and experiences are that relate to the development of engineering student identity and enhanced educational persistence. Six major themes of key factors and experiences emerged from the interview data.

1. Working in and accepting the collaborative nature of inquiry.
2. The ability to make a real contribution to society.
3. Challenging coursework and affirmation from mentors, which increase the desire to achieve.
4. Unique and intense experiences, which increase the desire to persist.
5. Decision-making independent of social rules and norms.
6. Goal-driven achievement.

5.3.1 Factor One: Collaborative Nature of Inquiry

Experiences that develop the identity of engineers, includes working in and accepting the collaborative nature of inquiry. Through the student interviews, peer collaboration was indicated as a part of being successful with challenging engineering tasks. Student engagement to think like an engineer is indicative of the nature of scientific inquiry and is a key component of STEM education. Inquiry-based instruction provides the opportunity to address timely and critical issues that bears success on student learning. All of the interviewed students acknowledged that working in the collaborative nature of inquiry is a key component of mastering engineering. Working in teams with trusted peers with similar work ethics was highly preferred to ensure the quality of the outcome.

Working in small teams to solve problems was indicated to be part of the development of the engineering student's identity. The students indicated that they felt a part of a group and had a sense of belonging when working as a cohesive team. This experience helped develop the student's identity as a trusted member of a group. Many students indicated that being a part of a team was a positive experience and led to personal improvement. However, if the team did not produce quality work, the students indicated that they felt it necessary to complete the project on their own time to ensure the quality of the work. Many of the students went beyond just completing the project and also discussed team development as being a part of the group. Working in teams to solve problems is a key experience in the development of the engineering student's identity.

Factor one, working in and accepting the collaborative nature of inquiry, supports Wenger's work on inquiry-based learning. This work promoted inquiry-based learning through the belief that learning occurs between everyone in a community of practice (Wenger, McDermott & Snyder, 2002). Students and practitioners engage in meaningful dialogue, sharing ideas and deepening their knowledge and expertise. When student join a community of practice, they adopt the attributes and language modeled by that community of practice. They become more confident and competent moving toward the role of expert for those in the community (Wenger et al, 2002). Students interviewed in this study revealed that this as a key factor and experience that related to engineering student identity development and enhanced persistence.

5.3.2 Factor Two: Real Contribution to Society

A factor that influences engineering student identity is the ability to make a real contribution to society. Students indicated that what influenced their decision to go into engineering was solving real-world problems their level of understanding increased. They also indicated that being a part of changes that are needed to improve lives is a key factor for wanting to pursue an engineering career. Students spoke about the need for change and how they would like to be a part of that change. Many mentioned how they would reflect back on the life knowing that they were a part of immense change. Being an astronaut through the space program was a key factor in a few student's abilities to complete their engineering degree.

Factor two, the ability to make a real contribution to society, is a key factor and supports Lent's work on Social Cognitive Career Theory. Lent's work focused on understanding the processes during which individuals form interests, make choices and attain achievements in occupational academic pursuits (Lent et al., 1994; Lent & Brown, 2006). A person's belief in their ability to accomplish actions required for a particular activity is linked directly to their ability to achieve in occupational and academic pursuits. The belief that the student has the ability to make a real contribution to society enhances their ability to accomplish academic pursuits and career choice goals, which build enhanced persistence.

5.3.3 Factor Three: Academically Challenging Coursework and Affirmation from Mentors

Experiences that influence persistence include challenging coursework and projects. Students revealed that their desire to academically achieve in their field of study is important. Many of the students explained that they felt it necessary to maintain a positive outlook and to seek affirmation from mentors, supervisors and professors while they increased their depth of understanding. Many stated that they had the desire to solve problems by being challenged and by applying mathematics to solve problems. This type of interaction motivated the students to master difficult course content and to persist to complete their engineering degrees.

Some students spoke about their internships and interactions with the president of the company. Others spoke about how a course challenged them and their interaction with their professor. Affirmation from respected professors and mentors helped the development of the student's identity as an engineer. These interactions solidified their desire to continue in the field of engineering and motivated them to persist in their studies.

The rich education standards included in the Next Generation Science Standards provide a coherent manner across disciplines for students to experience challenging coursework and projects. Engineering students in this study indicated their desire to academically achieve in their field through challenging coursework and projects, while maintaining a positive outlook and affirmation from professors as they increased their depth of understanding.

Factor three, academically challenging coursework and affirmation from mentors, is an experience that increased the students desire to achieve academically in their field of study. This factor supports Lent's theory of Social Cognitive Career Theory (Lent, 1994), as student's self-efficacy of their current curriculum increases as a personal motivation construct and an indicator of educational persistence.

5.3.4 Factor Four: Instability, Adversity and Intense Experiences

Experiences of instability, adversity and intense experiences are factors that have influenced persistence. These intense experiences are connected to identity exploration (Arnett, 2000) for emerging adults aged 18-25. When asked what influenced their decision to go into engineering, all of the students spoke about their family's educational experiences and financial challenges. In some cases, students had experienced financial instability and uncertainty which inspired them to continue their education to provide a better life for themselves and their families. One of the students was forced to take care of his terminally ill mother during his high school years and was unable to complete his coursework in the traditional manner. Three of the six students had intense experiences that molded them into the individuals they are today. Whether it was failure in the formal high school structure or inability to complete the first year of college, these experiences provided the driving force necessary to persist to complete their current engineering degree. These experiences are factors that influence persistence. From a developmental focus in emerging adulthood, these intense experiences are connected to their identity exploration and development (Arnett, 2000).

