EXAMINING THE RELATIONSHIP BETWEEN COOPERATIVE EDUCATION EXPERIENCES AND PROFESSIONAL IDENTITY DEVELOPMENT

Richard A. Robles

B.A. Northern Arizona University, 1996

M.S. Minnesota State University, Mankato, 2000

M.B.A. University of Cincinnati, 2008

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Gail F. Latta, Ph.D.

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Committee Approval:

Name [typed]	Signature and degree
Gail F. Latta	Gail F. Latta, Ph.D. Digitally signed by Gail F. Latta, Ph.D. DN: cn=Gail F. Latta, Ph.D., o=Xavier University, ou=Leadership Studies & HRD, email=gail@thelattas.net, c=US Date: 2020.05.29 14:45:10 -04'00' Ph.D. (Committee Chair)
Michael Flick	Michael Flick Digitally signed by Michael Flick Date: 2020.05.29 16:20:22 -04'00' Ph.D.
Michael Chikeleze	Digitally signed by Michael Chikeleze Date: 2020.06.01 12:35:37 -04'00' Ph.D.

5.29.2020

Date of Committee Approval

Program Director Approval:

Name [typed]	Signature and degree, Program Director
Gail F. Latta, Program Director	Gail F. Latta, Ph.D. Digitally signed by Gail F. Latta, Ph.D. Date: 2020.06.11 08:04:12 -04'00' Ph.D.

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Richard A. Robles

Dissertation Advisor: Gail F. Latta, Ph.D.

Abstract

The purpose of this study was to determine the extent to which professional development experiences like cooperative education (co-op) may influence undergraduate students' sense of professional identity as engineers. Researchers surveyed 97 baccalaureate engineering students using a modified engineering identity survey first developed by Meyers (2009), which was based on Arnett's (1994) Theory of Emerging Adulthood. Exploratory factor analysis responses generated two factors of identity development explaining 43.8% of the variance among respondents. The first factor (tasks) is composed of tasks students perceive they need to complete in order to become an engineer, while the second reflects behaviors that project confidence in being an engineer (confidence). The task factor showed weak predictive utility in differentiating fifth-year and first-year students and was found to be negatively correlated with the number of academic semesters and co-op experiences completed. The confidence factor did not have any correlation with either metric. Results of the study call for researchers to continue efforts to explore the dimensions of engineering identity and seek to understand the separate and reciprocal effects of classroom learning and co-op work experiences on student identity development.

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CHAPTER 1. Overview of the Study

Research Topic and Background

Identity is a widely studied construct. In their book introduction, Vignoles, Schwartz, and Luyckx (2011) state that identity guides life decisions, allows people to draw strength from their affiliation with social groups, and helps explain behaviors. While the social sciences have presented multiple definitions of identity, the professional disciplines have attempted to contextualize identity with a sense of professionalism. The term "professional identity" has been studied in professional disciplines such as teaching (Sutherland, Howard, & Markauskaite, 2006), higher education (Barbarà-i-Molinero, Cascón-Pereira & Hernández-Lara, 2017), health and social care (Adams, Hean, Sturgis, & Macleod Clark, 2006), and nursing (Worthington, Salamonson, Weaver & Cleary, 2013).

In recent years, engineering education has studied an "engineering identity" (Capobianco, French, & Diefes-Dux, 2012; Eliot, Turns, Xu, 2008; Mann, Howard, Nouwens, & Martin, 2009). Mann et al. (2009) argue that studying engineering identity development will:

1. Better prepare our students for practice;
2. Improve teaching and learning through curriculum renewal around developing an identity;
3. Promote and enhance student learning;
4. Communicate high expectations to students;
5. Respect and respond to the diversity of the student body;
6. Respect diverse talents and ways of learning;

7. Improve student retention; and
8. Better engage students with their learning (p. 2)

But much of the research is based on pre-adolescent settings (Capobianco, et al, 2012), enrollment in college engineering programs (Meyers, 2009; Pierrakos, Curtis, & Anderson, 2016), enrollment in mathematics and science courses (Godwin, et al, 2013), and post-graduation surveys (Kinoshita, Young, & Knight, 2014).

One additional possible context for exploring professional identity development is through student experiential learning opportunities, specifically cooperative education. Schneider's (Reilly, 2006) model of cooperative education intentionally allows students to gain supervised, full-time, progressive work experience while completing a college degree. Unlike other educational work experiences, cooperative education experiences are related to the student's major, recorded on a student's academic record, and compensated. Students receive faculty and professional mentorship, and participate in reflective practices that integrate the work experience with the students' academic and personal learning goals. Such an experience is considered a high-impact practice by the American Association of Colleges and Universities (2008).

Student participation in cooperative work experiences and internships have been shown to enhance skill development (Bartkus, 2001), efficacy (Edwards, 2014), and enhanced employability (Aamodt & Havnes, 2008). Recent reports have indicated that students who participate in professional work experiences related to their academic major were more than likely to obtain a job immediately after graduation (Busteed & Auter, 2017). Further, students experienced "higher job satisfaction in the early phases of one's career" and "enjoyed roughly 9% higher earnings than their counterparts who reported they were not working in a related field" (Wolniak & Engberg, 2019, p. 845).

Statement of the Problem

While researchers argue the need to explore professional identity development within a specific discipline like engineering, the research literature does not empirically identify professional work experiences as a variable moderating student identity development. Little is known about how professional engineering work influences student development while students are studying their intended discipline. On the other hand, experiential learning opportunities like cooperative education offer a best practice for students to gain professional development experience, in the form of full-time work experience, while they are still in school. Within the study of cooperative education literature, there is a need to better understand student experiences beyond students' levels of efficacy and confidence, and best practices, and to advance the research on how it impacts student development.

Additionally, the engineering education literature focused on identity development presents mixed empirical support for the relationship between cooperative education and engineering identity development. As stated previously, much of the presented literature on engineering identity development discusses completion of coursework, matriculation in an academic program, or post-graduation surveys. More research is needed to build the argument that cooperative education work experiences embedded into the student collegiate experience are needed to further student professional identity development.

Purpose of the Study

The purpose of this study is to explore the degree to which professional development experiences through cooperative education may influence engineering students' sense of professional identity as engineers. In the context of related literature, this study could provide another perspective on understanding how college students' identity development may be enhanced through out-of-classroom experiences. A secondary purpose is to explore the factor structure of the modified Arnett (1994) instrument developed by Meyers (2009) to assess engineering identity.

Theoretical Framework

This study will employ Arnett's (1994) theory of emerging adulthood. Arnett suggests, "that identity exploration is the primary factor that defines emerging adulthood" (Meyers, Ohland, Pawley, Silliman, & Smith, 2012a, p. 121). Building on the work of Erikson (1950, 1968), Levinson (1978), and Keniston (1971), Arnett identifies the following factors as necessary to becoming an adult: (a) accepting responsibility for actions; (b) making independent decisions; and (c) establishing a relationship with parents as equals. In his later work, Arnett (2000) states, "a key feature of emerging adulthood is that it is the period of life that offers the most opportunity for identity explorations in the areas of love, work, and worldviews" (p. 473). Specifically, college students are considering work experiences and educational paths, which become the foundation as they enter adulthood.

Another theoretical lens applicable to this research is cooperative education, which is a form of learning that aims to tie theory to practice through coordinated experiences as college students progress through an academic curriculum. Through paid or unpaid experiences, out-of-classroom learning is coordinated between an educational institution and a work environment. According to Howard (2012),

> [Cooperative education] prepares students to make a smooth and intentional transition from college to the workplace…. Students are placed in real-world contexts and required to make decisions, negotiate their different roles as students and workers, develop relationships with co-workers and supervisors, take on responsibilities, and work as members of teams. (p. 4)

Similar to emerging adulthood, students are placed in realistic situations where they are using the concepts obtained through their academic programs to learn the implications of their decisions and actions, and developing professional workplace competency to develop relationships with supervisors and practitioners (i.e., older adults) in the workplace.

Coupling these two theoretical concepts, cooperative education and emerging adulthood are well aligned. This research study applies the framework of emerging adulthood theory in the context of cooperative education. According to Schwartz, Côté, and Arnett (2005), if emerging adults are to make enduring life commitments (e.g., romantic commitments, career choices) by the end of their 20's, they must first undertake the psychological task of individually forming a stable and viable identity that can guide and sustain these commitments" (p. 202). The theory of emerging adulthood presents a viable theoretical framework for understanding how students develop a professional engineering identity.

Within the context of Arnett's (1994) theory of emerging adulthood, this study extracted the dimensions of emerging professional engineering identity underlying

Meyer's (2009) modified version of Arnett's assessment instrument. Subsequently, the relationship between the emergent factor structure and two components of engineering education was assessed among a sample of current engineering students enrolled in their first, third and fifth years of degree completion. The two components of engineering education assessed as predictors of emerging professional engineering identity were: academic curriculum and cooperative education experiences (see Figure 1).

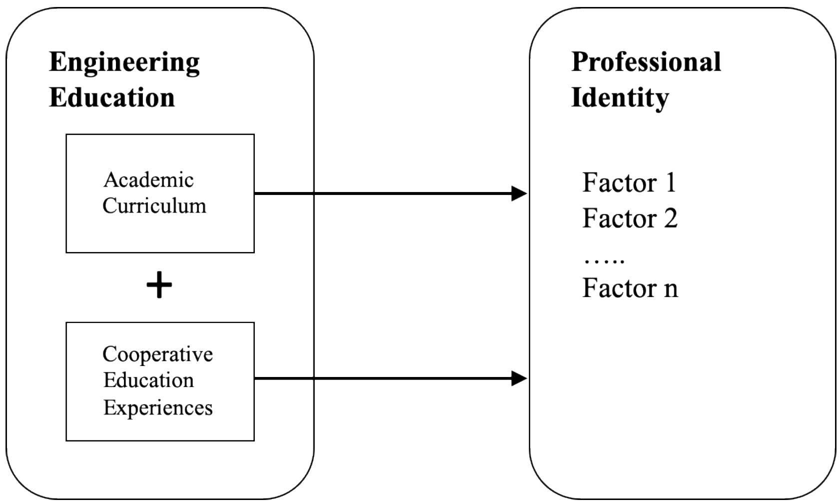

Figure 1. Theoretical Framework

Research Questions

The following research questions guided the research study:

1. What is the factor structure of emerging professional engineering identity reflected in the modified Arnett (1994) assessment instrument (Meyers, 2009)?
2. Do the identified factors related to engineering identity differ between engineering students in their first year of study compared to students in either their third or fifth year, or between students in their third and fifth years of study? (See Figure 2).

3. Among students earning engineering degrees, is the number of academic semesters completed correlated with one or more factors on Meyers' (2009) emerging professional engineering identity assessment instrument?
4. Among students earning engineering degrees, is the number of cooperative education experiences completed correlated with one or more factors on the Meyers' (2009) emerging professional engineering identity assessment instrument?
5. Among students earning engineering degrees, does subjective sense of engineering identity correlate with one or more factors on the Meyers' (2009) emerging professional engineering identity assessment instrument?

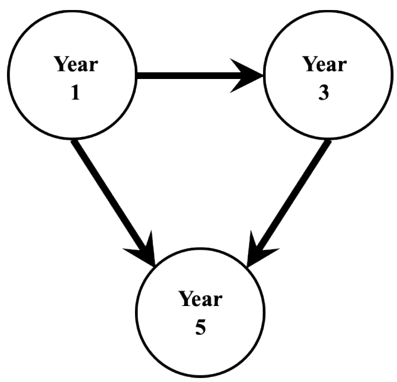

Figure 2. Comparison of Years in Curriculum

Methodology

This study employed survey methodology. Data were collected in an accredited college of engineering at a research-intensive university located in the Midwestern region of the United States. The target population included undergraduate students in aerospace engineering, architectural engineering, biomedical engineering, chemical engineering, civil engineering, computer engineering, computer science, construction management, electrical engineering, electrical engineering technology, environmental engineering, mechanical engineering and mechanical engineering technology. To qualify for participation, students in the targeted programs matriculated into one of the aforementioned academic programs.

