ONBOARDING EARLY-CAREER ENGINEERS:
KNOWLEDGE & SKILL ACQUISITION IN ROTATIONAL PROGRAMS

by

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A Dissertation

Submitted to the Faculty of Purdue University

In Partial Fulfillment of the Requirements for the degree of

Doctor of Philosophy

Department of Engineering Education

West Lafayette, Indiana

May 2020

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This dissertation is dedicated to the Memory of Oluyemisi Babajide and Ishola Adejola

ACKNOWLEDGMENTS

When I took a break from engineering practice to return for a PhD, it was to fulfill one of my 10-year goals. Under the circumstances at the time, I wasn't sure I made the right decision, but I always remembered my late mother Oluyemisi Babajide said to me two months before she passed away, "Whatever happens, Olubunmi, you go, and you finish." Well, Mother, I did. Thank you for your love and support. Your words kept me through it all.

To my father, Elijah Babajide, I couldn't have asked for a greater role model. You are the most selfless man I know. You are far too kind, and the world's greatest dad. I can only hope that I continue to make you proud.

To my husband, words cannot express how grateful I am for your support during this journey. You made sacrifices in many ways countless times and I can only hope that I am presented with the same opportunity to support your goals.

To my siblings, Dolapo and Seun Adepoju-Grace, Fanny and Ayo Babajide, Tobi and Ikepo Babajide, and Ope Babajide, you are all confirmation of God's love for me. Your words of encouragement and prayers kept me through many seasons in the process and for that I am grateful.

This journey was of growth. A very personal and reflective process that gave me so much insight and perspective into who I am and who I am becoming. I couldn't have been able to say these words my first semester in the program and I would be an ingrate if I do not thank the likes of Dr. Ruth Streveler for pushing me to reflect often.

There were many times I just could not see myself at the finish line. The will to complete this degree was just not there. I was encouraged by the actions of Dr. Michael Loui who never gave up on pushing me and guiding me. On days that I felt like quitting, his investment in me gave me all the encouragement I needed to persevere.

To my advisor, Dr. William Oakes, and co-advisor Dr. Michael Loui, and my committee, Dr. Mary Pilotte, Dr. Ed Berger, and Dr. Brent Jesiek, thank you for the amount of time you invested in me to become a scholar and all your input to my dissertation, publication, and conference papers. Your dedication to see me succeed is great and I am forever grateful for the support and encouragement you provided to me throughout this journey.

Finally, to my cohort, I count myself very lucky to have joined the ENE program with a fantastic group of men and women I now consider an extension of my family. Dr. Zahra Atiq, Dr.

Matilde Sanchez-Pena, Dr. Monique Ross, Dr. Delean Tolbert, Dr. Nicole Peterson, Dr. Juan Ortega-Alvarez, Dr. Avneet Hira, thank you for being my sounding board, my audience during mock presentations, my editors when I need one, my therapist on all matters, and my chef on days I forget to eat. I am forever grateful for your support and being some of my greatest cheerleaders.

I would also like to show my appreciation to Dr. Joyce Main and Dr. Allison Godwin for your support throughout the process. Your help in my quantitative analysis made a difference in my ability to complete a mixed-method study. To Timothy Luzader, thank you for extending your network and dedicating time to encourage me throughout the data collection phase.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Each year, employers invest substantial time, money, and resources in onboarding programs for new employees. In particular, engineering and manufacturing firms provide extensive training programs for new engineers. In one such program, a rotational onboarding program (ROP), new engineers rotate through assignments in multiple departments to gain experience in different parts of the employer's organization.

This dissertation study investigates the knowledge and skills that early-career engineers develop through ROPs by comparing the experiences of engineers who had participated in an ROP and direct-hire engineers who had not. This study also identifies factors that contribute to the engineers' perceptions of improvements in their knowledge and skills.

The researcher used an explanatory mixed-methods approach, with a quantitative phase followed by a qualitative phase. In the quantitative phase, a diverse sample of early-career engineers responded to a survey that captured their perceptions of the gains between their undergraduate and current levels of knowledge and skills in 11 learning outcome categories. The sample comprised 67 engineers who had participated in an ROP and 50 direct-hire engineers. The survey results indicate that the ROP engineers perceived significantly higher gains than the direct-hire engineers in five learning outcomes. In the qualitative phase, 24 of the engineers who had taken the survey were interviewed—14 engineers who had participated in an ROP and 10 direct-hire engineers. The interview data suggests that the ROP engineers developed professional networks within their ROP cohort and across the departments in which they had worked.

Finally, this dissertation study offers insights for both universities and employers. For universities, this study shows how the undergraduate experiences of early-career engineers contribute to their knowledge and skills in practice. For employers, the study's findings show which aspects of ROPs most benefit early-career engineers.

CHAPTER 1. INTRODUCTION

1.1 Background of the Problem

The perceived preparedness of university[1] graduates has been debated for decades in fields such as education, music, and healthcare (Pérusse & Goodnough, 2011; Creech et al., 2008; Duchscher, 2009). To prepare new employees for work at their organizations, many employers offer learning and training programs. In 2013, U.S. employers spent over $164 billion on employee learning and development (ASTD Staff, 2013). This investment in learning and development emphasizes the importance of the onboarding process for new employees. Additionally, this stake in human capital by employers is increasingly becoming an essential part of employee development, especially for the technical workforce.

Indeed, continued emphasis on work preparedness is still an important topic—particularly in the Science, Technology, Engineering, and Math (STEM) fields, because as technology evolves rapidly, there is heightened demand for engineers who can adapt quickly to new technology (Vest, 2008). Especially for engineers, employers seek graduates with skills beyond academic excellence in a chosen discipline alone; instead, employers seek candidates who can apply a broad range of skills deemed relevant to the workplace (Seely, 1999). As the world economy moves towards globalization and as technology continues to develop at a rapid pace, employers have become interested in engineers who are equipped with the skills and knowledge to develop advanced technologies. For this reason, early-career engineers must perform at a high level from their first day on the job (Green, Hammer, & Star, 2009).