Factor four, instability, adversity and intense experiences, are experiences that relate to student identity development and increased the student's desire persist in their education. As described in Arnett's theory of emerging adulthood (Arnett, 2000), changes over the past century have altered the nature of this developmental phase. Focus during emerging adulthood, ages 18-25, in highly industrialized or post-industrial countries characterizes a distinct period of life for young people. Intense experiences of instability and adversity during this developmental process impact student identity development and educational persistence.

5.3.5 Factor Five: Decision-Making Independent of Social Rules and Norms

A dispositional factor that influences engineering identity and persistence is that decision-making is independent of social rules and norms. Emerging adulthood focuses on identity exploration and is distinguished by relative independence from social roles and normative expectations (Arnett, 2000). During the interviews, all of the students that how their peers and families perceived them did not alter their decision to become an engineer. Many stated that although peers, family member and teachers had influenced their decision, social rules and norms were not a major factor in their decision to become an engineer. While some stated that their family and friends were accepting of their decision to become engineers, they clearly stated that it did not influence their decision. Social rules and norms were not a major factor in their decision to become an engineer.

Factor five, decision-making independent of social rules and norms is a dispositional factor that relates to student identity development and increased the student's desire persist in their education. As described in Arnett's theory of emerging adulthood (Arnett, 2000), independence of social rules and norms is a characteristic this developmental phase and has become normative in society. In contrast to Social Cognitive Career Theory (Lent, 1994, 2006), emerging adults do not create personal motivation constructs based acceptance from others nor on societal rules and norms. Emerging adults make decisions independent of peer and parental views and this uniquely impacts the student identity development and educational persistence.

5.3.6 Factor Six: Goal Driven Achievement

Goal-driven achievement is a factor that helps influence engineering identity and persistence. Students stated that they had personal career goals and that they were driven by these goals to focus on achieving high grades and to complete their degree. Achieving their individual goals was a primary reason they continued to persevere with their studies. Many of them felt that knowing they were smart enough to complete their engineering courses was also a factor in their ability to succeed. Students reflected on their grade point average and described how their confidence increased as they were able keep up with the difficult engineering coursework. Based on their academic success, many students considered double majoring in aeronautical and mechanical engineering. Students spoke with confidence and determination about their goals and achievements.

This factor is supported by Social Cognitive Career Theory where personal motivation constructs (interest and self-efficacy) and outcome expectations (career choice goals are key influencing factors to achievement (Lent et al., 1994, 2006). Choices and actions are influenced by expectations and goals. Understanding these processes of how students form interests, make choices, and attain achievements in academic pursuits is a factor that relates to engineering student identity and educational persistence for engineering students.

5.4 Implications and Recommendations

This section discusses the implications of the current study. First, the implications of the current study as they related to the theoretical framework upon which they are based are discussed. Second, the implications of the current study as they relate to the engineering educational community are discussed, along with specific recommendations for integration.

5.4.1 Implications of the Current Study to Theoretical Framework

Social Cognitive Career Theory provides the basis of the conceptual framework used in this research. Lent and Brown demonstrated that SCCT provides the personal and motivation constructs (interest and self-efficacy) along with outcome expectation of career choice goal. In this research, identity as described by Arnett (2000) is incorporated into this conceptual framework as a factor for engineering educational persistence. From this study, it is concluded that identity and the processes involved in identity formation impact engineering educational persistence. The conceptual framework in this study provides an initial framework for SCCT in the context of the current generation, emerging adulthood. From the findings of this study, personal motivation constructs (interest and self-efficacy), outcome expectations (career choice goals) along with identity formation provide a framework for understanding engineering educational persistence. Additional studies need to be pursued to verify this conceptual framework in the field of engineering as well as other STEM programs.

5.4.2 Implications to the Engineering Educational Community

The key factors and experiences identified in this study relate to the development of engineering student identity and enhanced educational persistence. The six major themes identified in this study can be used by engineering programs for student educational success and engineering program retention. Leveraging these factors would provide the ability to enhance engineering student identity and educational persistence.

5.4.2.1 Recommendations: Collaborative Nature of Inquiry

The first factor identified in this study was that working in and accepting the collaborative nature of inquiry are experiences that develop engineering identity. Peer collaboration helps students to be successful in mastering challenging engineering tasks. When students are engaged in scientific inquiry through collaboration, they begin to think like an engineer and therefore engineering identity increased. Students clearly preferred to work in a team with trusted peers with similar work ethics. However, when the quality of the outcome was jeopardized, students worked independently and then incorporated peer work to reach their goal. In cases where students in a team were not able to fully contribute, more qualified students would complete the overall team task. The most interesting part of this factor is that the quality of the task outcome was not compromised by working in a collaborative team. The development of the engineering student's identity involves not only working in the collaborative nature but also maintaining positive outlook while navigating amongst the different abilities of the individuals on the team to complete the quality required for the critical engineering task. The ultimate outcome in this learning experience is the ability to collaborate with peers and navigate the completion of a quality product while creating a process for project improvement and team development. Engineering (or STEM) programs need to overtly plan for and engage students in collaborative endeavors throughout their curriculum so that students learn well defined processes for project improvement and team development.

5.4.2.2 Recommendations: Ability to Make a Real Contribution to Society

The second factor identified in this study was that engineering educational persistence is influenced by the ability for the student to make a real contribution to society. Meaningful learning occurs when students solve real-world problems as they are inspired by making a contribution to society which improves the quality of life. Students strongly desire to be a part of these changes and this becomes a driving force in completing their courses and ultimately their engineering degree. Engineering projects need to be based on meaningful learning which connect to significant societal contributions to help encourage and sustain the educational persistence necessary to complete their engineering degree. Engineering (or STEM) programs must be constantly reviewed and revised to contain the most current and relevant real-world problems.