During the spring 2020 academic semester, students were recruited to complete a self-report assessment instrument developed by Meyers (2009), which is based on Arnett's Theory of Emerging Adulthood (1994, 1997, 2000, 2003, 2016). Students were first asked whether they consider themselves to be an engineer. Then students rated their level of agreement with a series of statements developed from an instrument by Meyers (2009). Statistical analysis extracted a factor structure of the instrument and assessed differences between participant groups based on the number of co-op semesters completed and number of academic years completed.

Definition of Terms

*Experiential Learning***.** Experiential learning is a learning process grounded in the student's experience, "whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping experience and transforming it" (Kolb, 1984, p. 41).

Cooperative Education. As a form of experiential learning, cooperative education is "the formal integration of classroom theory (academic education) with work experience (practical education) designed to expand, enhance, and enrich the student's academic training (University of Cincinnati, 2014, p. 3). Cooperative education work experiences are qualified to be career-oriented, formally recorded on a student's academic record, and offer a salary commensurate to a full-time employee. Also known as work-integrated learning, these work experiences are intentionally integrated in students’ curricula in an alternating sequence between work and classes.

Professional Identity. Trede, Macklin and Bridges (2012) state that professional identity is “a way of being and a lens to evaluate, learn, and make sense of practice” (p. 374). Trede et al. point out that professional identity includes employing technical skill, interpersonal skills, professional judgement and reasoning, critical self-evaluation, and self-directed learning when performing an expected role. The outcome is a personal sense of how one develops the expected values and behavior inherent as a member of a specific profession.

Engineering Identity. Engineering identity is a form of professional identity specific to the engineering profession. Morelock’s (2017) systemic literature review of existing engineering identity development literature points to Tonso’s (2014) professional identity perspective, “defined as involving negotiations between a professional role and the desires, needs, and strengths of the person preparing for that role” (Morelock, 2017, p. 1253). For the purposes of this study, engineering identity is defined by two themes Morelock outlined. Firstly, engineering identity is “the combination of other aspects of identity” (Morelock, 2017, p. 1247). Such aspects include students’ affiliations to school and academic program, and aspirations. Secondly, the combination of students’ identities results in a “perception of self or the profession” (Morelock, 2017, 1247). Dehing, Jochems, and Baartman (2013b) points out that engineering identity is defined by how one acts like an engineer, is recognized as an engineer, and how one believes oneself to be an engineer.

Assumptions

The research questions in this study were based on two operational assumptions.

First, sample participants completed the same amount and type of coursework during the first four semesters of their respective academic programs, including the requisite calculus, physics, chemistry, and composition courses. This also considered the possibility students entered the university with college credit afforded to them prior to entering the institution. In the end, students were on track with their respective academic curricula. Secondly, students participating in the cooperative education work experience are gaining exposure to a professional engineering environment that is connected to the student's engineering discipline.

Limitations

The research study had a number of limitations. Firstly, the study was focused on a college of engineering in a public urban research-intensive institution in the Midwest area of the United States. While there was possibility to expand the scope of the research study to multiple institutions and areas, it was not within the timeframe of doctoral research. Secondly, the study employed self-reported data from student opinions. Thirdly, the validity of the modified engineering identity instrument used in this study was not previously established. Finally, the researcher does not have control over students' cooperative education work experiences. Considering the various academic majors, students' work in professional roles and capacities are based on the employer's work needs and students' experiences are not comparable from one semester to the next.

Delimitations

For the purpose and scope of this study, there were two delimiters. First, research participants were limited to undergraduate college students studying engineering. Second, research participants resided and originated from industrialized Western societies.

Significance of the Study

Conclusions drawn from this research study will contribute to the growing scholarship of cooperative education, which calls for a need to present research beyond best practices and self-efficacy. Secondly, the theoretical framework contextualizes engineering identity development in a place in which traditional-aged college engineering students are developing. Finally, the study's model of identity development considers antecedents and characteristics of identity beyond aptitude and cognitive ability.

Organization of the Study

This research study is presented in five chapters. Chapter one provided background information that built the arguments for the purpose of the study. The chapter provided an overview of the theoretical framework, methodology, terminology, assumptions, limitations and delimitations. Chapter two presents a review of the literature covering research on cooperative education, professional identity development, and emerging adulthood. Chapter three describes the methodology used for this study, including instrumentation, participant recruitment and selection and protections, data collection, and data analysis procedures. Chapter four describes the results from the data analysis. Finally, chapter five will outline an interpretation of the data and outline implications for practice and future research.

CHAPTER 2. Literature Review

The purpose of this study was to determine how professional development experiences through cooperative education influence college student engineering identity. In order to properly address the associated research questions to this study, a literature review must thoroughly compare and contrast the recent research on engineering identity development, cooperative education, and emerging adulthood. Part one will define professional identity and how engineering education has investigated this identity within the context of a specific professional discipline. Part two will define cooperative education as a specific field of experiential learning and discuss the need for further research beyond student characteristics and best practices. Finally, the literature review will further define emerging adulthood and the associated literature to engineering education. Outlining the research in this manner will offer a perspective of understanding of how college student professional identity development should contextualize learning beyond traditional coursework.

Professional and Engineering Identity Development

Professional Identity

Drawn from the disciplines of developmental psychology, sociology, social psychology, and human ecology, identity is a concept that describes, "how individuals organize their experiences within the context of the environments in which they are situated" (Torres, 2011, p. 187). Connecting it to the learning process, students' identities may be socially created as they engage in learning environments (Torres, Jones, & Renn, 2009) such as a classroom. Student identities are also organized and shaped as they develop relationships with peers, faculty, and administrators. It becomes a process of "what we make of ourselves…a bridge between who we feel ourselves to be internally and who we are recognized as being by our social world" (Josselson, 1996, p. 27).

When one extends that definition of identity to include a sense of professionalism, there is no agreement on common definitions. The term "professional identity" spans a wide range of fields, including teaching (Sutherland, Howard, & Markauskaite, 2006), higher education (Barbarà-i-Molinero, Cascón-Pereira & Hernández-Lara, 2017), health and social care (Adams, Hean, Sturgis, & Macleod Clark, 2006), and nursing (Worthington, Salamonson, Weaver & Cleary, 2013). Trede, Macklin and Bridges (2012) conducted a literature search reviewing 20 higher education research articles that discussed professional identity development. When explicitly defining and describing professional identity, Trede et al. (2012) single out Paterson, Higgs, Wilcox, and Villenuve (2002) as the only article prescribing an actual definition. In reference to Paterson et al. (2002), Trede et al. point out that professional identity includes employing technical skill, interpersonal skills, professional judgement and reasoning, critical self-evaluation, and self-directed learning when performing an expected role. The outcome is a sense of personal adequacy and satisfaction and the individual "develops the values and behavior patterns consistent with society's expectations of members of the profession" (Trede et al., 2012, p. 374). Overall, professional identity is "a way of being and a lens to evaluate, learn, and make sense of practice" (p. 374). With that said, the definition implies that the individual must constantly renegotiate that sense of identity based on context and role.

One commonly cited framework (Capobianco, French, & Diefes-Dux, 2012; Eliot, Turns, Xu, 2008; Mann, Howard, Nouwens, & Martin, 2008) to explain this renegotiation is presented by James Gee (2001), whereby an individual assumes an "identity" when s/he is recognized in a particular way in a given context. So, for example, an individual is considered an engineer because "how the individual identifies herself as well as how others actively identify her in the social fields she is active" (Mann et al., 2008, p. 3). According to Gee (2001), one's identity is built "around four perspectives on what it means to be recognized as a 'certain kind of person'" (p. 100). The first perspective is nature-identity, which examines identity based on a state developed from forces in nature. Secondly, institutional-identity views an individual's position authorized by authorities within institutions. Third, discourse-identity examines an individual trait recognized in the discourse/dialogue of/with "rational" individuals. Finally, affinity-identity views experiences shared in the practice of affinity groups. As it relates to the research, Gee's identity perspectives offer a multiplicity of states for an individual to negotiate, explain, and draw meaning in order to communicate an identity.

Mann et al. (2008) also defined identity as a developmental process "by a given individual together with the others with whom she comes into contact" (p. 3). With that said, the authors imply that identity is developed within a social group. Pierrakos, Beam, Canstantz, Johri and Anderson (2009) stated that "group membership creates in-group self-categorization and enhancement in ways that favor the in-group at the expense of the out-group" (p. 3). Much of the research reviewed identifies the students' affiliation and enrollment in an engineering academic program as one such group membership. Higher education institutions have a responsibility in fostering such professional identity because of the implied pedagogy of reflection and learning. Trede et al. (2012) state that "professional identity development requires students' active engagement and agency in conjunction with appropriate support and mentorship from academics" (p. 378). They later state that institutions must lay claim to their role in the development process. Doing so would allow institutions the opportunity to further conceptualize and define the term identity within the specific contexts and facilitate space to learn about professional boundaries. In a separate article, Trede (2012) states, "there is a danger in not appraising workplace experiences…. A further downside of not critically reflecting on practice experiences is that students may learn undesirable habits without realizing this" (p. 160).

Engineering Identity Development

Engineering identity development emerged as an area of professional identity development research focused on understanding students' motivation to study engineering, which would later contribute to improving student recruitment and retention of engineering students. The research spans pre-adolescent learners (Capobianco, Diefes-Dux, Mena, & Weller, 2011; Capobianco et al., 2012) to students enrolled in engineering programs and alumni. Two studies led by Brenda Capobianco studied groups of elementary school children, grades one through five, in a metropolitan Midwest school. In the first study (Capobiano et al., 2011), researchers learned through the Draw-an-Engineer Test and interviews that children's conceptualizations of an engineer are "contextually framed and socially influenced" (p. 319). Their drawings portray an engineer as being a mechanic, laborer, and technician whose responsibilities included fixing, building, making, or working on vehicles, engines, and buildings. Interestingly, both males and females assigned gender labels to their respective drawings. Such labeling could explain how women view themselves as engineers, which is another strand of research in engineering identity development. Capobianco et al. (2012) later administered the Engineering Identity Development Scale on two samples of children grades one through five and concluded that the complexity and multidimensionality of engineering identity development will become more likely at different levels. Through factor analysis, Capobianco et al. (2012) concluded that

> Students can recognize and respond to items assessing their development of a more informed understanding of what engineers do (i.e., design, work in teams, use science and math, are creative) and who they want to become relative to engineering (i.e., solve problems that help people, design different things, and work on a team with engineers) as indicated by the engineering career factor (p. 709).

In essence, engineering identity formation occurs early in an individual's development as early as primary school levels. Research during the later stages of individual identity development delves into more nuanced contexts.

Pierrakos et al's (2009) study of eight first-year engineering students and their sense of an engineering identity led them to conclude that students who persisted in an engineering program had some knowledge of and interest in engineering through first-hand experience during high school. Students who also persisted engaged in engineering-related activities and formed social and professional networks while enrolled in an engineering program during college. Those students who ended up switching had limited knowledge of and exposure to engineering before and during college. Those who switched ended up realizing there did not have a sense of "fit" with the academic program due to the overwhelming pressures to adjust.

McGrath et al. (2013) examined interviews of an overlapping sample of 11 entering first-year students from through the same study Pierrakos et al. (2009) drew from to determine how those students perceived engineering. McGrath et al. (2013) utilized expectancy-value theory by focusing “on how costs influence other value dimensions specifically as it applies to persisters and switchers in order to understand how different students can view the same event from different value frames” (p. 3). In the end, students who persist in an engineering program tend to enjoy what they are doing and view tasks as part of a process to better themselves instead of a cost. Students’ pre-existing beliefs of engineering does influence predictions of success in a program.

McCartney and Sanders (2015) extended Pierrakos et al’s (2009) findings through their case study based on interviews with 12 computing students throughout the completion of their degree program. McCartney and Sanders (2015) sought out to understand how school- and job-related events (through internships or co-ops) affected students’ professional identity development. While courses affect students’ appreciation and interests differently, “expectations and attitudes toward career are a part of each student’s professional identity” (McCartney & Sanders, 2015, p. 155). While this study offers testimony why students persist and succeed in engineering, investigation is needed to understand how school- and job-related activities helps students define their identity and what specifically impacts their definition of a professional.