Although universities offer opportunities within the curriculum for engineering students to gain knowledge and skills deemed essential in practice, employers invest a substantial amount of money in onboarding programs. According to Klein and Polin (2012), the onboarding process comprises "all formal and informal practices, programs, and policies enacted or engaged in by an organization or its agents to facilitate newcomer adjustment" (p. 268). Moreover, the onboarding process can take between hours to months to complete (Klein & Polin, 2012). This dissertation presents a fundamental research study of the onboarding experiences of engineers. This study aims

[1] The terms *university* and *universities* is used in this dissertation study to describe institutions of higher education offering an undergraduate engineering program.

to help engineering education researchers, instructors, and administrators understand the learning experiences of early-career engineers.

1.2 Rotational Onboarding Programs

One method of onboarding is known as a *rotational onboarding program* (ROP). Moreno (2011) defined a rotational onboarding program as:

> A corporate program designed to hire recent college graduates into entry-level positions, offering them exposure to multiple areas in an organization through a series of 6-8 month assignments over a period of 18-24 months. Employees go through a job selection process for each new assignment and are evaluated on their performance at the end of each assignment. (p. 18)

According to the Corporate Leadership Council report, over 50% of top-100 organizations offer a form of rotational onboarding program (Corporate Leadership Council, 2004). ROPs are designed for new employees to spend time rotating through different departments within an organization to gain knowledge of each department and its practices for a specific duration of time. Rotational onboarding programs have been described to have potential benefits for newcomers (Zemke, 1989; Dailey, 2016). As part of their initial experience, these new employees are groomed for leadership roles through rigorous projects, mentorship, and in some cases, access to upper management (Dailey, 2016).

Rotational onboarding programs combine the general onboarding process with the job rotation method for new employee development. According to Huang (1999):

> Job rotation can be defined as lateral transfer of employees among a number of different positions and tasks within jobs where each requires different skills and responsibilities. Individuals learn several different skills and perform each task for a specified time period. Rotating job tasks helps worker [sic] understand the various steps that go into creating a product and/or service delivery, how their own effort affects the quality and efficiency of production and customer service, and how each member of the team contributes to the process. Hence, job rotation permits individuals to gain experience in various phases of the business and, thus, broaden their perspective. (p. 75)

The rotation of jobs in this context is part of the onboarding process, beyond the traditional newcomer orientation.

In engineering, the key features of ROPs are mentorship, group socialization, limited duration, design projects, and a focus on advanced education. Eriksson and Ortega (2006) researched three perspectives on why organizations choose to introduce rotational programs. These perspectives are for employee learning, employer learning, and employee motivation. The theory of employee learning suggests that new employees who go through a rotational program gain knowledge about the employer. The employer also learns about the new employees and can identify gaps in their technical abilities during the program. Lastly, rotational programs increase motivation by reducing boredom from mundane tasks (Eriksson & Ortega, 2006).

Rotational onboarding programs may have different names, even at the same organization. For example, Siemens provides three different programs for new engineering graduates[2] called the Engineering Development Program (EDP), the Engineering Leadership Development Program (ELDP), and the Projects and Services Leadership Development Program (PSLDP). The EDP and ELDP include design and testing while the PSLDP involves troubleshooting and business-related functions (Siemens Corporation, 2017).

According to the NACE's 2016 Recruiting Benchmarks Survey report from 12 industries and 233 employers, organizations offer rotational onboarding programs to increase the retention of new employees. The one-year and five-year retention rates of participants in such programs on average were 91% and 70.9%, versus 72.3% for one-year retention and 59.8% for five-year retention for those who did not participate in this form of onboarding program (NACE, 2016). These findings are consistent with findings from studies at Corning Glass Works and Texas Instruments in the early 1980s, which suggested that ROPs are effective in retaining employees. The findings further suggest that the program at Corning reduced the turnover rate by 69% over three years, compared with employees who did not participate in an ROP (Zemke, 1989). ROPs have continued to expand in practice since the 1980s and continue to grow in scope and duration. Some employers invest considerable time in ROPs, which can include two to three years of assignment rotations with each assignment lasting six to nine months (Kuok & Bell, 2005).

While overall satisfaction of rotational onboarding programs has been studied and trends identified (NACE, 2016), the onboarding programs early-career engineers experience in practice is seldom addressed in engineering education research (Stevens, Johri, & O'Connor, 2015; Trevelyan, 2010). Yet, in a study on workplace expectations, Katz (1993) briefly considered

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[2] In this dissertation study, the researcher uses "engineering graduates" to refer to engineering students who have recently graduated but are not yet employed, while "early-career engineers" or "engineers" refer to those who are currently employed in engineering practice.

onboarding programs for engineers but also suggested that further exploration should be considered to understand how onboarding programs might best bridge the gap between academic study and the practical aspects of an engineering career. Katz used the term "two-year training program" instead of the term "rotational onboarding program," but meant the same kind of program. According to Katz, the formal two-year training program presents an important opportunity for training and development among early-career engineers. Also, Katz suggested that educators of future engineers should learn how to improve their teaching by exploring the onboarding programs in engineering practice. Despite the call for a better understanding of ROPs, there is little research on the following aspects of ROPs: employer's requirements for onboarding new engineers, the job descriptions of these roles, and the employee's knowledge and skill gain during the program.

Research on rotational onboarding programs has implications for both the future of engineering programs in academia and training programs in engineering practice. Rotational onboarding programs could help engineering practitioners, engineering managers, corporations, and engineering researchers accomplish a few goals. These goals include 1) understanding the current state of an onboarding program from a corporate and individual perspective, 2) informing future revisions to current program structure, tackling retention challenges, 3) informing engineering programs on the role of the onboarding program in relationship to the ABET outcomes criteria that are used to gauge student outcomes success, and 4) contributing to further research on effective methods to evaluate onboarding programs for early-career engineers in practice. While there are many studies on general onboarding practices (Klein, Polin, & Sutton, 2015; Eriksson, 2001), there is little information available on specific onboarding processes for early-career engineers. One of the motivations for this work is to further the conversation by pursing a rigorous collection of qualitative and quantitative data on rotational onboarding programs in engineering practice, what they aim to achieve, and what is being done at the university level to prepare early-career engineers for their roles today. Conducting this research adds to the body of work in this area of engineering education beyond the institutional preparation of students for engineering careers and has relevance in understanding the experiences of early-career engineers in practice.