5.4.2.3 Recommendations: Challenging Coursework and Affirmation from Mentors

The third factor identified in this study was that challenging coursework and affirmation from mentors increase the desire to achieve and are experiences that influence persistence. The Next Generation Science Standards provide a framework that incorporates rich content and practice, and ultimately challenge academic experience. Engineering students enjoy applying mathematics to solve problems and strive to achieve academically through challenging endeavors. Interactions with professors and mentors also increase educational persistence as academic affirmation increases engineering identity. Similar positive affirmation occurs during engineering internships and increases student confidence in their ability to achieve. Engineering curriculum needs to strategically include well thought out challenges for students and educational opportunities that emphasize specific engineering achievement. These achievements need to be recognized and celebrated so that students desire success in their coursework. Additionally, role of the academic advisor needs to be expanded to a team of academic mentors to nurture and encourage educational persistence. The mentorship from professors and internships needs to purposely and deliberately include the student affirmation required to develop engineering identity.

5.4.2.4 Recommendations: Unique and Intense Experiences

The fourth factor identified in this study states that unique and intense experiences influence educational persistence for engineering students. Identity exploration for the current generation of emerging adults is connected to these intense experiences for this generation. These experiences can range from the failure to achieve academically, personal injury, terminal family illness to financial tragedy. These experiences of instability and uncertainty mold these young individuals to higher levels of personal achievement. As students, they are motivated to complete their degrees and provide a better quality of life for their families. The ability for students to share their personal stories needs to be incorporated into the college experience to strengthen student connections and to provide a common sense of belonging. These unique and intense experiences need to be shared in a safe forum in their educational community through student desired venues such as informal presentations, social media, campus newsletters and department gatherings to articulate student identity and the current generation of engineering or STEM students.

5.4.2.5 Recommendations: Decision-making Independent of Social Rules and Norms

The next factor identified in this study was that decision-making is independent of social rules and norms. This dispositional factor influences engineering identity and educational persistence. While engineering students certainly care about their peer and family views of their educational pursuit, their overall decision on the direction of their education was made independent of outside views. This finding is in contrast to Social Cognitive Career Theory, which states that a person's belief in their ability to accomplish a task is guided by social rules and norms and in highly influence by peer and family beliefs and opinions. The current generation of emerging adults are independent thinkers and decision makers, their belief in their ability to accomplish a task does not depend on traditional ways of building self-efficacy. Their belief in their ability to pursue their engineering degree is not guided by concepts in traditional theory. Because current engineering students have non-traditional beliefs about their ability to pursue their engineering degree, advising of engineering students should be cognizant of their independent decision-making process.

5.4.2.6 Recommendations: Goal Driven Achievement

The final factor identified in this study was that the goal-driven achievement influences engineering identity and educational persistence. Engineering students with high engineering identity and high educational persistence had clearly identified personal career goals and were driven to achieve in their courses by these goals. By successfully completing difficult engineering courses, students develop the confidence needed to persist to complete their engineering degree. Their academic success further enhanced their confidence in their ability to succeed in their career choice and thereby increased their self-efficacy. Engineering (or STEM) curriculum needs to include the self-reflective skills for students to recognize their achievement in their courses, and to identify and to examine their personal motivation and career goal.

5.5 Recommendations for Further Research

The current study offered several important insights to engineering student identity development and enhanced educational persistence, however continued study is required to verify and validate these findings. Recommended areas for future study include: multi-site research of the current study, validity of the conceptual framework presented in this study, a longitudinal study on educational persistence and engineering identity, and a research study that further describes the student experiences and factors that describe more specifically the developmental process of engineering identity.

One of the limitations for this study is based on the single-site design of the study. All of the data came from one small engineering college in the Northeast. Additional studies using the same mixed-methods design would aide in validating the conceptual framework and in clarifying the factors for engineering identity and educational persistence. I propose that initial expansion of studies be conducted in similar engineering colleges initially in the Northeast for universities using the CDIO syllabus to meet ABET accreditation. Once the conceptual framework is validated, additional studies could be conducted in other regional areas of the United States to determine if the factors for engineering identity and educational persistence are analogous. Studies gathered for regional areas must be contrasted and compared to determine the uniqueness and overlap of the engineering student experience. Common trends in factors and experiences must be identified to strengthen the conceptual framework and allow for definitive actions in updates to engineering (or STEM) programs.

Further analysis of the validity of the conceptual framework presented as part of this study is required. Additional research studies centered on the coupling of Social Cognitive Career Theory in the context of the current generation of emerging adults is required, to validate the framework. I propose that an area of research would be validation of the framework that combines identity development and educational persistence. Additionally, researchers must pay close attention to the factors that present themselves for individual career choice goals in STEM related fields as well as other career choices. These studies are not limited to engineering or STEM related fields and can be incorporated into frameworks for other career choices.

This study was conducted as a single isolated study for the current student body of engineers, as the students were only interviewed one time. Research studies of individual students or a set of students from high school through college would validate the factors and experiences determined for engineering identity and educational persistence. I propose that one area of future research be to perform a longitudinal study of individual students or a group of students from high school, through college into the student's career, and that the researcher pay close attention to the continuity of factors and experiences for individual students. Factors and experiences gathered in these students would determine whether these factors and experiences are a trend for the current generation or a newly defined model for future research.

This study included surveys and interviews of students who have persisted in engineering to determine factors and experiences that relate to engineering student identity development. Studies that include information about students who have not persisted in engineering is also required to determine if these factors and experiences are unique to those who persisted. Additional studies centered on the process of student identity development would also be useful to understand the sequential steps of identity development. Further research associated with understanding the developmental process of identity for engineering and STEM students is critical. I propose that one area of future research would be to articulate and then validate the sequence of steps in the process of identity development by studying different grade levels of students through high school and college. Developmental trends need to be identified and explored to determine which steps aide in the development of student identity and which ones are detrimental. With a better understanding of the developmental process of identity and the factors contributing to it, the curriculum practices and educational standards could be expanded to include deliberate actions that develop identity which further ensures educational persistence and retention for the body of students interested in STEM fields.