Watson, Pierrakos, and Newbold (2010) furthered Pierrakos et al.’s (2009) study with the intent to discover “the contributors to initial development of an engineering identity in students” (p. 1). Interviews, surveys, and focus groups with students delved into understanding students’ knowledge and perceptions about engineering and what influences them towards an engineering discipline. The researchers' qualitative methods concluded that students have a limited knowledge of the engineering profession but their interest in the profession stems from their interest in math and science, prior exposure to engineering (through an activity or by someone in the profession), and the way engineers think (Watson et al., 2010). A majority of the males from the online survey were attracted to the hands-on and building aspects of engineering while the females were attracted to the math and science, life-long learning, and creative aspects of the profession. Overall, students expressed a desire to know more about the profession, which then informed how the researchers implemented the engineering curriculum during the students' first-year experience.

The work of Pierrakos and associates has evolved into the development of the Engineering Student Identity Survey (E-SIS, Curtis, Anderson, & Pierrakos, 2017; Curtis, Pierrakos, & Anderson, 2017; Pierrakos, Curtis, & Anderson, 2016). The instrument was developed based on samples of engineering students over a seven-year period, resulting in a final sample of 668 students. The instrument developed features the following 11 subscales: Unified self-concept, distinctiveness, participation, self-enhancement, social support, in-group cooperation, visibility of affiliation, sense of belonging, citizenship behaviors, interest, and attitudes toward becoming an engineer. Current reports do not offer a statistically supported model of development based on the subscales presented. Pierrakos et al., (2016) stated "all subscales were not able to significantly differentiate between cohorts in the same way… this observation may indicate that students come in with and maintain certain strong aspects of Engineering Identity and develop others as they progress through the program" (p. 4). With that said, this author questions what are the “other” parts of identity development that could be included in development of the E-SIS. Given the research presented, the E-SIS was developed in the context of students’ participation in engineering courses. Unless otherwise noted, one must assume that any identity development instrument is based on students’ participation in coursework and work experience is not considered.

While Pierrakos and associates have attempted to develop a quantified measure of identity development, Morelock (2017) suggests electronic portfolio (eportfolio) construction as a one means to identify tangible markers of qualitative development. An eportfolio is a “digitized collection of artifacts, including demonstrations, resources, and accomplishments that represent an individual, group community, organization, or institution” (Lorenzo & Ittelson, 2005, p. 2). For college students, the eportfolio represents a container of selected work to showcase their skills and a reflection of what they learned.

One notable group of studies focused on advanced engineering students completing eportfolio preparation workshops towards the conclusion of their collegiate experience (Eliot & Turns, 2011; Guan, Lappenbusch, Turns, Yellin, 2006; Guan, Turns, Yellin & Kumar, 2005; Kilgore, Sattler, & Turns, 2013; Lappenbusch & Turns, 2007; Turns & Lappenbusch, 2006; Turns, Sattler, Eliot, Kilgore & Morband, 2012). Results focused on how eportfolios facilitated student development towards effective reflection through scaffolding. In particular, Morelock (2017) mentions that portfolio construction reinforced students’ identification as engineers, as a process, and the constructed portfolios offered meaningful evidence of their development.

Eliot, Turns and Xu (2008) and Eliot and Turns (2011) mention the concept of students developing internal and external frames of reference. An external frame of reference of one's professional identity is based on workplace abilities and expectations, where one is one frames their interests and comparisons to others based on social interactions in the professional environment. Internal frames of reference delve into how one reconciles those expectations with respect to personal values, goals, and definition of self. Combined, students' frames of reference offer opportunities to understand how students make sense of their experiences and the contexts in which identity develops, and scaffolds language to trace how students negotiate their identity within a given context.

Cooperative Education

Cooperative education was first introduced at the University of Cincinnati by Herman Schneider in 1905. After failed attempts at Lehigh University, the concept was intended to link theory with practice through "the alternation of time spent in classroom instruction with time spent in work based practical experience in the students' chosen fields" (Cates & Cedercreutz, 2008, p. 21). Schneider's proposal presentation to the university was well received and caught attention from the Cincinnati Society of Mechanical Engineers and the Cincinnati Metal Trades Association. After garnering the support, Schneider presented what later became known as "The Cincinnati Plan" to the university's Board of Directors in early 1905. While the proposal was passed on an experimental basis by a five to four vote, the decision was filled with doubt as evidenced by a quote in the contract, "We hereby grant the right to Dean Schneider to try, for one year, this cooperative idea of education…[for] the failure of which, we will not assume responsibility" (Reilly, 2006, p. 16).

In September 1906, the first student cohort of Schneider's cooperative education program included 12 mechanical, 12 electrical and 3 chemical engineering first-year students. These students were divided into paired partners (one did not have an alternating partner) and assigned to work at one of 12 companies in the Cincinnati area. While one student attended class every other week his partner was working at the assigned company. Schneider supervised the students through morning conferences on the weekends, meeting with all 27 students.

During the first years of the program, Schneider adjusted the program by shortening the number of years required to graduate (six to five) by having students work and take courses over the summer, and he lengthened the work period from one to two weeks. After initial reviews and feedback, enrollment in The Cincinnati Plan dramatically grew in the numbers of students and companies participating. By 1919, the university's centennial, the cooperative education program approached 800 students enrolled and 135 participating companies.

Since its implementation in 1906, cooperative education has promoted a universal idea of integrating practical and relatable work experience with a more formal and structured educational curriculum (Gardner & Bartkus, 2014). According to Gardner and Bartkus (2014), a review of the literature identifies this practice under names like work-integrated learning, work-based learning, cooperative and work-integrated education, vocational education and training, career and technical education, work placement, project-based learning, experiential education, experiential learning, professional development, and community/civic engagement. Regardless of how researchers classify these forms of learning, "they all share a fundamental belief that integrating a practical experience (such as work) with an educational experience (such as formal coursework) creates synergies that result in meaningful benefits for students and other stakeholders" (Gardner & Bartkus, 2014, p. 37).

Among the common studies on cooperative education, there exists a significant amount of literature evaluating cooperative education within the context of curriculum and program evaluation. Noyes, Gordon, and Ludlum (2011) analyzed close to 10,000 student course grades and grade point averages and aligned the data to professional accreditation standards (i.e., the Accreditation Board for Engineering and Technology). Results showed that students who completed at least one semester of co-op had significantly higher course grades. As students completed more co-op work semesters, they outperformed those students who did not participate in a co-op experience. Blair, Millea, and Hammer (2004) achieved similar results and noted that students with co-op work experience earned higher starting salaries after graduation. Haag, Guilbeau, and Goble (2006) also used accreditation standards and aligned them to their internship program evaluation. Their study showed that employers were extremely satisfied with the internship program, student's performance, and the relationship with between the employer and higher education institution.

The findings Haag et al. (2006) reported also noted that students perceive to have a grasp of the skills and abilities required of them by the accreditation standards, but they seemed to be less skilled in planning, preparing, writing reports, and presenting material. The lack of clarity of skills realization may be a result of context and time. Kinoshita, Young, and Knight (2014) conducted a survey of 1,339 engineering alumni at 31 different institutions and asked respondents to retrospectively rate their skill level during the graduation year and three years after graduating from college. Their analysis showed that skill development from work experiences were realized three years after graduation. While there was a small number of respondents in their survey who had actually co-op work experiences, the authors speculated that institutions should “facilitate discussions that help students engaging in such experiences recognize the relevance [of the skills gained] for their learning and development” (Kinoshita et al., 2014, p. 6).

One of the more prevalent studies on the outcomes and impact of cooperative education has been focused on student self-efficacy. Most recently, Edwards (2014) conducted a qualitative study of 16 students before and after their work placement and interview responses “that by far the greatest change in students’ views following their placement was in relation to their confidence in being able to talk about their skills and strengths, and how confident they felt about making job applications and/or attending interviews” (p. 236). While the research supported previous research, this particular study suggested “there is a genuine change in how [the students] felt about themselves as a direct result of their experiences during the placement” (p. 237). Edwards’ findings seem to support Raelin et al’s (2011) study of 1,637 engineering students from four institutions, two of which required students to complete a co-op work term.

According to Coll and Kalnins (2009), “quantitative research in co-op very seldom explicitly identifies its theoretical underpinnings, but it generally seems to be based on a comparative/experimentalist approach (or quasi-experimentalist) approach with its roots in empirical positivism” (p. 1). With that in mind, the authors wanted to know the nature of interpretive or qualitative research? The two authors reviewed qualitative research articles spanning the 30 years focused on cooperative education, internships, and experiential education. From their research, the following four themes emerged:

1. Exploring co-op students'perceived personal growth;
2. Contributing to a broader set of educational and societal needs;
3. Addressing the issues in co-op practice and management; and
4. Presenting the views of the employer and other stakeholders (Coll & Kalnins, 2009).

Overall, much of the interpretive/qualitative research in cooperative education "has been mostly concerned with student perceptions of their placement experiences; their 'lived experience' which is presented in more detail than possible in qualitative work" (Coll & Kalnins, 2009, p. 9).

Zegwaard and Hoskyn (2015) and Hoskyn and Zegwaard (2016) followed up Coll and Kalnins's findings and limited their analysis based on the number of submissions to the International Journal of Work-Integrated Learning (formerly known as the Asia-Pacific Journal of Cooperative Education), which is the prominent refereed research publication for cooperative education and work-integrated learning. While the number of research articles have steadily increased from the single-digit quantities in 2011 to double-digit quantities in 2015, the number of research articles employing a qualitative methodology has also increased. Given the trends identified by Hoskyn and Zegwaard and Coll and Kalnins, there is an overall need for more empirical research overall focused on cooperative education.

Relating cooperative education and professional identity development, Dehing, Jochems, and Baartman (2013a) conducted semi-structured interviews with 14 electrical engineering, mechanical engineering and civil engineering instructors in higher education to explore how students develop a sense of professional identity as they progress through an engineering curriculum. Based on a theoretical framework that includes Sheppard, Macatangay, Colby, and Sullivan (2008) and Sullivan's (2004) mentoring model and Ibarra's (1999) concept of identity construction based on professional, or provisional, selves, Dehing et al. (2013a) concluded workplace learning in industry fosters identity development because "these situations provide authentic engineering challenges, powerful professional role models, interaction with professionals, and a forum for experimentation with the students' own professional role behavior" (p. 6). Overall, faculty observed that students' responsibilities in the workplace and how they were viewed by their supervisors influenced their sense of professional identify.

Dehing et al's (2013a) findings led to Dehing, Jochems, and Baartman's (2013b) quantitative study of 256 third-year engineering students. Using the same mentoring (Sheppard et al., 2008; Sullivan, 2004) and identity construction models (Ibarra, 1999), they sought to understand the extent engineering students developed an identity during workplace learning, the identity developmental models students experience while working, and the effects these developmental models had on student identity development. Analysis of pre- and post-experience workplace learning surveys led researchers to conclude that workplace learning "has an overall positive effect on engineering students' development of clarity" (Dehing et al., 2013b, p. 58). Students with a higher sense of clarity as an engineer either gained further identification as an engineer or reconsidered their expectations of the profession. Students with a lower sense of clarity as an engineer gained a greater appreciation of the profession as a result of the work experience or feel even less committed to the profession.

Emerging Adulthood

The concept of emerging adulthood is a period of time coined by Jeffrey Arnett (1994, 1997, 2000, 2003, 2016). According to Arnett (2000), “emerging adulthood is neither adolescence nor young adulthood but is theoretically and empirically distinct from them both” (p. 469). He goes on to state that individuals have a period of independence from expectations based on social roles and have the opportunity to explore a “variety of possible life directions in love, work, and worldviews….when little about the future has been decided for certain” (p. 469). Heavily influenced by the works of Erikson (1950, 1968), Levinson (1978), and Keniston (1971), emerging adulthood features five distinctive characteristics:

1. The age of identity explorations,
2. The age of instability,
3. The age of self-focused age,
4. The age of feeling in-between, and
5. The age of possibilities (Reifman, Arnett, & Colwell, 2007).

Additionally, the years of emerging adulthood are emphasized by change and exploration. Demographically, this period begins as early as the age of 18 years and spans up to age 25, which spans the time individuals are generally enrolled in higher education (Arnett, 2000; Reifman et al., 2007).