Before entering professional practice, early-career engineers have experiences in the university that can inform their perception of engineering practice. Furthermore, the undergraduate curriculum offers students several opportunities to gain experience at different points while in the university. These opportunities include cooperative education; often called "co-op," internship experiences, project-based learning activities, and senior capstone design projects. These are all experiences that promote learning outcomes meant to develop the knowledge and skills needed for success in engineering practice.

For early-career engineers, rotational programs aim to develop technical skills, socialize employees across cross-functional teams, and develop professional skills (Frase-Blunt, 2001). Because an ROP is often the first full-time employment for a small minority of engineers in practice after graduation, and, in some cases, their first introduction to real design projects with cost, quality, and safety constraints beyond capstone design projects, it is an essential part of their learning and development. As employers utilize these types of programs, it is important to understand the impact of rotational onboarding programs on knowledge and skill gain, and to characterize factors that influence the gains that early-career engineers perceive during their transition into engineering practice. Although several studies have examined the experiences of early-career engineers, few have examined formal onboarding programs for new engineering employees.

1.3 Importance of this Dissertation Study

Previous studies addressed various topics on the experiences of early-career professionals, such as the differences in expectations between early-career engineers and managers during the onboarding process (Korte, Brunhaver, & Sheppard, 2015), the gaps between the academic and career preparations of engineers (Sheppard, Matusovich, Atman, Streveler, & Miller, 2011), and the differences in experiences of early-career engineers and those with years of experience (Brunhaver, Korte, Barley, & Sheppard, 2017). These three previous studies and other studies of early-career engineers (Klein & Polin, 2012; Lattuca, Strauss, & Volkwein, 2007) have not examined the effects of onboarding programs.

In contrast with previous studies, this dissertation study explores the effects of onboarding programs, comparing the knowledge and skill gains of engineers who participated in ROPs with the experiences of direct-hire engineers who did not participate in ROPs. The dissertation study also investigates factors that influence how early-career engineers perceive their experience. Furthermore, this dissertation study examines what undergraduate engineering curricula may lack in preparing students for engineering practice.

1.4 Purpose of the Study

The purpose of this dissertation study is to complement the current literature on the school to work transition by exploring the impact of the professional development experience on early-career engineers. Specifically, this dissertation study seeks to compare the gains in knowledge and skills in the university and during the ROP experience for those who participated in an ROP, and after two or more years' experience in practice for direct-hire engineers. Additionally, this study explores the relationship between the academic and non-academic experiences of undergraduate students and the outcomes of their rotational onboarding program experience.

CHAPTER 2. LITERATURE REVIEW

This chapter presents previous studies that considered the specific characteristics of academic experiences that prepare students for a career in engineering practice. This chapter also considers the perceptions of both students and employers regarding these experiences. Furthermore, the chapter considers the perceptions of engineering students and new engineering graduates before and after entering the workforce, employers' perceptions of engineering graduates, the role of cooperative education, the place of capstone design project experiences, and project-based experiences in student preparedness for the workforce, as well as the university-industry relationship. Finally, this chapter describes the importance of ABET outcomes to the university-industry relationship and addresses onboarding programs in engineering practice.

Previous research studies on early-career engineers primarily examined the transition from university to practice. Several studies considered employer and employee expectations during the onboarding socialization process (Korte, Brunhaver, & Sheppard, 2015), or foundational knowledge and skills that early-career engineers consider significant to their current roles (Passow, 2012; Lattuca, Terenzini, Knight, & Ro, 2014; Brunhaver, Korte, Barley, & Sheppard, 2017). Other studies investigated the practical definition of an engineer (Dunsmore, Turns, & Yellin, 2011) and examined how early-career engineers make career choices (Brunhaver, Matusovich, Streveler, Sheppard, Carrico, & Harris, 2016). In this next section, the researchers explore some of these studies of early-career engineers' formal onboarding programs.

2.1 Early-Career Engineers

The transition of new engineers into practice is well-documented in previous studies. For example, Brunhaver, Korte, Barley, and Sheppard (2017) conducted semi-structured interviews of 57 early-career engineers who held full-time positions. The study sought to understand the differences between their experiences as undergraduate students and their experiences as full-time engineers. This study identified deficiencies in engineering curricula that prevent universities from graduating fully prepared students; engineering curricula focus primarily on theory, but engineering practice involves both technical and nontechnical knowledge and skills. Another important aspect of engineering student preparation is aligning with what is important in engineering practice, which this study identified a lack of as well.

To understand the ways undergraduate engineering programs provide educational experiences that support the *Engineer 2020 Vision*[3], Lattuca, Terenzini, Knight, and Ro (2014) conducted a 6-part longitudinal study which included a survey of 1,403 alumni from 31 U.S. universities. The study found that after three years in practice, early-career engineers considered three professional skills to be the most important: teamwork, professionalism, and written and oral communication. Moreover, they considered leadership and program management skills important in their current position in engineering practice. Yet, the alumni recalled that their university programs emphasized teamwork more highly than communication and professional skills.

Other previous studies include longitudinal studies, such as the Engineering Pathways Study, which investigated what could be done at the university and in engineering practice to facilitate engineering graduates' transition into practice. This study was conducted in stages. During the early stages of the Engineering Pathways Study, Sheppard, Matusovich, Atman, Streveler, and Miller (2011) interviewed 30 early-career engineers to explore their experiences in engineering practice. Sheppard et al. found that internships and cooperative experiences provide students with insight into engineering practice. Furthermore, they found that engineering practice requires more spontaneous brainstorming and solution generation than is taught in undergraduate curricula. The findings from this study were used to develop a survey instrument titled Pathways of Engineering Alumni Research Study (PEARS), which was administered to approximately 500 participants.

A follow-up study by Brunhaver, Gilmartin, Grau, Sheppard, and Chen (2013) administered the PEARS survey instrument to alumni from four universities. This study examined three types of roles in which early-career engineers work in professional practice, namely as engineering practitioners, consultants, and managers. The findings of this study suggest that the different engineering roles performed by early-career engineers affect each individual's perspective on their job and self. Engineering managers were least likely to consider their role as engineering-related or to identify as an engineer. In contrast, engineering consultants were more

[3] The Engineer 2020 report was written by educators and engineers in practice and published by the National Academy of Engineering. The report identifies model attributes of future engineers. The report also recommends ways to improve student development and prepare them to address complex challenges in the future.

likely to consider themselves engineers and to pursue advanced engineering licensure and certificates.