5.6 Researcher Reflection

The economy, the power and the leadership of the United States is critically dependent on how we educate and motivate students into STEM careers. With a recent surge in STEM education policy, we commit to understanding how to correct and improve the performance of students in the United States in mathematics and science. We begin to look at the flaws in our educational system with the hope of preparing students for the workforce and reducing the gap in ability between the United States and other nations. With many attempts in mathematics and science education over the past decade, the focus has moved to state-level STEM policy focused on educational improvement for the next generation. The implementation of both new curriculum standards and classroom practices are the foundation for recommended changes necessary to increase future STEM students in higher education. However, curriculum standards and classroom practices are only half of the problem that requires attention. The development of student identity and more specifically STEM identity must be addressed to ensure STEM educational retention and persistence. As seen in this study, the factors that increase engineering identity and educational persistence are unique to the current generation of emerging adults. A better understanding of this generation of students' learning attitudes and motivations is critical to strengthen learning abilities and enhance self-efficacy in STEM fields. Our commitment to move our country back to the top in science and mathematics education begins with a commitment to understand the current generation of students: their interests, their identity, their academic self-confidence and their student self-efficacy.

5.7 Conclusions

The goal of this study was to analyze the relationship between identity development of engineering students and their educational persistence to continue in engineering programs. This study asked if there is a correlation between student academic self-confidence and their identity as an engineer, and if there is a correlation between engineering student self-efficacy and their educational persistence. This study confirmed that there is a moderate linear correlation between student academic self-confidence and their identity as an engineer, and that engineering identity can meaningfully be predicted by academic self-confidence. This study also confirms that there is a moderate linear correlation between engineering self-efficacy and educational persistence, that engineering identity can be meaningfully predicted by engineering self-efficacy.

This study then asked what are the key factors and experiences that relate to engineering student identity development and enhanced educational persistence. Students who had high scores in engineering student identity development and in enhanced educational persistence were then individually interviewed. Analysis of the interviews of these select students offers insight into key influences in the development of engineering identity and factors that contribute to educational persistence. The key factors and experiences found in this study provide initial insight into the conceptual framework for Social Cognitive Career Theory in the context of Emerging Adult Theory. These key factors and experiences include experiences that develop engineering identity, factors that influence engineering educational persistence and dispositional factors that influence both engineering identity and persistence. Factors that develop engineering identity include: working in and accepting the collaborative nature of inquiry, challenging coursework and receiving affirmation from mentors. Experiences that influence engineering persistence include: the ability to make a real contribution to society, unique and intense experiences connected to identity development, and goal driven achievement. A dispositional factor that influences engineering identity and persistence is decision-making independent of social rules and norms. An understanding of the factors that influence engineering identity and educational persistence, provides critical aspects in the development of identity and persistence and ultimately the dynamics in engineering student retention.

The findings in this study contribute to the engineering educational community and to developmental psychology and sociology. As we gain greater understanding of the multiple factors and experiences that influence the development of identity in post-secondary engineering students and the underpinnings for student educational persistence, we can make connections to the pedagogical issues inherent in STEM education and the educational leadership required in support of student needs.

APPENDIX A: Informed Consent Document

Title of Study: Factors in Engineering Educational Persistence

Investigators: Susan M McKenzie

Introduction

The purpose of this study is to learn more about how your confidence, interests, and commitment across a variety of academic subjects related to your academic success as an engineering student. You are being invited to participate in this study because you are at least 18 years old and have expressed interest as an engineering student at your university.

Description of Procedures

Your participation in this study will involve participating in a survey of approximately 100 questions. Based on your answers in the survey, you may be selected for an interview to further explore your thoughts and views.

Risks

If you decide to participate in this study, there are no foreseeable risks at this time from participating other than increased self-awareness. All identifying information from your input will be kept confidential. Findings from the study may be used in publications; however, your individual identification will be kept confidential.

Benefits

If you decide to participate in this study, there will be one direct benefit, you will become more self-aware about your confidence, interests, goals, and career outcomes to pursue a variety of occupations and be more thoughtful about your career plans. The other benefit is to society in general. It is hoped that the information gained in this study will benefit society by helping researchers and practitioners better understand how confidence to pursue certain occupations affects the career decisions we make.

Costs and Compensation

There are no costs or compensation for participation in this study.

Participant Rights

Your participation in this study is completely voluntary and you may refuse to participate or leave the study at any time. If you decide to not participate in the study or leave the study early, it will not result in any penalty or loss of benefits to which you are otherwise entitled.

Confidentiality

Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. The Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect the records for quality assurance and data analysis. These records may contain private information.

To ensure confidentiality to the extent permitted by law, participants will be assigned a unique code and letter that will be used on forms instead of their name. Your identifying information will not be stored with your responses and will only be accessed by the author. After the study is completed, we will destroy identifying information within 5 years. If the results are published, your identity will remain confidential.

Contact Information:

You are encouraged to ask questions at any time during this study. For further information about the study contact, Dr. Peg Ford, Associate Dean, School of Education Southern New Hampshire University, m.ford1@snhu.edu. If you have any questions, about the rights of research subjects, please contact Dr. Peg Ford, Associate Dean, School of Education Southern New Hampshire University, m.ford1@snhu.edu.