Given the aforementioned theorists, Arnett (1994) developed a 40-item questionnaire that was initially administered to 346 college students. During the first part of the questionnaire, students were asked, “Do you think that you have reached adulthood?” (Arnett, 1994, p. 216). Respondents indicated “yes”, “no”, or “in some respects yes, in some respects no”. Students were then asked to rate a series of qualities, behaviors, and statuses as necessary to be considered an adult. They were asked to respond either “yes” or “no”. In the initial questionnaire, the criteria for the transition to adulthood was divided in subcategories that related to role transitions, cognitive transitions, emotional transitions, behavioral transitions, biological transitions, legal and time-based transitions, and gender-specific requirements and other responsibilities. Based on the results, Arnett (1994) concluded, “adult status is conceived by them mainly in terms of independence and self-sufficiency and, during the process of emerging adulthood, they gradually pursue those ends” (p. 223).

In a subsequent study, Arnett (2001) refined the statistical analysis of the questionnaire based on 171 adolescents, 179 emerging adults, and 165 young-to-midlife adults. This time around, the statistical analysis was more nuanced and the subscales were labeled as Individualism, Family Capacities, Norm Compliance, Biological Transitions, Legal/Chronological Transitions, and Role Transitions. Through statistical analysis, internal reliabilities for the subscales ranged from 0.55 (Legal/Chronological Transitions) to 0.88 (Family Capacities). Consistent with the previous study, individualistic criteria were considered likely markers of adulthood. Specifically, all three age groups indicated that accepting responsibility for one’s actions, independently developing a set of personal values and beliefs, establishing an equal adult relationship with parents, and being financially independent from one’s parents are necessary for adulthood (Arnett, 1997).

Carman (2008) argued that Arnett's (2003) analysis and factor structure "suggests that there might be an alternative model to the seven factor conceptually-derived" (p. 9). She deployed Arnett's instrument to an American college sample of 365 students, ages 18 to 28. Using exploratory factor analysis (Floyd & Widaman, 1995; Kahn, 2006), Carman (2008) found and interpreted a five-factor structure that included the following constructs: Family Capacities, Long-term Commitments, Norm Compliance, Psychological/Chronological Transitions, and Financial Independence. Based on the alternative structure, the researcher suggests that "individuals perceive becoming an adult as a multidimensional process" (Carman, 2008, p. 86).

Arnett's theory was transformed into the a 31-item Inventory of the Dimensions of Emerging Adulthood (Reifman et al., 2007), which consisted of the following subscales: Identity Exploration, Experimentation, Negativity, Other-Focused, Self-Focused, and In-Between. In combined studies, Reifman et al. (2007) noted that factor analysis supported five of the emerging adulthood subscales but "some of the subscales did exhibit large correlations ($r > 0.7$) with each other" (p. 6). Internal consistency was reported as generally strong and reliability correlations were between 0.64 and 0.76 with the exception of the In-Between subscale. It is worth noting that the inventory is a significant change from Arnett's (1997) previous instrument. For example, the IDEA asks respondents to rate their agreement to whether a particular statement is descriptive of their life at the moment. Arnett's (1997) original instrument asks respondents to "indicate whether you think the following must be achieved before a person can be considered to be an adult" (p. 9). Since then, the instrument was modified for a Turkish population (Atak & Çok, 2008), where researchers noted three factors (Identity

Exploration, Negativity, and Self-Focused) based on 296 respondents ages 15 to 34. Another peer-reviewed study revised the IDEA to a 21-item instrument for a study of 2,397 high school students in Southern California (Lisha, Grana, Sun, Rohrbach, Spruijt-Metz, Reifman & Sussman, 2014).

As mentioned previously, emerging adults have the opportunity to explore their identity in the areas of love, work, and worldviews. According to Arnett (2000), "with regard to work, a similar contrast exists between transient and tentative explorations of adolescence and the more serious and focused explorations of emerging adulthood" (p. 473). He goes on to say that work experiences are opportunities to prepare for adult roles. While emerging adults begin to explore various jobs, they are exploring identity issues as it relates to strengths, interests, and career options. In a similar vein, emerging adults as college students are exploring their educational paths considering possibilities that would prepare them for future work.

Murphy, Blustein, Bohling, and Platt (2010) recognized the growing literature for Arnett's theory, but points out "this literature has not fully explored the role of work and career development in the transition of emerging adults" (p. 175). When one attempts to find studies employing the theory of emerging adulthood and its inventory, the theory and/or inventory was coupled with another theory and/or inventory. As is the case with Murphy et al's (2010) study, where the researchers integrated concepts like career adaptability and risk and resilience, their qualitative study of ten individual interviews illustrated that "the perception of a 'smooth transition' was not associated with current life satisfaction, as one might expect" (Murphy et al., 2010, p. 179). The amount and degree of social support an emerging adult receives while in college influences one's life satisfaction as they transition from college to career. Their findings suggest that “a balance of relational support and space to develop autonomy and competence in the adult world seems to function as an optimal context to promote growth” (p. 180). It is possible that such balance and support exists through cooperative education.

Within the context of engineering identity research, Meyers (2009), Meyers, Ohland, Pawley, and Christopherson (2010), Meyers, Ohland, Pawley, Silliman and Smith (2012b), and Meyers, Ohland, and Silliman (2012a) adopted Arnett’s instrument in their survey of undergraduate engineering students and alumni in spring 2009. In their attempt to contribute to the engineering education research literature on quantitative assessments contributing to engineering identity, the researchers attempted to address whether students consider themselves to be engineers and what factors do students believe are essential in defining an engineer. In their quantitative analysis, the authors cited “being able to make competent design decisions”, “being able to work with others by sharing ideas”, “accepting responsibility for the consequences of actions”, “speaking/communicating using accurate technical terminology”, “completing an undergraduate engineering degree”, and “making moral/ethical decisions considering all factors” (Meyers et al., 2012b, p. 125) as the most frequently cited qualities essential to be an engineer among students. On the other hand, alumni were more selective due to a greater understanding of the field (Meyers et al., 2012a). One other notable quality alumni considered essential for being an engineer was “establishing relationships with fellow engineers” (p. 110). Qualitative interviews among students offered that while student work experiences were not statistically supported as essential to whether one identifies as an engineer, work experiences such as co-ops and internships both positively and negatively influences how one identifies as an engineer. If as all else, “these experiences have been indicated in helping clarify the path for students in terms of selecting and confirming their intended field of study” (Meyers et al., 2010, p. 1556). Such a finding supports Arnett’s (2000) argument that emerging adults are exploring possibilities for future work roles and responsibilities.

Examination of Meyers’ (2009) and Meyers et al’s (2010, 2012a, 2012b) instrument raises question regarding the validation and reliability of the instrument, which is the impetus for this research. Meyers (2009) developed the criteria for her instrument on Arnett’s (1997) initial criteria for the transition to adulthood. Yet Meyers cited Reifman, Arnett and Colwell’s (2007) internal reliability results based on the Dimensions of Emerging Adulthood, which is different from Arnett’s initial criteria for the transition to adulthood. Further, Reifman et al’s (2007) results may have been confounded when the IDEA was used with additional measures. With that said, this study aimed to address this gap in the research.

Summary

This literature review provides a foundation for the study. When considering the research on professional identity development, specifically engineering identity, there exists various approaches and models to understanding identity. But the literature is not sufficiently robust enough with a validated and consistent quantifiable manner to measure identity development. Rather than measuring identity at the end of coursework, cooperative education offers a unique contextual lens for engineering identity development. But the research literature lacks a sufficient lens to view identity and quantify development. Finally, emerging adulthood theory offers a possible theoretical lens to quantify markers on how students explore their identities as engineers. The next chapter offers details of the study based on the rationale presented through the literature review.

CHAPTER 3. Methodology

Introduction

The purpose of this study is to determine the extent to which professional development experiences through cooperative education (co-op) may influence engineering students' sense of professional identity as engineers. Using a theoretical framework that links Arnett's (1994) theory of emerging adulthood with perspectives on the benefits of cooperative education, this research study was designed to explore whether co-op work experiences influence professional engineering identity development and whether co-op work experiences coupled with student coursework have a greater influence on identity development than student coursework. The methodology employed to test these research questions is described in this chapter, organized in the following sections: (a) theoretical framework; (b) research questions; (c) description of the population; (d) selection of participants; (e) participant recruitment; (f) instrumentation; (g) data collection; (h) data analysis; and (i) protecting participant rights.

Theoretical Framework

This study employed Arnett's (1994) theory of emerging adulthood. Arnett suggests, "that identity exploration is the primary factor that defines emerging adulthood" (Meyers, Ohland, Pawley, Silliman, & Smith, 2012a, p. 121). Building on the work of Erikson (1950, 1968), Levinson (1978), and Keniston (1971), Arnett identifies the following factors as necessary to becoming an adult: (a) accepting responsibility for actions; (b) making independent decisions; and (c) establishing a relationship with parents as equals. In his later work, Arnett (2000) states, "a key feature of emerging adulthood is that it is the period of life that offers the most opportunity for identity explorations in the areas of love, work, and worldviews” (p. 473). Specifically, college students are considering work experiences and educational paths, which become the foundation as they enter adulthood.

Another theoretical lens applicable to this research is cooperative education, which is a form of learning that aims to tie theory to practice through coordinated experiences as college students progress through an academic curriculum. Through paid or unpaid experiences, out-of-classroom learning is coordinated between an educational institution and a work environment. According to Howard (2012),

> [Cooperative education] prepares students to make a smooth and intentional transition from college to the workplace…. Students are placed in real-world contexts and required to make decisions, negotiate their different roles as students and workers, develop relationships with co-workers and supervisors, take on responsibilities, and work as members of teams. (p. 4)

Similar to emerging adulthood, students are placed in realistic situations where they are using the concepts obtained through their academic programs to learn the implications of their decisions and actions, and developing professional workplace competency to develop relationships with supervisors and practitioners (i.e., older adults) in the workplace.

Coupling these two theoretical concepts, cooperative education and emerging adulthood are well aligned. This research study applied the framework of emerging adulthood theory in the context of cooperative education. According to Schwartz, Côté, and Arnett (2005), if emerging adults are to make enduring life commitments (e.g., romantic commitments, career choices) by the end of their 20's, they must first undertake the psychological task of individually forming a stable and viable identity that can guide and sustain these commitments" (p. 202). The theory of emerging adulthood presented a viable theoretical framework for understanding how students develop a professional engineering identity.

Within the context of Arnett's (1994) theory of emerging adulthood, this study extracted the dimensions of emerging professional engineering identity underlying Meyer's (2009) modified version of Arnett's assessment instrument. Subsequently, the relationship between the emergent factor structure and two components of engineering education was assessed among a sample of current engineering students enrolled in their first, third, and fifth years of degree completion. The two components of engineering education to be assessed as predictors of emerging professional engineering identity are: academic curriculum and cooperative education experiences (see Figure 3).

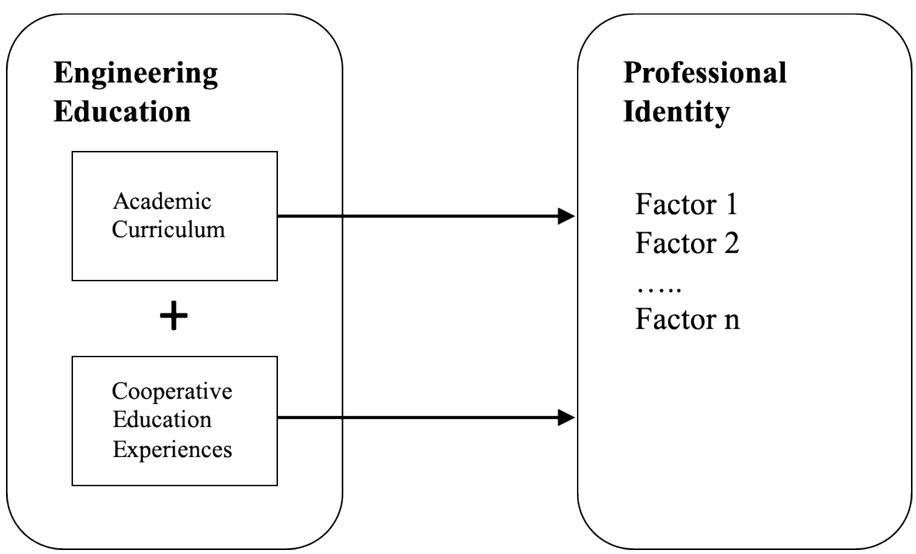

Figure 3. Theoretical Framework

Research Questions

The following research questions guided the research study:

1. What is the factor structure of emerging professional engineering identity reflected in the modified Arnett (1994) assessment instrument (Meyers, 2009)?