Finally, Korte, Brunhaver, and Sheppard (2015) performed a qualitative research study of early-career engineers regarding the transition from school to work and the differences between their expectations of work and their actual work experiences. The study was conducted with 41 early-career engineers and 15 managers from three different organizations, namely an automobile manufacturer, a computer component manufacturer, and a state government transportation agency. The findings of this study suggest that the new employee sometimes misinterpreted the socialization process. For example, new employees reported that they expected formal guidance and structured training; however, training was provided mostly informally, leading to disappointments in relationships for both the employee and the manager. The study concluded that the differences in expectations and experiences between employee and manager inadvertently affect the quality of employee learning, performance, and satisfaction during the socialization process.

2.2 Students' and Early-Career Engineers' Perceptions of Engineering Practice

According to John Roundhill, vice president of The Boeing Company, employers expect that early-career engineers should understand science fundamentals, design, and manufacturing processes involved in the field of engineering, and that they should communicate proficiently, work effectively on multidisciplinary teams, take a systems perspective, and understand the context of engineering practice (Dunsmore, Turns, & Yellin, 2011). Research suggests, however, that student conceptions of engineering work sometimes contrast with the realities of engineering practice. Dunsmore, Turns, and Yellin (2011) examined the engineering journals of 27 undergraduate mechanical engineering students in an Introduction to Manufacturing class and discovered that engineering students might not thoroughly understand how the curriculum is designed to prepare them for a career in professional practice. Furthermore, findings from the study suggest these students consider engineering practice rather than their experiences in academia as "real world," and therefore they fail to understand how their classroom activities prepare them for professional practice (Dunsmore, Turns, & Yellin, 2011, p. 337). In a separate longitudinal study with 160 engineering students at four universities, Matusovich, Streveler, Miller, and Olds (2009) found seniors who were still uncertain about what it means to be an engineer and what engineers actually do in practice.

Like engineering students, many early-career engineers often have inaccurate perceptions of engineering practice. In a qualitative study considering early-career engineers in multiple countries, Trevelyan (2010) found that engineers in practice often define engineering work as technical activities, such as performing calculations and designing artifacts. These engineers underestimate the importance of social interactions in engineering settings (Trevelyan, 2010; Faulkner, 2007). The findings of these research studies indicate that many students graduate from engineering programs without fully understanding what they are expected to do. This lack of understanding could explain why employers claim that undergraduate engineering programs do not adequately prepare early-career engineers for work in engineering practice (Brunhaver, Korte, Barley, & Sheppard, 2017). In response, engineering programs have improved their curricula to offer various opportunities for engineering students to gain pre-professional experiences, and some employers provide onboarding programs for early-career engineers to enhance their technical skills and learn professional expectations. The following sections describe these pre-professional opportunities and onboarding programs.

2.3 University Curricula and Preparedness

In the past, employers have complained that undergraduate curricula failed to prepare engineering students successfully for practice. In response, many universities in the United States have transformed their curriculum to improve its quality and meet the ABET accreditation standards. According to Moskalik (1994), educational design is changing as academia reinvents the engineering educational process to make academic training more relevant to engineering practice. The engineering curricula underwent several changes over the years. In the 1990s, the National Science Foundation sponsored eight coalitions of colleges and universities to improve engineering education. One of the coalitions was the Foundation Coalition. The NSF challenged this coalition, which is an alliance of seven colleges and universities, to rethink their pedagogy and to innovate new curricula for engineering (Cordes, Evans, Frair, & Froyd, 1999). The consortium of universities in the Foundation Coalition shared a common mission to collaboratively implement changes in the engineering curriculum that extend the experience of engineering students beyond the traditional classroom environment (Cordes, Evans, Frair, & Froyd, 1999). Although the NSF coalitions program is no longer active, it reshaped academia in that most universities have revamped their engineering curricula to better align with the needs in engineering practice. This alignment was achieved by incorporating the learning of technical and non-technical skills via design projects while incorporating contextual activities that helped students draw relationships between social and academic domains.

Other NSF programs include the Department Level Reform program, which spawned innovations such as Purdue's Multidisciplinary Engineering program (Daniels, Wood, & Kemnitzer, 2011), and the recent Revolutionizing Engineering Department (RED) program, which aims to redesign engineering and computer science curricula and change departmental cultures to improve the professional development of undergraduate students (NSF.gov). In the next section, the researcher examines undergraduate experiences that are designed to prepare engineering students for engineering practice.

2.4 Undergraduate Experiences and Preparation for Engineering Practice

2.4.1 Cooperative Education and Internship Experiences

Cooperative education is defined as a structured approach to learning which integrates classroom learning with practical work experiences, in a discipline that supports their academic and career goals (CREED n.d.). Cooperative education programs are typically designed as a partnership between universities, employers, and students (American Society for Engineering Education, n.d.). Cooperative education adopts the experiential approach to learning developed by philosopher John Dewey, who believed that all meaningful education includes experiential learning (Dewey, 1938). Dewey explained the importance of experiential learning in educational experiences, and that practical experience must be meaningful to the student's education goals (Dewey, 1938). For engineering students, cooperative and internship experiences constitute an introduction to engineering practice (Sheppard, Matusovich, Atman, Streveler, & Miller, 2011).

According to Haddara and Skanes (2007), research studies on cooperative education between the 1960s and 1980s had a narrow focus; some studies contradicted one another and the findings of these studies were not generalizable. Although several studies discussed "what is believed about co-op" (Finn, 1997, p. 38), they lacked rigorous arguments for the validity of the findings. Yet, recent research on cooperative and internship experiences has conclusively demonstrated that there is value in cooperative programs. According to Parsons, Caylor, and Simmons (2005), cooperative education experiences can inspire intellectual stimulation. These experiences help students gain both non-technical and technical skills that can enhance problem-solving abilities that are desirable to employers.