Participant Signature

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document and that your questions have been satisfactorily answered. You also understand that your signature indicated you have given the researcher permission to access your enrollment status at your college from the registrar's office. You will receive a copy of the signed and dated written informed consent prior to your participation in the study.

Please initial one of the following:

________ Yes, I agree to participate in this study as written above.

□ I understand that the information obtained will be used to inform the development of a dissertation.

□ I understand that I may withdraw from the study at any time without any consequences.

□ I acknowledged that the researcher, Susan McKenzie, has agreed to protect my confidentiality.

________ No, I do not agree to participate in this study as written above.

Participant's Name (printed) ______________________________

Participant's Signature___________________________________

Date ____

Investigator Statement

I certify that the participant has been given adequate time to read and learn about the study and all of their questions have been answered. It is my opinion that the participant understands the purpose, risks, benefits, and the procedures that will be followed in this study and has voluntarily agreed to participate.

Signature of Person Obtaining Informed Consent _____________________

Date ____

APPENDIX B: Survey Information

Item number	Scale
1- 7	Demographics
8-15	Engineering experience
16-24	Science and Math Self-efficacy (FSS, Fouad & Smith, 2002)
25-33	Science and Math Outcomes expectations (FSS, Fouad & Smith, 2002)
34 – 42	Science and Math Goals (FSS, Fouad & Smith, 2002)
43	Engineering
44 – 67	Career Commitment
68 – 73	Career Decidedness
74 – 111	Sources of Academic Self-Efficacy (Anderson & Benz, 2001)

Please complete the following information in the indicated spaces:

1. NAME: in the space labeled “NAME” on the first answer sheet.

2. IDENTIFICATION NUMBER:

3. SEX: in the space labeled “SEX”

4. Please select from the following age categories:

( ) under 18 ( ) 18 – 19 ( ) 20 – 21 ( ) 22 – 25 ( ) 26 – 29 ( ) over 30

5. Do you have military experience? ( ) Yes ( ) No

6. Have you attended any other educational institution prior to your current university?

( ) Yes ( ) No

If yes, prior educational institution ______________, credit hours ___________.

7. Would you be willing to participate in a follow-up one-on-one interview during May or June 2015?

( ) Yes ( ) No

<u>Answer the following questions beginning with the question #1 on the 1st answer sheet.</u>

1. Please indicate your ethnicity on the answer sheet:
    a. Caucasian/ White
    B. African- American
    c. Hispanic-American
    d. Asian – American
    e. Native American
    f. International Student
    g. Other (example: bi-racial)

2. Your Marital Status:
    a. Single
    b. Married
    c. Divorced/ Separated

3. Major Choice Status (choose only one)
    a. I am undecided about a major
    b. I am tentatively decided about a major
    c. I have decided on a major

4. Have you declared a major?
    a. Yes
    b. No

5. What is your career choice status (choose only one)
    a. I am undecided about a career
    b. I am tentatively decided about a career
    c. I have decided on a career.

6. What is your current standing in school?
    a. Freshman
    b. Sophomore
    c. Junior
    d. Senior
    e. Graduate student

7. What are your educational aspirations?
    a. Some college / no degree
    b. Associate Degree
    c. Bachelor's Degree
    d. Master's Degree
    e. Doctorate (PhD)
    f. Law Degree (JD)

Please indicate the extent to which you agree or disagree with the statements below by filling in the appropriate bubble (choose a "1", "2", or "3") on your answer sheet.

1 = I have and do plan to do these activities
2 = I have not done these activities but I plan to do them in the next year
3 = I have not done these activities and do not plan to do them in the near future

8. Shadowed an engineering professional
9. Completed an externship with an engineering professional
10. Interviewed an engineering professional about their work.
11. Volunteered in an engineering facility
12. Had a family member who is an engineering professional
13. Joined an organization associated with engineering
14. Attended organizational meetings of an organization associated with engineering
15. Taken a certification course for engineering

Please indicate the extent to which you agree or disagree that you could do each statement below by filling in the appropriate bubble on the answer sheet.

1= Very Strongly Disagree	2=Mostly Disagree	3= Slightly Disagree
4 = Slightly Agree	5= Mostly Agree	6 = Very Strongly Agree

I feel confident that with the proper training I could:

16. Classify animals that I observer.
17. Earn an A in a calculus course.
18. Earn an A in a college physics course.
19. Figure out the amount of wall paper needed to cover a room.
20. Earn an A in Chemistry.
21. Keep financial records and determine how much to spend for a university student organization.
22. Figure out how long it will take to travel from Des Moines to St. Louis, driving 55 mph.
23. Design and describe a chemistry experiment that I want to do.
24. Earn an A in an advanced calculus course.

Please indicate the extent to which you agree or disagree that you could do each statement below by filling in the appropriate bubble on the answer sheet.

1= Very Strongly Disagree	2=Mostly Disagree	3= Slightly Disagree
4 = Slightly Agree	5= Mostly Agree	6 = Very Strongly Agree

25. If I get good grades in chemistry, then my friends with approve of me.
26. If I get good grades in calculus at college, then my parents will be pleased.
27. If I take a lot of math classes at college, then I will be better able to achieve my future goals.

28. If I do well in science courses at college, then I will be better prepared for the work world.
29. If I learn math well, then I will be able to do lots of different types of careers.
30. If I take a math course at college, then I will increase my grade point average.
31. If I do well in science classes at college, then I will do better in life.
32. If I get good grades in science at college, then my parents will be pleased.
33. If I get good grades in math at college, then my friends will approve of me.

34. I am committed to study hard in my calculus course at college.
35. I plan to take more science courses at college than will be required of me.
36. In the future, I plan to volunteer time to help others.
37. I plan to take more math classes at college than will be required of me.
38. I am committed to study hard in my science courses.
39. I intend to enter a career that will use math.
40. I am determined to use my science knowledge in my future career.
41. Learning about different cultures will be beneficial to my career.
42. I intend to enter a career that will use science.
43. I consider myself an engineering student.