2. Do the identified factors related to engineering identity differ between engineering students in their first year of study compared to students in either their third or fifth year, or between students in their third and fifth years of study? (See Figure 4).

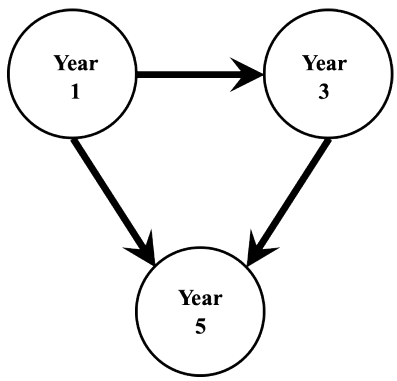

Figure 4. Comparison of Years in Curriculum

3. Among students earning engineering degrees, is the number of academic semesters completed correlated with one or more factors on Meyers' (2009) emerging professional engineering identity assessment instrument?

4. Among students earning engineering degrees, is the number of cooperative education experiences completed correlated with one or more factors on the Meyers' (2009) emerging professional engineering identity assessment instrument?

5. Among students earning engineering degrees, does subjective sense of engineering identity correlate with one or more factors on the Meyers' (2009) emerging professional engineering identity assessment instrument?

Description of Population

The target population included undergraduate college students participating in baccalaureate engineering programs with a required cooperative education component in the curricula. The selected setting was a Midwestern urban research-intensive institution that offered 13 undergraduate engineering programs. These undergraduate programs are accredited by the Accreditation Board for Engineering and Technology and the Higher Learning Commission. In any given academic year, the total student population for this particular college of engineering is roughly 4,500 undergraduate students.

Embedded in the academic majors is the cooperative education program, which is administered through an office of experiential learning and career development. Students participate in the cooperative education program starting with a first-year experience seminar. During the course, students become familiar with key learning components of the cooperative education program, understand the job search process and associated policies, and develop strategies and behaviors that will position them for successful employment in an engineering job related to their major. Specifically, students learn how to develop a co-op-specific resume, understand and practice the components and strategies for interviewing, understand the professional behaviors expected of them in the workplace, and identify possible career pathways associated with their academic program. While obtaining a co-op job is not a requisite to pass the course, the intended outcome is that students will apply what they learned in the class to successfully obtain a co-op job before their second year.

Students complete their first co-op work experience in the second year of study, either in the fall or spring academic semester. During that semester, students are expected to work 40 hours per week for the full academic semester. Once the work semester is completed, students return to coursework and continue the next sequence of courses prescribed by the academic program. Alternating between work and academic semesters continues until the summer before the graduation year. At the end of the student's collegiate career, they will have completed five co-op work semesters, amounting to at least 20 months of full-time work experience. As a result, a student will complete their baccalaureate degree within five years.

The programmatic cooperative education model at this institution consisted of a multilateral relationship between the university, the student, and the co-op employer. Within this model, the university individual (the faculty co-op advisor) connects students to co-op job opportunities, ensures that students participate in work activities that are appropriate to the student's academic program, and monitors and assesses the student's learning while on the job. Secondly, the employer's role in the triad relationship is to design and offer work assignments that meets the employer's business needs and a student's academic program. They are also responsible for providing professional supervision, mentorship, and support while the student is employed. Finally, the student's role is to be fully participatory in the program, engaging in conversations with the university and employer with the intent to have meaningful work opportunities for professional growth and development.

Ideally, learning occurs when the student talks with her/his supervisor or mentor while on the job and through reflective debrief meetings with the faculty member when the student returns to coursework. Reflective meetings with the faculty member are conducted within the framework of Kolb's (1984) Experiential Learning Model. Briefly, the two-dimensional model presents a learning process grounded in the student's experience, "whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping experience and transforming it" (Kolb, 1984, p. 41). The first dimension dialectically portrays the grasping of experience, viewing the Concrete Experience to the Abstract Experience; and the second dimension dialectically portrays transforming the experience from Reflective Observation to Active Experimentation. The result is a four-stage iterative model, whereby an individual's immediate concrete experience forms the basis for reflective observation. These reflections are examined to form abstract concepts that are later experimented to then create new experiences.

Selection of Participants

This study employed a purposeful convenience sample of all students enrolled in an engineering baccalaureate program. The sample was purposeful in so much that the recruited students came from a college of engineering. The sample was convenient because students self-selected to participate in the study. There were 4,553 potential study participants. Table 1 lists the majors and the potential number of study participants.

Recruitment

A cooperative education program office staff member obtained a list of potential study participants from the institution's student information system based on the students

Table 1. *List of Potential Study Participants*

Major	Number of Students
Aerospace Engineering	337
Architectural Engineering	187
Biomedical Engineering	341
Chemical Engineering	609
Civil Engineering	370
Computer Engineering	357
Computer Science	431
Construction Management	236
Electrical Engineering	401
Electrical Engineering Technology	99
Environmental Engineering	147
Mechanical Engineering	722
Mechanical Engineering Technology	316
Total	4553

enrolled in the college of engineering. All students enrolled in their first, third, and fifth year of study during the Spring 2020 semester were eligible to participate in this study. A solicitation email was sent to all eligible participants by a co-op program administrator (not a co-investigator) who was not connected to the students in the targeted majors (See Appendix A). The invitation to participate in the study was during the first half of the spring 2020 semester. The email message briefly described the study and provided an anonymous link to the Qualtrics survey. When students accessed the survey, they were instructed to read the IRB-approved informed consent form (Appendix B). Those who consented and confirmed they were at least 18 years of age advanced to the survey instrument (Appendix C). Those who did not consent or who were not at least 18 years of age were thanked for their participation. An affirmative consent was when the student clicked agreement to the terms of the informed consent (i.e., clicking “I agree”) and confirmed they were at least 18 years of age.

At no time did the co-investigators have access to the list of eligible study participants nor their email addresses. The list was kept by the co-op program administrator in a password-protected spreadsheet stored on a portable USB flash drive. The co-op program administrator who volunteered to send the recruitment email kept the USB flash drive locked in a desk drawer. Prior to data analysis, the list of participants and their email addresses were destroyed.

Instrumentation

The study adopted the self-reported instrument developed by Meyers (2009), Meyers, Ohland, Pauley, and Christopherson (2010), Meyers, Ohland, and Silliman (2012a) and Meyers, Ohland, Pawley, Silliman, and Smith (2012b), which was adapted from Arnett (1994, 1007, 2001). The Arnett instrument posed the question, “Are college students adults?” Meyers (2009) in her doctoral dissertation, surveyed a cross section of engineering students over the course of one semester. Meyers et al. (2012a) also administered the instrument to a cross-section of engineering students and alumni within the last ten years of receiving their baccalaureate degree. In the instrument Meyers and associates administered, the first question respondents answered was, “Do you consider yourself to be an engineer?" Respondents would answer "Yes", "In Some Respects Yes and Some Respects No", or "No". Respondents were then directed to a list of 29 statements and were asked to rate their agreement to whether they felt each statement was necessary to be considered an engineer. Respondents responded "Yes" or "No" to each statement. In Meyers's (2009) initial study, the researcher appended 11 statements related to the engineering accreditation criteria for student performance to the list of statements respondents rated as factors that are necessary to be considered an engineer. She also asked respondents to rank the accreditation criteria statements from most important to least important. Finally, the researcher asked respondents demographic information (i.e., year in school, age, gender, living situation, work experience, research experience, student organization involvement and engineering discipline; Meyers, 2009). Meyers (2009) asserted construct validity through multiple reviews and revisions by experts, including Arnett in the early stages of instrument development. Unfortunately, Meyers (2009) did not formally establish instrument validity and reliability because modifications to the existing instrument was considered situation specific. Because measures were considered to minimize misinterpretation of the instrument, Meyers cited Reifman et al's (2007) internal reliability of the dimensions of emerging adulthood, ranging from 0.70 to 0.85 and a test-retest reliability ranging from 0.37 to 0.76.

For the purposes of this study, the survey was administered through Qualtrics (Appendix C). Similar to Meyers' (2009) and Meyers et al's (2012a, 2012b) instrument, participants initially answered the question, "Do you consider yourself to be an engineer?" responding either,"Yes", "In Some Ways Yes and Some Ways No", or "No". They then rated their level agreement to the list of 29 statements as necessary to be considered an engineer. They rated their agreement as “Strongly Disagree”, “Somewhat Disagree”, “Somewhat Agree”, or “Strongly Agree”. The list of statements did not include the 11 accreditation-related statements Meyers (2009) included in her instrument. The Likert anchors of “Strongly Disagree” to “Strongly Agree” were the same anchors Reifman et al. (2007) used for the Inventory of the Dimensions of Emerging Adulthood. Having students rate the list of 29 statements using these Likert anchors enhanced variability. An example of such engineering statements included, “obtaining a full-time employment” is necessary to be considered an engineer (Meyers et al., 2012, p. 106). After responding to the Likert-scale items on the Meyers instrument, participants responded to three additional multiple choice questions related to program completion (number of co-op semesters completed) and prior exposure to the engineering profession. These questions permitted co-investigators to screen respondents for confounding variables such as having an immediate family member who is an engineer, or prior work experience in the field.

Data Collection

Data collection was set to the highest levels of anonymity through Qualtrics; thus, no Internet protocol addresses or other traceable identifiers or geolocations were not collected. The survey instrument and responses were housed in a password-protected Qualtrics account accessible by only the co-investigators. The extracted data was housed in a password protected, cloud-based account (i.e., Dropbox) accessed with an additional password, accessible only by the co-investigators.

Only complete participant responses were included in the data analysis. The data collection period occurred between ninth and eleventh weeks of the spring 2020 academic semester. A recruitment email (Appendix A) and reminder email message (Appendix D) was sent to students by the volunteer co-op program administrator (not a co-investigator). Students who did not complete the survey within the allotted time period were excluded from the study.

Data Analysis

To address the first research question, Likert-scale responses to the 29 statements rating the degree to which each is considered necessary to being an engineer was analyzed using exploratory factor analysis (Kahn, 2006). Extracted dimensions reflecting the structure of emerging engineering identity captured by the modified Arnett (1994) instrument was identified for use in subsequent hypothesis testing in this study. Students' level of agreement to the first survey question was assigned a value of one for "no", two for "in some ways yes and some ways no", and three for "yes". Students' level of agreement to the 29 statements was assigned a value of one for "Strongly Disagree", two for "Disagree", three for "Agree", and four for "Strongly Agree". ANOVA analysis was conducted to compare differences among the various class cohorts. To address the final three research questions, rank order correlation was conducted to determine whether completed academic semesters, cooperative education work semesters completed, and participants' subjective view of identity predict any of the factors related to engineering identity identified through factor analysis.

Protecting Participant Rights

All participant responses were collected anonymously through the Qualtrics website, which was set to the highest level of anonymity. This means that no IP addresses or other Internet-based tracking information were collected. The list of participant email addresses was be maintained by a co-op staff member (not a co-investigator) and stored in a locked file separate from the data and was used solely for recruiting purposes. All communication with participants was carried out by the co-op staff member, not the co-investigators. Only the co-investigators had access to the anonymous data file created in Qualtrics, not the co-op staff member. No information that would permit participant responses to student identities was collected. Prior to data analysis, the list of eligible participants and their email addresses was destroyed by the co-op staff member, and all associated email messages sent to these prospective participants was deleted from the staff member's email inbox and archive. The collected data for this study will be retained for up to three years on a password-protected computer, at which point the data will be deleted.

Summary

This chapter restated the purpose of this research. Participants were chosen from students who participated in the first year of engineering coursework at an accredited college of engineering at a Midwestern state university. To optimize the sample drawn, a description of the sample was presented. In addition, the proposed instrument was discussed along with how the respondent data was going to be analyzed.

CHAPTER 4. Data Analysis

Introduction

The purpose of this study is to determine the extent to which professional development experiences in the form of cooperative education (co-op) may influence engineering students' sense of professional identity as engineers. Using a theoretical framework based on Arnett's (1994) theory of emerging adulthood self-report data were collected from engineering students to explore whether co-op work experiences influenced the development of their professional engineering identity and whether co-op work experiences coupled with student coursework had a greater influence on identity development than student coursework alone. This chapter presents the analysis of data collected and is organized in the following sections: sample size, descriptive statistics, data inspection, and testing the research questions.