In a report titled *Employers' perceptions of the employability skills of new graduates*, a senior engineer at a food production company noted that he would prefer to hire an engineering graduate some experience. He explained that besides technical skills, he considers life skills and previous work experience in addition to the engineering graduates' collegiate experience (Lowden, Hall, Elliot & Lewin, 2011). Furthermore, Parsons, Caylor, and Simmons (2005) examined the benefits of cooperative experiences on first-term co-op students. Their findings further suggest that students learn how to use techniques, skills, and modern tools, and they gain a clear understanding of the professional and ethical responsibilities of an engineer in practice. Still, of all the desirable skills, co-op students were least likely to learn effective written communication, design, and conduct of experiments (Parsons, Caylor, & Simmons, 2005). Internships and cooperative experiences help students to see the relevance in the classroom experience (Wilson, 1987) and help students to develop competencies necessary to succeed in engineering practice (Brumm, Hanneman, & Mickelson, 2005). Furthermore, a student's opportunity to gain work experience enhances their exposure to industry dynamics. This experience also enhances their preparedness for professional practice (Lowden et al., 2011; Parsons, Caylor, & Simmons 2005; Haag, Guilbeau, & Goble, 2006; Billet, 2011).

Although many praise the concept of cooperative and internship experiences, some critics of cooperative education argue that it is difficult to quantify the effects of the experience and to correlate these effects with educational and industry objectives (Hackett, Martin, & Roselli, 1998). Korte, Brunhaver, and Sheppard (2015) have called for further research to better understand how cooperative education and internship programs enhance the experiences of engineering students. This call for more research suggests that future studies should consider how cooperative programs and internships prepare engineering students for full-time employment in practice. In response to this call, this dissertation study includes cooperative education and internships among the undergraduate experiences that are considered as potential influences on the preparation of early-career engineers.

The benefits of partnerships between universities and industry are evident in the outcomes both for student preparation and for the organizations that employ these students. There are various reasons why employers might participate in cooperative education programs. Braunstein and Stull (2001) surveyed 93 employers who participated in such programs. The results of the study demonstrate that employers often use the co-op program to screen potential employees and to find passionate workers. These employers also see the partnership with the university as a positive way to interact with an academic institution and use the program to hire workers for special projects. Some of the other advantages of cooperative programs for employers are that they facilitate entry-level recruiting, improve access to and by minority employees, and boost average retention (Brown, 1987). Today, advocates of cooperative education continue to emphasize the value of these programs and employers continue to invest in partnerships with universities. Although participation in an internship or cooperative experience is not a requirement for engineering students at most universities, many students gain similar pre-professional experiences through capstone design projects, which are described in the next section described in the next section.

2.4.2 Capstone Design Experiences and Engineering Curricula

To be accredited, a university's engineering program must satisfy the criteria published by ABET (formerly the Accreditation Board for Engineering and Technology). One criterion requires a "major design experience" (ABET, n.d.). This experience often takes the form of a capstone design project. Goldberg (2007) described capstone design courses as

> The culmination of a student's first 3 to 4 years of their undergraduate engineering education. They provide students with an opportunity to work in teams and apply what they have learned in previous coursework to the solution of an open-ended real-world problem. Appropriately structured senior design courses also provide students with opportunities to develop their design, analytical, project management, communication (written and oral), and interpersonal (teamwork, negotiation, and conflict resolution) skills. (p. 5)

These projects demonstrate the student's ability to design a system, component, or process to meet desired needs within realistic constraints, and to use techniques, skills, and modern engineering tools necessary for engineering practice (ABET, n.d.). Through the completion of a capstone project, students provide evidence that they achieved ABET objectives by delivering a comprehensive product that synthesizes their knowledge of various topics, demonstration of technical and non-technical knowledge, and utilization of knowledge in practical engineering applications (Otieno & Mirman, 2003).

To date, many research studies have explored the effectiveness of senior capstone design. Researchers such as Anwar and Marchetti (2000); Batzer and Schmidt (2002); Otieno and Mirman (2003); Ward (2013); Jiji, Schonfeld, and Smith (2015); and Hotaling, Fasse, Bost, Hermann, and Forest (2012) found that capstone design projects are effective in teaching technical and non-technical skills and attributes. They also found that these projects provide students with experience working on design tasks in multidisciplinary teams. It is important to acknowledge that to facilitate long-term learning, students need multiple opportunities to develop the skills necessary to progress from novice to expert. Furthermore, students may begin to develop specific skills at the university level and continue to develop these skills during employment.

2.4.3 Service-Learning and Career Development

Capstone projects are one form of project-based learning in engineering. Another form is service-learning. In engineering education, service-learning courses are designed with the addition of characteristics such as community partnership (Bielefeldt, Paterson, & Swan, 2010) and performed in a 'real-world' context that fulfills a community need (Coyle, Jamieson, & Oakes, 2005). Bringle, Phillips, and Hudson (2004) defined service-learning as

> Course-based, credit-bearing educational experience in which students (a) participate in an organized service activity that meets identified community needs and (b) reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of civic responsibility. (p. 227)

Most studies on service-learning focus on student learning outcomes for professional and non-professional skill development (Cannon, Deb, Strawderman, & Heiselt, 2016) and preparedness for work in the industry (Huff, Zoltowski, & Oakes, 2016; Carberry, Lee, & Swan, 2013; Shelby, et al., 2013). Research considering the effects of service-learning on career development suggests that students who participate in service-learning programs have more defined goals than those who do not, and that these students gain pre-professional experience when the service-learning in which they participate aligns with their professional goals (Artale & Blieszner, 2001, as cited in Karlsson, 2016).

Several studies have examined how service-learning prepares engineering students for professional practice (Vaz & Quinn, 2015; Huff, Zoltowski, & Oakes, 2016). For example, Huff, Zoltowski, and Oakes (2016) studied the overall experiences of alumni of the Engineering Projects in Community Service (EPICS) program, which enables students to interact with community partners to solve real-world problems (Coyle, Jamieson, & Sommers, 1997; Jamieson, Oakes, & Coyle, 2002). The study surveyed the alumni of the program to examine how their experience in EPICS helped them develop a variety of professional skills needed in engineering practice. The findings from 523 respondents suggest that their experience with EPICS prepared them to understand design as an iterative process. Furthermore, EPICS helped them to gain a deeper understanding of the design project lifecycle, and to grasp the importance of situated knowledge when designing as a team. In addition, the service-learning pedagogy helps students fulfill many ABET outcomes, such as the abilities to design a system, to function on multidisciplinary teams, and to identify and solve engineering problems (Ropers-Huilman, Carwile, & Lima, 2005).