Please indicate the extent to which you agree or disagree that you could do each statement below by filling in the appropriate bubble on the answer sheet.

1= Very Strongly Disagree	2=Mostly Disagree	3= Slightly Disagree
4 = Slightly Agree	5= Mostly Agree	6 = Very Strongly Agree

44. My career field is an important part of who I am.
45. This career field has a great deal of personal meaning to me.
46. I do not feel "emotionally attached" to this career field.
47. I have created a plan for my development in this career field.
48. I do not have a strategy for achieving my goals in this career field.
49. I strongly identify with my chosen career field.
50. I do not identify specific career goals for my development in this career field.
51. I do not often think about my personal development in this career field.
52. The costs associated with my career field sometimes seem too great.
53. Given the problems I encounter in the career field; I sometimes wonder if I will get enough out of it.
54. Given the problems in this career field, I sometimes wonder if the personal burden is worth it.
55. The discomforts associated with my career field sometime seem too great.
56. I do not feel a strong sense of belonging to this career field.
57. I frequently tell people how great my career field is.
58. I readily learn new techniques and procedures with my career field.
59. The benefits of this career field outweigh its costs.
60. I am constantly trying to improve the skills I need in my career field.

61. I feel irresponsible if I do not keep up with the developments within my career.
62. Through my career field has its difficulties, I will continue to try hard.
63. I will continue to work hard in my career field, despite its problem areas.
64. When I initially meet others, I usually don't tell them my career field.
65. In social setting, I rarely discuss my career field.
66. I often discuss my career field with people outside of it.
67. I know I need to reach my goals in this career field.

68. I am exploring a number of different majors.
69. I sense that there are a number of majors that might be good for me.
70. Engineering is really the only career option I am considering.
71. Since there are other good majors for me, it's hard for me to decide which one is best.
72. It is important to decide your major early if you are an engineering student.
73. I sense my best fit with career options is with engineering.
74. Thinking about first semester grades makes me nervous.
75. I was uncomfortable taking tests in school.
76. I get a sinking feeling when I think of succeeding at school.
77. I get really uptight when I have a lot of homework to do.
78. I almost never get uptight about studying.
79. I usually don't worry about how I'll do in my classes.
80. Studying makes me feel uneasy and confused.
81. Studying makes me feel uncomfortable and nervous.
82. Taking tests makes me nervous.
83. People have told me that I am a good student.
84. My peers have told me that I have good study skills.
85. I received strong encouragement to do well in school as a child.
86. Older people have told me that I have good study skills.
87. Other people see me as doing poorly in school.
88. My parent(s) encouraged me to be proud of my academic success.
89. I was encouraged to use my academic skills to assist me with my career success.
90. High school teachers rarely complimented me on my ability to be a good student.
91. My parents encouraged me to be a good student.
92. My teachers have told me that I have good study skills.
93. My favorite teachers are strong academically.
94. Many of the adults I admire have strong academic skills.
95. My career role model did poorly in school.
96. My friends tend to avoid academic excellence.
97. My parents are not strong academically.
98. Many adults I know have good academic abilities.
99. Many of my friends are pursuing work that does not require academic skill
100. My parents succeeded in college.
101. I know few people who are talented in getting good grades.
102. I always had difficulty getting good grades.
103. I always do well in my courses.
104. I have always been attracted to books.
105. I always feel like I know what I am doing at school.

106. School has always been difficult for me.
107. I did worse in school than most of my high school acquaintances.
108. When I don’t understand something at school, I work at it until I understand it.
109. I always have had good study skills.
110. I have tried to improve my ability to do well in school whenever I could.
111. I have always done well in school.

APPENDIX C: Interview Questions

The following interview questions will serve as a guide to begin the conversation, but the interview will be semi-structured to allow follow-up questions and a comfortable conversational discussion.

1. What do you think influenced your decision to go into Engineering?

2. Can you describe events or interests in your past that made you want to be an Engineer?

3. Can you describe more specifically your decision to become an Engineer?

4. In your time at your University, can you describe a time that you really felt a part of a group? What experiences made you feel you were a part of that group?

5. To contrast this experience, can you describe a time since being at your University that you felt that you did not belong to a group? Specifically, what about this experience made you feel like you did not belong?

6. As an Engineering student, can you think of a time where you really felt you belonged? Are there any activities, programs, or specific experiences that help to make you feel a part of the College of Engineering?

7. Can you think of a time, as an Engineering student, where you did not feel you belonged? Is there anything that would help you to feel you belonged?