Sample Size

Shortly after approval from the Institutional Review Board, recruitment messages were sent to 956 students in the first year of their engineering program, 935 students in the third year of their engineering program, and 795 in the fifth and final year of their engineering program. Students had a little over two weeks to visit and complete the Qualtrics survey. At the conclusion of the collection period, 99 first-year students, 48 third-year, and 50 fifth-year students responded, totaling 197 responses. Fourteen respondents who were less than 18 years of age and did not consent to participate in the study were removed from the final data set. Additionally, 86 responses were removed because the student did not fully complete the survey producing a record that had missing values. The resulting data set consisted of 97 complete responses for analysis. a 3.6%

return rate. While opinions vary for determining the appropriateness of sample sizes for factor analysis, Williams, Onsman, and Brown (2010) point out that a small sample size of at least 50 may be adequate for factor analysis.

Descriptive Statistics

Statistical analysis was conducted using IBM SPSS Statistics, Version 24. The primary variables of interest were the 29 items on the survey adopted from Meyers' (2009) instrument of engineering identity, which was based on Arnett's (1994) instrument on emerging adulthood. Responses were based on a four-point Likert scale of 1=Strongly Disagree, 2=Disagree, 3=Agree, and 4=Strongly Agree. Table 2 presents the descriptive statistics for each of these survey items, including the mean and standard deviation.

Table 2. *Descriptive Statistics*

Variable	Mean	Std. Deviation	n
1. Being able to make competent design decisions	3.62	0.488	97
2. Being able to teach engineering content to another person	3.20	0.589	97
3. Speaking / communicating using accurate technical terminology	3.37	0.601	97
4. Feeling confident in engineering work without confirmation from others that the approach is technically sound	3.05	0.782	97
5. Making moral / ethical decisions considering all factors	3.59	0.641	97

6. Accepting responsibility for the consequences of actions	3.65	0.560	97
7. Making a long-term commitment to a company	2.26	1.003	97
8. Making a long-term commitment to a career	2.69	1.084	97
9. Being able to support a family financially	2.61	0.963	97
10. Establishing relationships with other engineers	3.16	0.759	97
11. Being able to work with others by sharing ideas	3.64	0.504	97
12. Committing to engineering as a major	3.14	0.841	97
13. Committing to the completion of an engineering degree	3.18	0.829	97
14. Avoiding procrastination on work responsibilities	2.93	0.832	97
15. Doing your best work beyond the minimum requirements	3.29	0.735	97
16. Showing up for class and meetings prepared	3.32	0.730	97
17. Participating actively in meetings	3.20	0.745	97
18. Being able to lead a design team / initiative	3.22	0.780	97
19. Possessing natural engineering ability	2.67	0.863	97
20. Excelling in subjects relating to mathematics and science	3.21	0.763	97

21. Completing the first year of engineering education	3.27	0.823	97
22. Gaining practical engineering experience while still an undergraduate	3.21	0.816	97
23. Serving as a mentor to another engineering student	2.59	0.851	97
24. Obtaining full-time employment	3.11	0.865	97
25. Completing an undergraduate engineering degree	3.29	0.735	97
26. Completing a graduate engineering degree	2.36	0.970	97
27. Completing the first stage of professional licensure (FE: Fundamentals of Engineering Exam)	2.65	0.842	97
28. Completing the second stage of professional licensure (PE: Professional Engineer Exam)	2.54	0.890	97
29. Reaching the age of 22	2.36	1.165	97

Data Inspection

Prior to conducting a factor analysis, the data should be assessed for suitability and whether relationships exist within the data set. According to Howard (2016), Bartlett's Test of Sphericity and the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy are the two popular tests. Table 3 presents the results of those two tests. The KMO value of 0.83 is meritorious as the index must be greater than 0.6 for factors to be formed. Additionally, Bartlett's Test of Sphericity was significant (Chi-square = 1656.831, df = 406, p = 0.000).

Table 3. *KMO and Bartlett's Test*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.830
Bartlett's Test of Sphericity	Approx. Chi-Square	1656.831
	Df	406
	Sig.	0.000

Testing the Research Questions

Research Question 1: *What is the factor structure of emerging professional engineering identity reflected in the modified Arnett (1994) assessment instrument (Meyers, 2009)?*

To address this question, Floyd and Widaman (1995) suggest "a series of steps that includes estimating, or extracting, factors; deciding on how many factors to retain; and rotating factors to an interpretable orientation" (p. 287). Principal Components Analysis (PCA) was the selected factor analytic method for this study. A varimax orthogonal rotation was selected. In the initial analysis, no specific number of factors to retain was specified. Instead, Kaiser's criteria of a factor's eigenvalue of greater than or equal to one was the decision rule applied to identify factors. Table 4 presents the resulting analysis.

Principal Components Analysis resulted in eight factors of initial eigenvalues greater than or equal to one explaining 71.4% of the total variance in the data set. The first factor explained 34.1% of the variance. After that, there was a dramatic decrease in the amount of variance explained between the first and second factor, which explained 9.71%. Beyond the second factor, the third through fifth factors explained 5.57% to 3.55% of the variance.

Table 4. *Initial Factor Specification Based on Eigenvalues ≥ 1*

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% Var	Cum %	Total	% Var	Cum%	Total	% Var	Cum %
1	9.88	34.1	34.1	9.88	34.1	34.1	3.54	12.21	12.21
2	2.81	9.71	43.8	2.82	9.71	43.8	3.54	12.20	24.4
3	1.616	5.57	49.4	1.616	5.57	49.4	3.27	11.26	35.7
4	1.551	5.35	54.7	1.551	5.35	54.7	2.89	9.97	45.6
5	1.388	4.79	59.5	1.388	4.79	59.5	2.15	7.41	53.0
6	1.280	4.41	63.9	1.280	4.41	63.9	1.905	6.57	59.6
7	1.131	3.90	67.8	1.131	3.90	67.8	1.813	6.25	65.9
8	1.030	3.55	71.4	1.030	3.55	71.3	1.594	5.50	71.4

Inspection of the Scree plot (Figure 5) suggests two factors should be retained. The scree plot is a plot of the factors (x-axis) versus the observed eigenvalues (y-axis). When examining the scree plot, the test "involves looking for the last substantial drop in eigenvalues" (Kahn, 2006, p. 691). In this case, there is a substantial drop between factors one and two, and two and three. The line begins to flatten out into a straight line beginning with the third factor.

To confirm this result, a parallel analysis was performed. According to Kahn

(2006), “A parallel analysis generates eigenvalues from a random set of data based on the same number of variables and the same number of cases” (p. 692). A table through SPSS generated eigenvalues at the 95th percentile based on the variables used in the factor analysis. The first two randomly generated eigenvalues (2.37 and 2.11) were less than the observed root values (9.88 and 2.82). Further examination of the generated and observed eigenvalues showed that the randomly generated eigenvalues were greater than the observed roots after the second factor. In factor analysis, “factors are retained when the actual eigenvalues surpass random ordered eigenvalues” (Williams, Onsman & Brown, 2010,p. 8). As a result, parallel analysis confirmed that two factors should be retained.

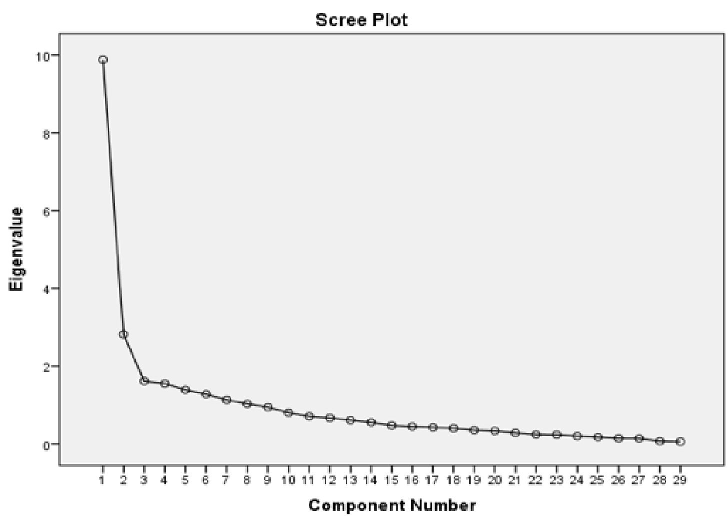

Figure 5. Scree Plot

Another iteration of the factor analysis was conducted, this time fixed on only two factors to extract. Table 5 presents results of the resulting two factor analysis explaining 43.8% of the total variance in the data set. Similar to the first iteration, there exists a difference between the first and second factors. The first factor explained 29.7% of the variance and the second factor explained 14.08% of the variance.

Table 5. *Results of 2-Factor Solution Explaining 43.8% of the Variance in the Data Set*

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cum %	Total	% of Variance	Cum %
1	9.88	34.1	34.1	8.62	29.7	29.7
2	2.82	9.71	43.8	4.08	14.08	43.8

The next step in the analysis was to determine which survey items loaded on each of the two factors. This was done by examining the Rotated Component Matrix. Items greater than 0.5 were retained as they “contribute most to naming the factor” (McCoach, Gable, & Madura, 2013, p. 143). Additionally, an item was removed if there was a loading difference of 0.20 or less between the first and second factors. Based on the factor loadings, eight items were removed. A final factor analysis was performed with the eight items removed. Without the eight items, the resulting two factors extracted explained 47.4% of the total variance. Table 6 presents the 15 items loading on the first factor. Co-investigators interpreted items loading on factor 1 as reflecting a checklist of activities an individual must accomplish to achieve a sense of engineering identity.

Table 7 presents the remaining six survey items that loaded on the second factor. Interpretation of the survey items loading on the second factor were interpreted by the co-investigators as reflecting an internal sense of self confidence related to engineering identity. There was a statistically significant positive correlation between the two extracted factors, that was not so large as to suggest the factors were assessing the same dimension, $r = 0.235$, $n = 97$, $p = 0.020$.

Table 6. *Factor Loadings for Survey Items Loading on Factor 1.*

Item	Factor Loading Value
Committing to the completion of an engineering degree	0.780
Completing the first stage of professional licensure (FE: Fundamentals of Engineering Exam)	0.779
Making a long-term commitment to a company	0.765
Completing a graduate engineering degree	0.738
Committing to engineering as a major	0.728
Making a long-term commitment to a career	0.722
Completing an undergraduate engineering degree	0.721
Completing the second stage of professional licensure (PE: Professional Engineer Exam)	0.718
Reaching the age of 22	0.682
Gaining practical engineering experience while still an undergraduate	0.642
Obtaining full-time employment	0.622
Completing the first year of engineering education	0.591
Serving as a mentor to another engineering student	0.583
Being able to support a family financially	0.569
Excelling in subjects relating to mathematics and science	0.556

Table 7. *Factor Loadings for Survey Items Loading on Factor 2.*

Item	Factor Loading Value
Making moral / ethical decisions considering all factors	0.705
Being able to make competent design decisions	0.703
Accepting responsibility for the consequences of actions	0.701
Speaking / communicating using accurate technical terminology	0.590
Being able to work with others by sharing ideas	0.585
Feeling confident in engineering work without confirmation from others that the approach is technically sound	0.564

Prior to proceeding with subsequent analysis the emergent factors were assessed for normality. Factor 1 was found to have a skew of 0.057 (SE=0.245) and kurtosis of -0.101 (SE=0.237). For factor 2 the skewness was -0.448 (SE=0.245) and kurtosis was -0.515 (SE=0.485). While skew and kurtosis were within acceptable limits, the Shapiro-Wilk test for normality was significant for both factors at less than 0.05, indicating a significant deviation from normal distribution. Accordingly, non-parametric Spearman's rho tests were used to assess hypothesized correlations. Additionally, results of the ANOVA conducted to evaluate Research Question 1 cannot be extrapolated beyond the study participants, since the assumption of normality was not met by the data.