Research studies on early-career engineers perennially demonstrates that employers desire engineering graduates who possess the skills and attributes gained from programs such as cooperative education and internship experiences, service-learning, and senior capstone design projects. For example, a study of alumni of Worcester Polytechnic Institute conducted by Vaz and Quinn (2015) found that some employers find it beneficial to hire employees with project-based learning experiences.

2.5 Engineering Practice Training and Development Programs

Although capstone projects do much to prepare students for work in engineering practice, some organizations still provide extensive training to early-career engineers to develop the knowledge and skills necessary to succeed on the job. Interestingly, several goals of onboarding programs are also covered in the ABET curricular requirements. This overlap in objectives indicates that both ABET accredited institutions and employers strive to develop similar competencies among engineers. It is important to explore the onboarding program in engineering practice because educational institutions often do not understand how the curricula and extracurricular activities align with how employers onboard engineering graduates. Conversely, employers might not know the true return on investment of their programs if aspects of the program goals have been developed in engineers during their undergraduate experience.

There are many studies on general onboarding in technical fields, especially in the fields of computer technology and software development (Gittleman, Horrigan, & Joyce, 1998; Eriksson & Ortega, 2006). In practice-based learning, employees learn how to become both a competent professional and an innovator in practice during the onboarding process (Johnson & Senges, 2010). This style of onboarding requires employees to participate in communities that allow them to be mentored by senior employees while also taking on small projects. Additionally, this type of onboarding program encourages peer-learning and collaboration with colleagues. These practices increase meaningful interactions among employees, morale, and overall job satisfaction. A study by Fagerholm, Ganchez-Gunea, Borenstein, and Munch (2014) examined the role of mentorship in improving productivity during the onboarding of software developers in virtual teams at Facebook. The study findings indicate that the mentoring support given to the developers made them more active, and that mentorship played a significant role in assisting new employees in selecting tasks and performing them independently.

2.6 Engineering Rotational Onboarding Programs

Engineering onboarding programs have four primary goals: to develop technical skills, to enhance professional skills, to promote networking, and to enculturate newcomers to the organization (General Electric; Lenovo; Babajide, Al Yagoub, & Ohland, 2019). Yet, the focus on knowledge and skills as categorized by the ABET outcomes and the *Engineer 2020* report varies between these programs. Because few of the research studies have explored how these programs prepare engineers for traditional roles, many researchers examine publicly available information from organizations to gain insight. Rotational programs, or "leadership development programs," have evolved into training grounds for early-career engineers who work in fields related to engineering and manufacturing. Employers often have specific requirements such as GPA and soft requirements for applicants such as internship or cooperate education experience (GE), or less than three years of experience in engineering practice (Ford Motor Company). Furthermore, employers have defined goals for their onboarding programs. For example, the purpose statements of the rotational onboarding programs provided by Caterpillar Inc. and Elliot Turbo exhibit their particular goals. The company Caterpillar Inc, noted,

> [Our] Rotational Development program offers you a broad exposure to Caterpillar, presents diverse project responsibilities, engages you in a global team, provides

> cross-functional job experiences and includes valuable networking opportunities with all levels of Caterpillar Leadership. This program provides the foundation for future success of Caterpillar's engineers, technologists, and technical professionals. Product Development Track is a 12-18-month multi-rotational program focused on building technical competency within…full product lifecycle of design, test, simulation, and technical support. (Caterpillar Inc., 2017)

Elliot Group, a global equipment manufacturer, describes their rotational onboarding program as follows:

> The Rotational Engineering program is an introduction to the rotating equipment industry and is designed to provide new engineering graduates with a comprehensive on-boarding and training experience. Incumbents will acquire an understanding of the Elliott organization, our product lines, and the various engineering processes from application to design manufacturing, and aftermarket services. Trainees perform engineering assignments designed to develop professional work knowledge and experience. Projects will vary by assignment but will require the application of engineering theory, standard techniques, procedures and criteria consistent with entry-level engineers. (Elliot Group, 2014)

While these stated goals are not representative of all such programs offered in the industry, these employers state that the key objective of their programs is to "build technical competency" (Caterpillar, 2017) and that new hires learn "various engineering processes from application to design" (Elliot Group, 2014).

Several studies examined the role of such programs in the career development of early-career engineers and suggest that career development outcomes are a primary benefit of those who engage in such programs (Karlsson, 2016). According to Crumpton-Young et al. (2010), organizations such as Lockheed Martin, National Instruments, Raytheon, and GE (formerly General Electric) offer rotational programs to help new engineers transition from academic life to the corporate world. These types of programs consist of leadership training, rotational assignments, and career development activities. The primary goals of the programs include the development of business, technical, and problem-solving skills among new hires. In addition, these programs aim to develop professional skills such as writing, interpersonal skills, and leadership skills (Jollands, Jolly, & Molyneaux, 2012; Spinks, Siburn, & Birchall, 2006).

Rotational programs are widely used by organizations in the product development and manufacturing industries to enhance relevant skills and to develop optimum engineering talent. The administration of such programs is as important as the objectives of the program to ensure positive outcomes. According to Aggour (2009), onboarding programs must not merely be the responsibility of the human resource department, but rather, should reach the technical departments of the organization and require participation from the engineering departments to ensure that early-career engineers develop the necessary technical and professional skills during the onboarding process. Rotational onboarding programs require a collaboration between human resource and engineering departments to improve knowledge and skills of early-career engineers.

2.7 Research Questions

In the engineering education literature, there are few studies of professional development programs in practice. Although these studies examined early-career engineers' transition into engineering practice, these studies did not consider how the undergraduate experiences of early-career engineers connect to their onboarding experience in practice. It is now widely accepted that student learning happens inside and outside of the classroom environments. Consequently, universities are focusing on incorporating activities in and out of the classroom to enhance students' university experience. In a longitudinal study on how undergraduate students are influenced by their university experiences, Astin (1993) found that students who actively participate in academic activities, extracurricular activities, and interact with faculty personnel are more likely to have better academic outcomes. Furthermore, students' interactions with faculty outside the classroom are as important as classroom experiences. These university experiences could determine the retention, success, and personal development of the student (Astin, 1984; Pascarella & Terenzini, 1991; Tinto, 1993). Part of the aim of this dissertation study is to consider the undergraduate experiences of early-career engineers that contribute to their knowledge and skill gain in practice.