8. Can you remember the first time you "felt like an Engineer?"

9. Is there a certain experience that made you feel like you weren't an Engineer?

10. What inspires and encourages you to continue as an Engineering student?

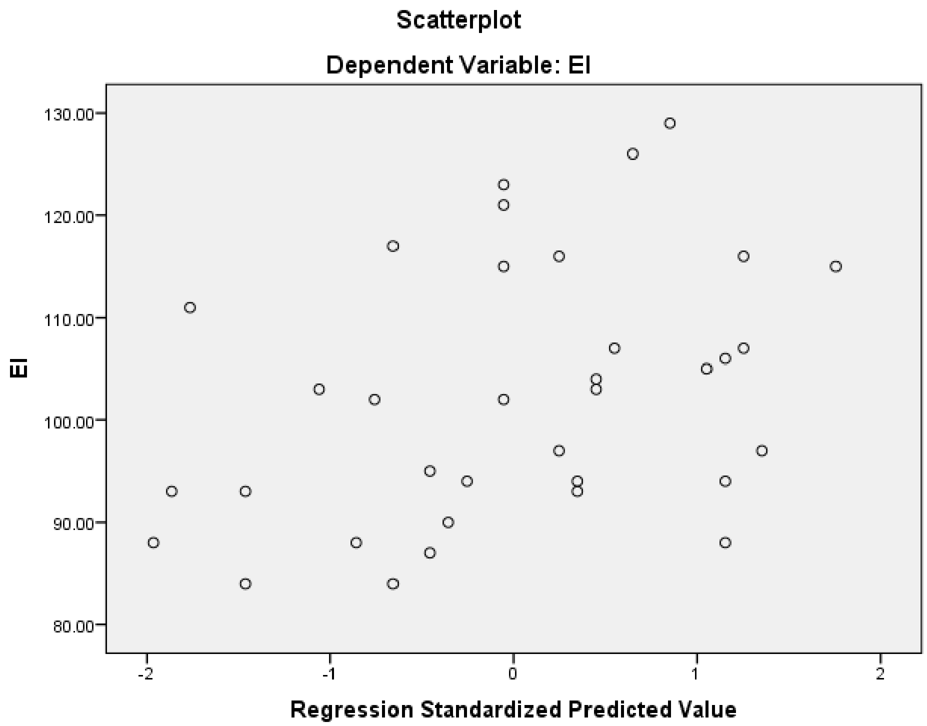
11. Are there any specific experiences that have inspired or encouraged you that you could provide detail on?

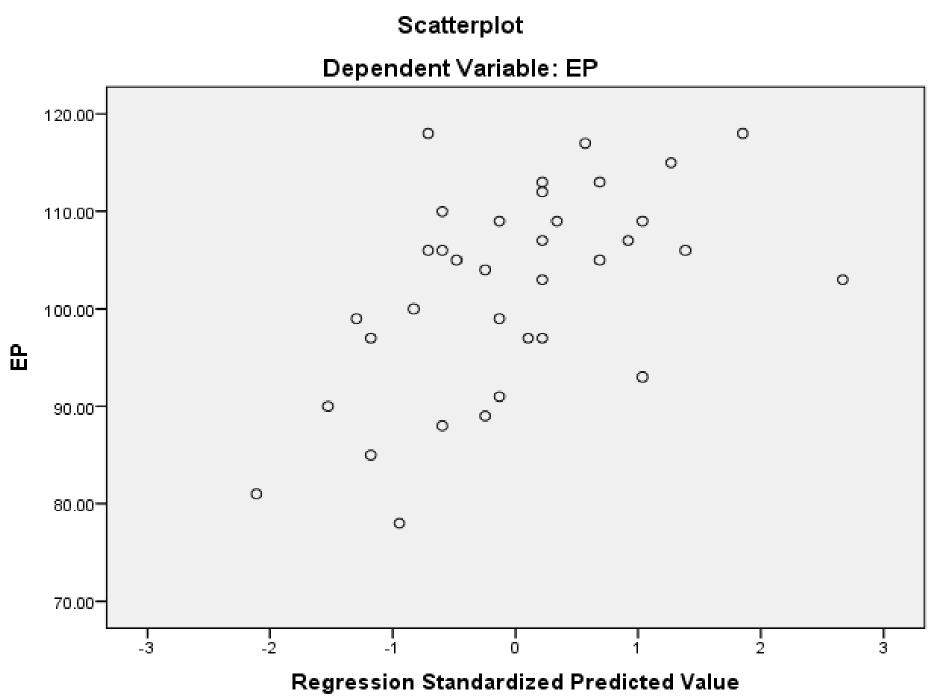
12. How were you perceived by your peers when you decided to become an Engineer?

13. How were you perceived by your family and close friends when you decided to become an Engineer?

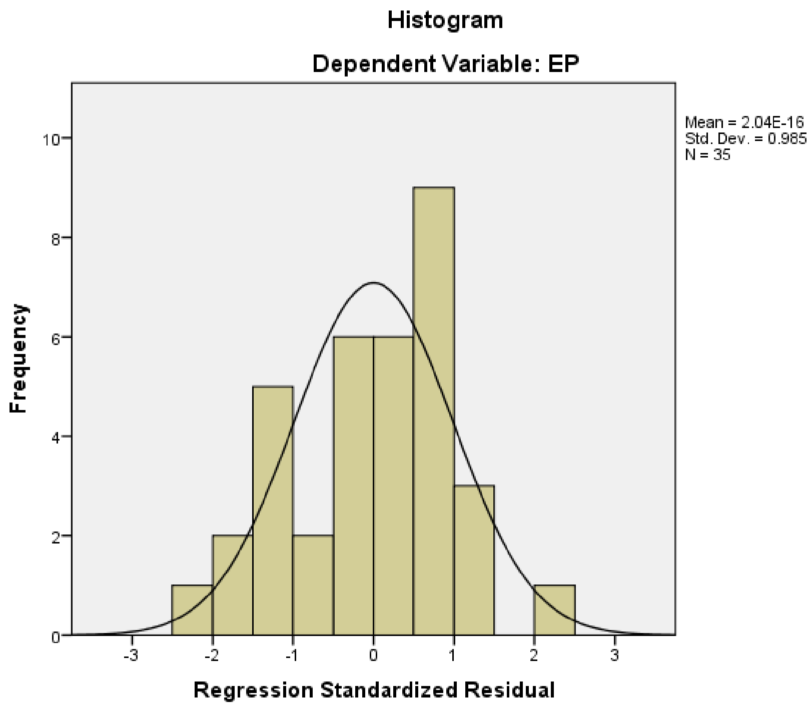
14. How do your teachers respond when you tell them you would like to be an Engineer?