Research Question 2: Do the identified factors related to engineering identity differ between engineering students in their first year of study compared to students in *either their third or fifth year, or between students in their third and fifth years of study?*

To address the second research question, a one-way ANOVA was conducted to compare the effect of students' years in school on factor one (the checklist factor). There was a significant effect on the degree of students' engineering identity, $F(2,94) = 3.826$, $p = 0.025$. Post-hoc comparisons using Tukey HSD indicated the fifth-year mean score of the checklist factor ($M = 38.6$, $SD = 7.64$) was significantly different than the first-year ($M = 44.8$, $SD = 9.15$). However, the third-year mean score of the checklist factor ($M = 42.1$, $SD = 9.79$) did not significantly differ from the first-year and fifth-year students. These results suggest participants in this study did not increase in their sense of engineering identity until sometime after their third year of engineering education compared to their first year engineering identity. Because the data were not normally distributed this finding cannot be extrapolated to the entire population of engineering students sampled or to students in other engineering programs.

Another one-way ANOVA was conducted to compare the effect of students' years in school on factor two (the confidence factor). There was no significant effect of years in school on students' engineering identity as it relates to their level of confidence $F(2,94) = 0.168$, $p = 0.829$. Post-hoc comparisons using Tukey HSD indicated no statistical relationship between the number of years of education completed and students' level of confidence for the first year ($M = 21.1$, $SD = 2.34$), third year ($M = 20.9$, $SD = 2.78$), or fifth year ($M = 20.7$, $SD = 1.77$). Taken together, these results suggest as participants in this study completed their first three years of engineering education, there is no change in their engineering identity. Only sometime after their third year, did students who participated in this study perceive they had completed tasks they considered essential to attaining an engineering identity, but this perception is not accompanied by any change in their level of confidence. These results cannot be interpreted as applying to engineering students beyond those who participated in this study because the data collected were not normally distributed.

Research Question 3: Among students earning engineering degrees, is the number of academic semesters completed correlated with one or more factors on Meyers' (2009) emerging professional engineering identity assessment instrument?

Bivariate correlation analysis was performed using Spearman's rho to assess the relationship between the number of academic semesters completed with the two extracted factors. There was a statistically negative correlation between the number of academic semesters completed and factor 1, the checklist factor, r -0.318, n = 97, p = 0.001. There was a non-significant negative correlation between the number of academic semesters completed and factor 2, the confidence factor, r = -0.072, n = 97, p = 0.469. These results suggest that as engineering students complete more tasks on the checklist (by virtue of advancing their engineering education), their sense of engineering identity declines with no accompanying change of confidence of their engineering identity.

Research Question 4: Among students earning engineering degrees, is the number of cooperative education experiences completed correlated with one or more factors on the Meyers' (2009) emerging professional engineering identity assessment instrument?

Another bivariate correlation analysis was performed using Spearman's rho to assess the relationship between the number of co-op semesters completed and the two extracted engineering identity factors. There was a statistically significant negative relationship between the number of co-op semesters completed and factor 1, the checklist factor, $r = -0.337$, $n = 97$, $p = 0.001$. There was no correlation between the number of co-op semesters completed and factor 2, the confidence factor, $r = -0.068$, $n = 97$, $p = 0.506$. This suggests an increasing number of co-op experiences had a negative effect on students' sense of engineering identity with respect to completing required tasks, and no effect on confidence in their engineering identity.

Question 5: Among students earning engineering degrees, does subjective sense of engineering identity correlate with one or more factors on the Meyers' (2009) emerging professional engineering identity assessment instrument?

The initial question on the Meyers' survey asked respondents to rate their agreement to the statement "Do you consider yourself to be an engineer", to which respondents selected, "Yes", "In some ways yes and some ways no", or "No". Responses to this question were excluded from the factor analysis reported above. Spearman's correlation analysis revealed no significant relationship between students' responses to this question assessing their subjective sense of engineering identity and either of the two extracted factors. Similar to the correlation analyses performed to address the previous research questions, there was no statistically significant correlation between subjective sense of engineering identity and either factor 1 ($r = -0.129$, $n = 97$, $p = 0.207$) or factor 2 ($r = -0.030$, $n = 97$, $p = 0.770$).

Summary

In this chapter, a description of the sample data was presented. This was followed by a description of how the responses from 97 first-year, third-year, and fifth-year students were analyzed through exploratory factor analysis. Such a statistical process resulted in two identified factors that contribute to engineering identity. These two factors were examined to determine differences among students based on their year-in-school, number of academic semesters completed, number of co-op work semesters completed, and students' subjective sense of engineering identity. The final chapter will interpret the findings from the data analysis and discuss the implications for practice and future research.

CHAPTER 5. Interpretation and Implications

Introduction

In the previous chapter, the presentation and analysis of data was reported. This final chapter consists of a summary of the study, discussion of the findings, limitations, implications for future practice, and recommendations for future research. The purpose of the latter half of this discussion is meant to expand on the conclusions drawn from the data analysis to provide insight on how they may influence engineering education, experiential learning, and cooperative education. Finally, an overall statement is offered to capture the essence of what has been attempted through this research.

Summary of the Study

The purpose of this study is to determine the extent to which professional development experiences in the form of cooperative education (co-op) may influence engineering students' sense of professional identity as engineers. Using a theoretical framework based on Arnett's (1994) theory of emerging adulthood self-report data were collected from engineering students to explore whether co-op work experiences influenced the development of their professional engineering identity and whether co-op work experiences coupled with student coursework had a greater influence on identity development than student coursework alone.

The study adopted a self-reported instrument first developed by Meyers (2009). The modified instrument first asks respondents, "Do you consider yourself to be an engineer?". Respondents then rated their agreement to 29 statements as necessary to be considered an engineer. Respondents then answered three multiple choice questions related to the number of co-op semesters completed, prior exposure to the engineering profession, and whether they had an immediate family member who is an engineer or had prior work experience in the field. This study analyzed responses from 97 students enrolled in a baccalaureate engineering program in the Midwestern part of the United States.

Discussion of the Findings

In addressing the first research question, findings from the exploratory factor analysis indicated there exists two factors. The first factor is best described as a checklist. Respondents considered task-oriented statements like “committing to the completion of an engineering degree”, “completing the first stage of professional licensure”, “making a long-term commitment to a company”, “completing a graduate engineering degree”, “committing to engineering as a major”, “making a long-term commitment to a career”, “completing an undergraduate engineering degree”, “completing the second stage of professional licensure”, “reaching the age of 22”, “gaining practical engineering while still an undergraduate”, “obtaining full-time employment”, “completing the first year of engineering education”, “serving as a mentor to another engineering student”, “being able to support a family financially”, and “excelling in subjects relating to mathematics and science” as necessary to being considered an engineer. This finding supports McGrath et al. (2013) where engineering students view such tasks as part of a process to better themselves instead of a cost. Further, these tasks could be viewed as students’ perceived societal expectations of what is expected of members of the engineering profession (Trede et al., 2012).

The second factor is best described as qualities to gain confidence towards an engineering identity. Respondents considered “making moral/ethical decisions considering all factors", "being able to make competent design decisions", "accepting responsibility for the consequences of actions", "speaking/communicating using accurate technical terminology", "being able to work with other by sharing ideas", and "feeling confident in engineering work without confirmation from others that the approach is technically sound" as necessary to being considered an engineer. While these qualities are not explicit tasks or milestones to accomplish, these are behaviors necessary to interact with other engineers. By sharing ideas designing engineering solutions, one will gain the confidence to become an engineer.

Compared to Meyers's (2009) study, her study cited "being able to make competent design decisions", "being able to work with others by sharing ideas", "accepting responsibility for the consequences of actions", "speaking/communicating using accurate technical terminology", "completing an undergraduate engineering degree", and "making moral/ethical decisions considering all factors" as essential qualities to be considered an engineer.

The second research question takes the identified factors and determines if there are differences among study participants enrolled in their first, third, or fifth years of engineering study. Based on the statistical analysis performed, these students gain a sense of engineering identity in their fifth year of study, compared to their first year, but only with respect to the first factor extracted from the Myers' (2009) instrument characterized as a checklist of activities. Because the data analyzed were not normally distributed, however, these results cannot be extrapolated to the entire population of engineering students sampled, or to other populations of engineering students outside study participants. There were no statistically significant differences among first, third and fifth year students on the second engineering identity factor relating to levels of confidence. Examination of the items supporting the factor of gaining confidence towards an engineering identity does not specify a time when these items are supposed to occur during a student's matriculation in an engineering program. While "completing the first year of engineering education" is a time-bound accomplishment or "committing to engineering as a major" provides an individual with tangible outcomes like a degree or a job, that does not appear to be the case with the items supporting the second factor. Similar limitations apply to the extrapolation of these results, due to the deviation from normal distribution of the sample.

The correlation analysis conducted to address the third research question found a negative correlation between the number of academic semesters completed and the first factor, relating to completing a checklist of items to become an engineer. There was a non-significant negative correlation between number of academic semesters completed and the second factor relating to confidence.

Results addressing the fourth research question found the number of co-op work experiences a student completed was negatively correlated with students' engineering identity with respect to completing tasks, but had no correlation with the confidence dimension of engineering identity. Meyers (2009) reported a similar conclusion based on logistic regression models that students with experiences like an internship or undergraduate research position did not help explain students' self-identification as an engineer. This finding is also not contradicted by Kinoshita et al.'s (2014) finding that skill development from work experiences was realized three years after graduation.

Finally, in addressing the final research question, there was no statistically significant correlation between students' subjective sense of engineering identity and either of the engineering identity (checklist or confidence). Out of the 97 respondents, 63.9% self-identified as an engineer. One could argue that sense of identity is imposed by the nature of the educational experience given that faculty who impose the title when referencing students in course lectures, through co-op experiences, and the institutional affinity of enrollment in a college of engineering (Gee, 2001). While students subscribe to the title and label of being an engineer, this sense of identity was not reflected in their more detailed responses to the Engineering Identity scale. More empirical evidence is needed to understand how students integrate and define for themselves the identity of an engineer.

Limitations

In addition to the limitations stated in the first chapter, one of the glaring limitations impacting the results of this study was the low response rate. Only of 97 of the 2,686 students solicited provided complete, valid responses for analysis, a 3.6% return rate. Nearly that same number or responses, 86, had to be removed prior to analysis because they were either incomplete or invalid (reporting more than one response to one or more questions). It is unclear what the impact of this lack of data integrity may have been on the representativeness of the final sample. It is also unclear whether the overall response rate was affected by the fact that the last week of data collection coincided with university-wide measures to curtail the spread of coronavirus and COVID-19 disease.

Implications and Applications

Results from this study offer a few implications and applications for persons in faculty or administrative roles associated with cooperative education. This study explored the degree to which professional development experiences through co-op may influence engineering students' sense of professional identity as engineers. While two dimensions were identified and tested as potential correlates of engineering identity, only one (related to completing tasks) was found to differentiate among students based on the number of years of engineering education completed. That factor was negatively correlated with both the number of semesters and the number of co-op experiences completed, the opposite of what was predicted. No significant relationships were found between the second factor related to confidence and either the number of semesters or number of co-ops completed. As a result, administrators have no basis for asserting either coursework or co-op experiences promote engineering identity. While there is some evidence to suggest students may begin to exhibit some change in their engineering identity in their fifth year of study, relative to their first year (at least with respect to completing tasks associated with engineering identity), additional efforts are needed to link the experiences learned in the classroom and while working on co-op to engineering identity.

Future Research

Despite the limitations identified, this study offers opportunities for future research. Further research might employ alternative strategies to recruit a larger sample in order to verify results, which would increase the external validity of these findings. Recruitment could be coordinated with college academic advisors and co-op faculty. Additionally, data collection at multiple colleges of engineering with cooperative education programs would offer the opportunity to further explore whether cooperative education work experiences influences identity development within the first half of student enrollment. Finally, the instrument employed in this study could be deployed in the first half of students' enrollment in an engineering program. Doing so would establish a baseline and measure of development as students complete core engineering courses and prior to entering elective or concentration courses.

Future research is also needed to identify additional dimensions of engineering identity. Drawing upon previous research, applying grade point averages (Noyes et al, 2011) as a variable may offer further insight on how a measurement of student learning (or deficiency) correlates with students' sense of engineering identity. Another variable to incorporate in a future research study would be that of self-efficacy (Bandura, 1986), which might contribute to expanding the second factor identified through this study. A final variable to consider would be that of Person-Job Fit (Kristof, 1996), which explains "fit between the abilities of a person and the demands of a job (i.e., demands-abilities) or the desires of a person and the attributes of a job (needs-supplies)" (p. 8). Incorporating a variable of fit would contribute to a student's suitability in an engineering job or academic program. In the end, applying another theoretical framework would enhance the dimensionality of the research design and address student matriculation and success.