Previous studies investigated the socialization process of onboarding, but few have explicitly considered the knowledge and skills gained by early-career engineers in rotational onboarding programs. Conducting research on onboarding programs in engineering practice could also clarify what contributes to early-career engineers' ability to succeed and to become lifelong learners. This dissertation study explores the perceived knowledge and skills that early-career engineers gain in ROPs and as direct-hires to understand factors that contribute to their perceptions. A *direct-hire* is defined as an early-career engineer who did not participate in an ROP. This dissertation study is organized to address the following four research questions:

RQ1: What are the differences in the perceived level of knowledge and skills gained between the university experience and experiences of ROP and direct-hire early-career engineers?

RQ2: How do the backgrounds of early-career engineers, such as demographic factors and university environment, relate to their ability to perform in engineering practice?

RQ3: How do the academic and non-academic experiences of early-career engineers relate to their ability to perform in engineering practice?

RQ4: What are the similarities and differences in the experiences of ROP and direct-hire early-career engineers?

2.8 Conceptual Framework

Because this dissertation concerns the school-to-work transition, learning outcomes, and early-career success, it requires a conceptual framework that considers the university experience, onboarding program experiences, and perception of knowledge and skills gained during the onboarding process in engineering practice. The conceptual framework for this dissertation is primarily informed by the framework of Volkwein, Terenzini, Strauss, and Sukhvaatar (2004), which captures the influence of the ABET EC2000 accreditation criteria on the curriculum, faculty culture, and policies of engineering programs in universities. The framework of Volkwein et al. (2004) describes the extent to which the ABET EC2000 accreditation criteria influence the engineering student experience at a university from a programmatic standpoint, student engagement with the learning process, and the employer’s perspective on preparedness for work in engineering practice. Additionally, the framework of Volkwein et al. indicates that institutional context and peer environment influence students’ outcomes (Volkwein et al., 2004). Furthermore, the framework shows how the EC2000 criteria influence internal organizational factors such as curriculum and instruction, organizational policies and practices, and faculty culture in engineering programs.

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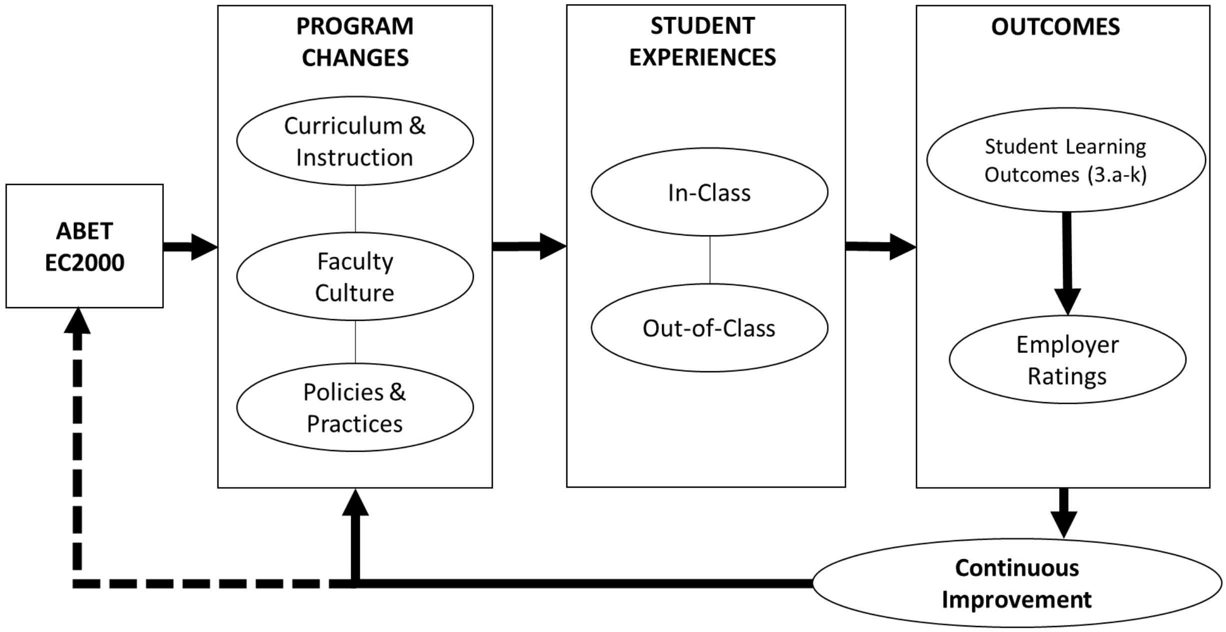

Figure 2-1. Conceptual framework for study. Taken from Volkwein et al. (2004).

ABET Outcomes

ABET requires accredited programs to demonstrate that engineering students achieve specific outcomes in technical and non-technical knowledge, skills, and attributes. In this dissertation, references to knowledge and skills align with the definition of competencies by Passow (2012), who stated,

> Competencies are defined as the knowledge, skills, abilities, attitudes, and other characteristics that enable a person to perform skillfully (i.e., to make sound decisions and take effective action) in complex and uncertain situations such as professional work, civic engagement, and personal life. (p. 97)

Universities are required to develop curricula that enable engineering students to acquire the knowledge and skills specified in the ABET EC2000 criterion 3, which prepares students for engineering practice[4]. Although the new ABET criteria took effect during the 2019–2020 school year, the population in this study graduated from university in 2018 or earlier. Therefore, the researcher used learning outcomes a–k in EC2000 criterion 3 in this study.

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[4] Recently, ABET has changed the criteria for engineering accreditation. These changes took effect starting with the 2019–2020 school term (ABET, 2017). The major difference between the old and the new student learning outcomes in criterion 3 is a reduction from 11 total outcomes to 7 outcomes. Additionally, the new criteria omits two of the old criteria: life-long learning and the use of engineering tools.