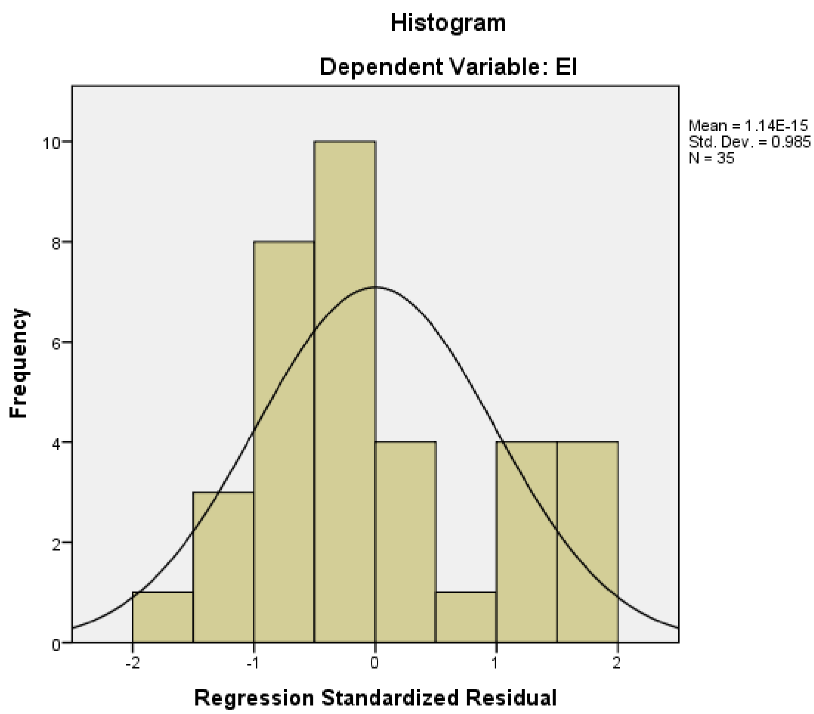
APPENDIX D: Quantitative Data Scatter Plots: Engineering Identity and Educational Persistence



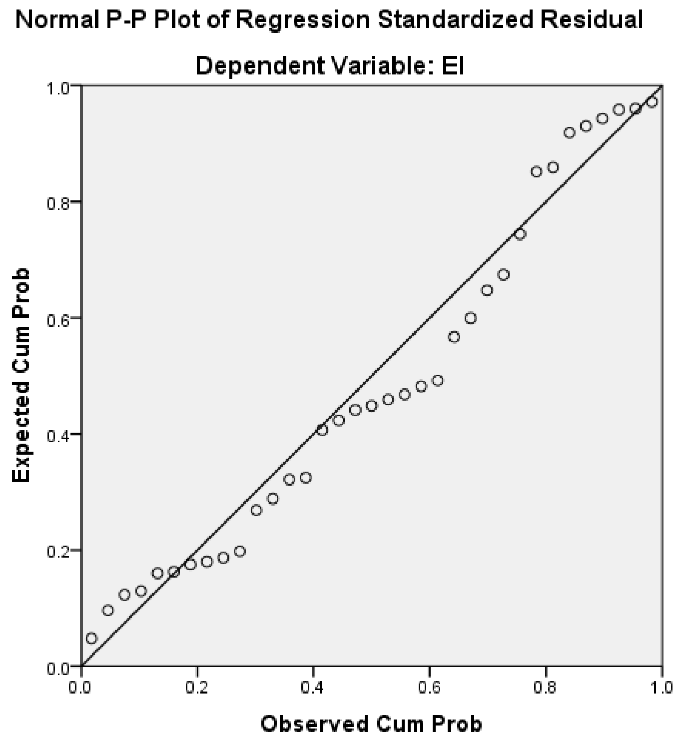


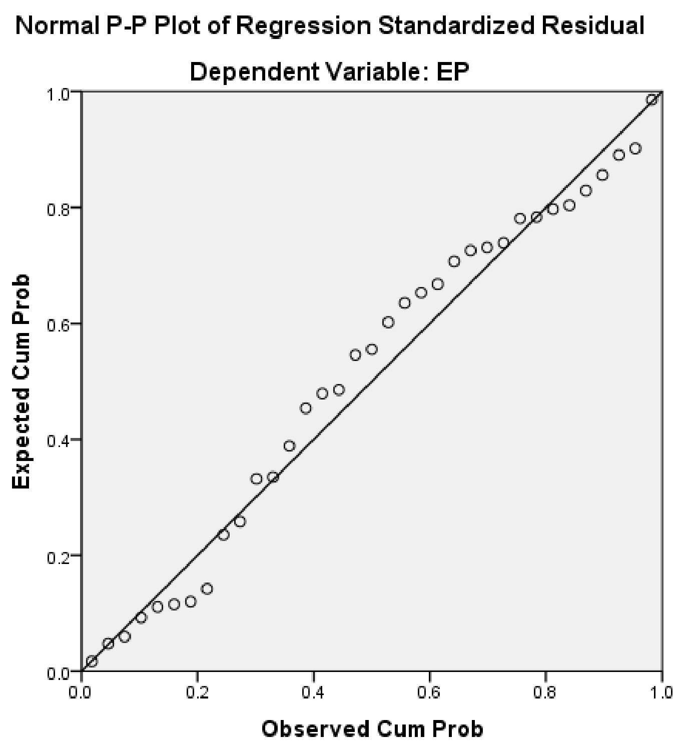
APPENDIX E: Quantitative Data Normalized Residual Plots: Engineering Identity and Educational Persistence





APPENDIX F: Quantitative Data Normalized Residual Plots: Engineering Identity and Educational Persistence





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