Finally, future research could also consider the nature of students' co-op work assignments. This would include possible variables like industry, role, and responsibility as potential predictors of engineering identity. Students' impressions of identity may oscillate due to the nature of the co-op program, switching between attending classes to going to work. Overall student satisfaction could also influence student engineering identity as one progresses in a position, company or industry.

Conclusions

Becoming an adult is a developmental process (Arnett, 2000). Becoming an engineer has been compared to the process of becoming an adult, but within a specific professional context (Meyers, 2009). Findings from the study reported here contribute to the scholarship around college student development in the context of engineering identity development. Factor analysis of responses to Myers' (2009) survey of emerging engineering identity completed by first-year, third-year, and fifth-year students enrolled in a baccalaureate engineering program generated two factors explaining 43.8% of the variance among respondents. These factors reflect tasks students perceive they need to complete in order to become an engineer and behaviors that reflect confidence in being an engineer. While the first factor (tasks) showed weak predictive utility in differentiating fifth-year students from first-year students, it was found to be negatively correlated with both number of semesters and number of co-op experiences completed. The other factor (confidence) had no predictive utility and was not correlated with either metric of degree completion. These results do not support the argument that cooperative education experiences contribute to engineering identity development, and suggest there may even be a deleterious effect of both coursework and co-op experiences on students' perceptions that completing a series of tasks will enhance their engineering identity. The results also suggest that neither coursework nor co-op have any effect on students' confidence in their engineering identity. Together, results of this study implicate the need for researchers to continue efforts to develop more effective metrics of engineering identity to inform faculty and administrators’ understanding of the separate and reciprocal contributions of classroom learning and co-op work experiences to students’ engineering education.

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Appendix A

Student Recruitment Email

Dear [Student's First Name]:

We hope that your semester is off to a wonderful start. The Division of Experience-Based Learning and Career Education is sending this message on behalf of two researchers from Xavier University's Leadership Studies Doctoral program to invite your participation in a study being conducted to learn more about how particular aspects of engineering education contribute to the preparation of professional engineers. You are eligible to participate in this study because you are a currently enrolled student in the College of Engineering and Applied Science. The study is being conducted by Richard Robles, as part of his doctoral requirements under the supervision of Dr. Gail F. Latta, Program Director & Associate Professor of Leadership Studies at Xavier University.

Students who are currently pursuing a degree in engineering are eligible to participate. Participants are being solicited who are at all levels of degree completion, from first semester to their final year of study. Students who choose to participate will be asked to respond to a one-time, anonymous, online survey that should take no more than 10-15 minutes to complete.

Your decision whether to participate in this study is completely voluntary and will be known only to you. Neither the College of Engineering, nor the researchers will know whether you decide to participate in this study, and no data you contribute will permit researchers to link response to any individual respondents. Your decision whether to participate in this study will have no impact on your status as a student in the College of Engineering or participation in the co-op program.

To learn more about the study any how to participate, please follow the link provided below. Please respond by Friday, February 7, 2020. Here is the link to participate:
[URL to Qualtrics Survey]

Should you have any questions about the study, please contact the co-investigators, Richard Robles at (513) 556-0337 or roblesra@ucmail.uc.edu and Dr. Gail F. Latta, (513) 745-2986 or lattag@xavier.edu.

Thank you for your consideration of this invitation.

Sincerely,

The Division of Experience-Based Learning & Career Education
on behalf of Professors Robles and Dr. Latta.

Appendix B

Informed Consent

My name is Richard Robles, a doctoral student conducting dissertation research under the supervision of Dr. Gail F. Latta, Program Director & Associate Professor of Leadership Studies at Xavier University. We are contacting you to invite your participation in a study of students earning degrees in engineering. The purpose of this study is to determine how particular educational experiences contribute to the preparation of professional engineers. As a participant in this study will be asked to complete an anonymous online survey rating how relevant to being an engineer you consider each of 29 descriptive statements. The survey includes nine additional questions concerning elements of your degree completion and prior experience with engineering. No personal information will be collected that would permit researchers to know the identity of any individual respondents. The entire survey should take no longer than 10-15 minutes to complete. There are no anticipated risks associated with participation in this study, nor will there be any direct benefits or compensation for participating. If you are interested in learning more about the study, please continue reading.

Nature and Purpose of the Project
The purpose of this study is to explore how particular aspects of engineering education contribute to the preparation of professional engineers. Survey research methods will be used to solicit anonymous responses to an online survey from current engineering students at the participating institution. Permission has been obtained from the institution to solicit your participation in this study, but your decision whether to participate is entirely your own, and will be known only to you. The study involves examining the experience of current engineering students at various stages of degree completion, from the first semester to the final year of study. Students who participate will complete the survey once, at their current level of degree completion. No follow-up of any sort will be required.

Why You Were Invited to Take Part
As a student in the College of Engineering at the participating institution, you are eligible to participate in this study because you are currently either enrolled in courses or participating in a cooperative education experience. As a currently enrolled engineering student, your perspective is relevant to this study.

Study Requirements
If you choose to participate in this study, you will be asked to complete an anonymous online survey consisting of 29 Likert-type ratings scales and 9 multiple choice questions. Survey questions will ask participants to rate the relevance to being an engineer of 29 descriptive statements, and respond to 9 additional questions characterizing your experience with engineering education. The survey is anticipated to take 10-15 minutes to complete. No demographic or personally identifying information will be collected that would permit researchers to identify individual survey respondents. Results will be analyzed and reported only in the aggregate. Individual participant anonymity and

institutional confidentiality will be maintained in all published and professional presentations of study results.

Anticipated discomforts/risks
There are no anticipated risks related to participating in this study.

Benefits
There will be no direct benefits to you for your participation in the study. However, as a student currently enrolled in an engineering degree program, your perspective is important to this study and will inform future research on the topic.

Confidentiality/Anonymity
All of your responses will be collected anonymously through the Qualtrics website, which will be set to the highest level of anonymity. This means that no IP addresses or other Internet-based tracking information will be collected. Responses you submit will not be linked to the email address used to contact you about this study, nor will any personally identifying information will be collected that would permit researchers to know the identity of individual respondents. Your email address and all messages sent to solicit your participation in this study will be deleted after data collection has been completed. The anonymous data collected for this study will be retained for up to three years on a password-protected computer, at which point the data will be deleted.

Compensation
There will be no compensation awarded for your participation in this study.

Refusal to participate in this study will have NO EFFECT ON ANY FUTURE SERVICES you may be entitled to from the University. You are FREE TO WITHDRAW FROM THE STUDY AT ANY TIME WITHOUT PENALTY.

If you have any questions at any time during the study, you may contact the co-investigators, Richard Robles at (513) 556-0337 or rich.robles@uc.edu, and , Dr. Gail F. Latta, Ph.D. at (513) 745-2986 or via lattag@xavier.edu. Questions about your rights as a research participant should be directed to Xavier University's Institutional Review Board at (513) 745-2870 or irb@xavier.edu.

You may print a copy of this form for your records, or contact Richard Robles at (513) 556-0337 or via email at rich.robles@uc.edu to request a copy be sent to you.

I have been given information about this research study and its risks and benefits and have had the opportunity to contact the researchers with any questions, and to have those questions answered to my satisfaction. By completing the elements of the study as previously described to me, I understand that I am giving my informed consent to participate in this research study.

Choose one:

- ☐ I consent to participate
- ☐ I do not consent to participate

Choose one:

- ☐ I certify that I am at least 18 years of age
- ☐ I am not at least 18 years of age

Appendix C

Survey Instrument

1. Do you consider yourself to be an engineer?

   - ☐ Yes
   - ☐ In some ways Yes and Some Ways No
   - ☐ No

--- Page Break ---

2. Please read the following statements and indicate the degree to which you agree each is necessary to being considered an engineer.

		Strongly Disagree	Disagree	Agree	Strongly Agree
(1)	Being able to make competent design decisions	☐	☐	☐	☐
(2)	Being able to teach engineering content to another person	☐	☐	☐	☐
(3)	Speaking/communicating using accurate technical terminology	☐	☐	☐	☐
(4)	Feeling confident in engineering work without confirmation from others that the approach is technically sound	☐	☐	☐	☐
(5)	Making moral / ethical decisions considering all factors	☐	☐	☐	☐
(6)	Accepting responsibility for the consequences of actions	☐	☐	☐	☐
(7)	Making a long-term commitment to a company	☐	☐	☐	☐
(8)	Making a long-term commitment to a career	☐	☐	☐	☐
(9)	Being able to support a family financially	☐	☐	☐	☐

(10)	Establishing relationships with other engineers	□	□	□	□
(11)	Being able to work with others by sharing ideas	□	□	□	□
(12)	Committing to engineering as a major	□	□	□	□
(13)	Committing to the completion of an engineering degree	□	□	□	□
(14)	Avoiding procrastination on work responsibilities	□	□	□	□
(15)	Doing your best work beyond the minimum requirements	□	□	□	□
(16)	Showing up for class and meetings prepared	□	□	□	□
(17)	Participating actively in meetings	□	□	□	□
(18)	Being able to lead a design team / initiative	□	□	□	□
(19)	Possessing natural engineering ability	□	□	□	□
(20)	Excelling in subjects relating to mathematics and science	□	□	□	□
(21)	Completing the first year of engineering education	□	□	□	□
(22)	Gaining practical engineering experience while still an undergraduate	□	□	□	□
(23)	Serving as a mentor to another engineering student	□	□	□	□
(24)	Obtaining full-time employment	□	□	□	□
(25)	Completing an undergraduate engineering degree	□	□	□	□
(26)	Completing a graduate engineering degree	□	□	□	□
(27)	Completing the first stage of professional licensure	□	□	□	□

	(FE: Fundamentals of Engineering Exam)				
(28)	Completing the second stage of professional licensure (PE: Professional Engineer Exam)	☐	☐	☐	☐
(29)	Reaching the age of 22	☐	☐	☐	☐

--- Page Break ---

3. Before this semester, how many co-op semesters did you complete? (drop down box)

- ☐ 0 Co-op Experiences
- ☐ 1 Co-op Experience
- ☐ 2 Co-op Experiences
- ☐ 3 Co-op Experiences
- ☐ 4 Co-op Experiences
- ☐ 5 Co-op Experiences

4. Prior to attending college, please describe any engineering-related jobs or activities.
   - ☐ I had **NO PRIOR EXPERIENCE** with engineering related jobs or activities
   - ☐ I **RARELY** participated in engineering related jobs or activities
   - ☐ I **OCCASIONALLY** participated in engineering related jobs or activities
   - ☐ I participated in **A MODERATE AMOUNT** of engineering related jobs or activities
   - ☐ I participated in **AN EXTENSIVE AMOUNT** of engineering related jobs or activities

5. Do you have a parent or sibling(s) who holds a degree in engineering or is a practicing engineer?
   - ☐ Yes
   - ☐ No

Appendix D

Student Email Reminder

Dear [Student's First Name]:

You should have received an email a couple of weeks ago regarding an invitation from Rich Robles and Dr. Gail F. Latta, Ph.D. to participate in a research study on various aspects of engineering education contribute to the development of professional engineers. The original solicitation message is appended below.

If you have not had a chance to respond, there is still time to participate. Participation involves responding to a short, anonymous online survey administered through Qualtrics. To learn more about the study any how to participate, please follow the link provided below. Please respond by Friday, February 7, 2020.

Here is the link to participate:
[URL to Qualtrics Survey]

Your decision whether to participate in this study is completely voluntary and will be known only to you. Neither the College of Engineering, nor the researchers will know whether you decide to participate in this study, and no data you contribute will permit researchers to link response to any individual respondents. Your decision whether to participate in this study will have no impact on your status as a student in the College of Engineering or participation in the co-op program.

Should you have any questions about the study, please contact the co-investigators, Richard Robles at (513) 556-0337 or roblesra@ucmail.uc.edu and Dr. Gail F. Latta, (513) 745-2986 or lattag@xavier.edu.

Thank you for your consideration of this invitation.

Sincerely,

The Division of Experience-Based Learning & Career Education
on behalf of Professors Robles and Dr. Latta.