The 11 ABET EC2000 outcomes are

a. an ability to apply knowledge of mathematics, science, and engineering;

b. an ability to design and conduct experiments, as well as to analyze and interpret data;

c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;

d. an ability to function on multidisciplinary teams;

e. an ability to identify, formulate, and solve engineering problems;

f. an understanding of professional and ethical responsibility;

g. an ability to communicate effectively (orally, written);

h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;

i. a recognition of the need for, and an ability to engage in life-long learning;

j. a knowledge of contemporary issues; and

k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. (ABET, 2016)

Students can achieve these outcomes through both curricular and co-curricular activities. These activities include pre-professional internships, cooperative work experiences, and participation in team projects, both on and off-campus (Shuman et al., 2005). Because students who achieve these outcomes have the competencies needed in engineering practice, many employers require applicants for engineering positions to have degrees from ABET-accredited programs (Babajide, Al Yagoub, & Ohland, 2019). These employers continue building the competencies of their new engineers in onboarding and training programs.

Like Volkwein et al. (2004), Terenzini and Reason (2005) present a framework that incorporated aspects of the engineering student experience; however, Terenzini and Reason identify more details about the overall student academic experiences. For example, the framework of Terenzini and Reason (2005) offers an explicit and detailed mapping of the factors that influence student success during their university life, especially in their first year. This framework also assumes that students enter the university with a variety of background characteristics, e.g., personal, academic, and social (Terenzini & Reason, 2005). Furthermore, students' past experiences are also important in preparing and influencing them to attain their degree choices. Students' prior experiences influence how they engage in the different opportunities and experiences that their institutions offer. Even though this framework mainly considered the first-year university experiences, it can be used to examine the effects of the overall university experience for students.

The frameworks of Terenzini and Reason (2005) and Volkwein et al. (2004) consider student experiences, namely, classroom, out-of-classroom, and curricular experiences that constitute the peer environment (see Appendix L for descriptions of each experience). All student experiences are situated within the context of the university's characteristics, policies, structure, environment, faculty, and peer cultures.

The frameworks of Volkwein et al. (2004) and Terenzini and Reason (2005) describe only the university experiences of engineers. Because this dissertation examines how early-career engineers' competencies develop between their university experiences and their onboarding experiences, the Social Cognitive Career Theory (SCCT) developed by Lent, Brown, and Hackett (2002), shown in Figure 2, was also adopted to aid in exploring where early-career engineers perceive their gain in knowledge and skills in preparation for their engineering career.

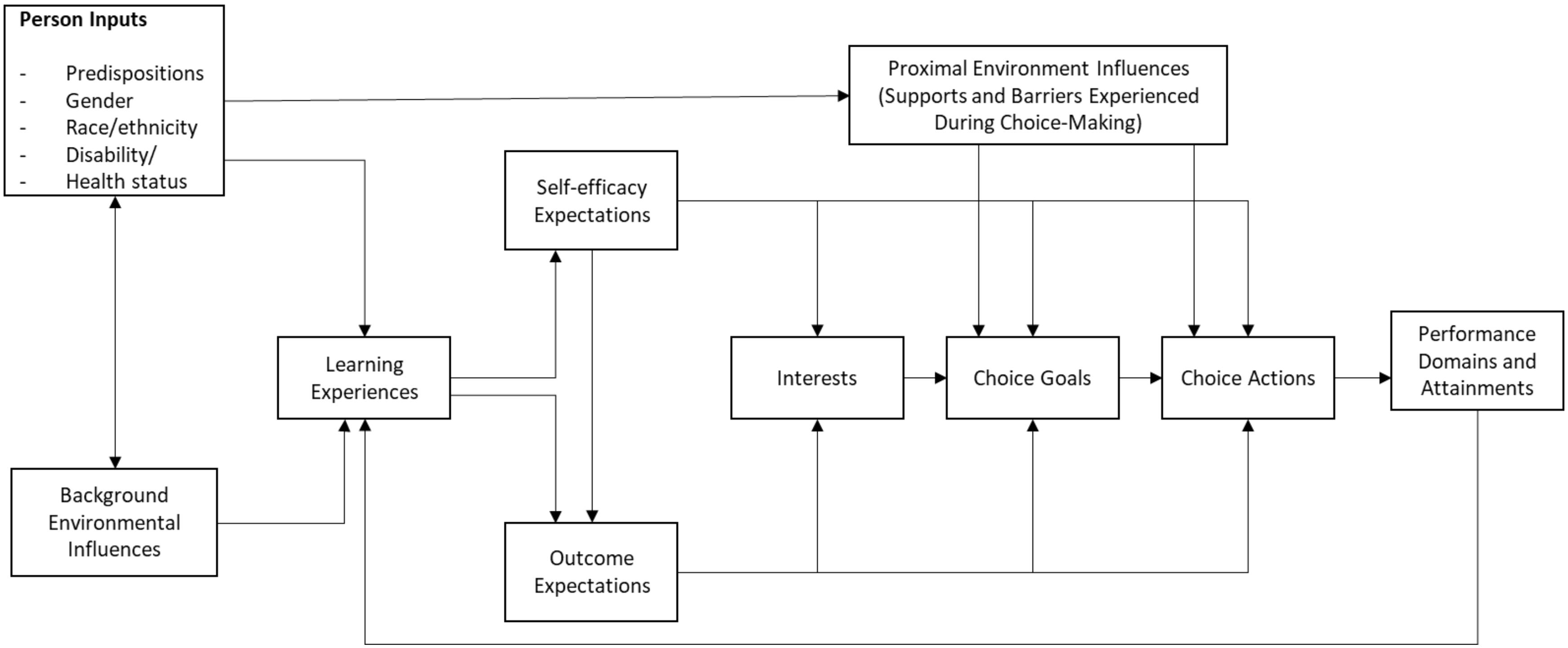


Figure 2-2. View of how career-related interests and choices develop over time (SCCT). Taken from Lent, Brown, and Hackett (1994) as cited by Lent, Brown, and Hackett (2002).

SCCT theory acknowledges the role of the learning experiences that early-career engineers perceive from their university experiences to frame their expected outcomes as engineering graduates and professionals. According to Lent, Brown, and Hackett (2002), SCCT is a theory designed to describe three interconnected features of career development: development of fundamental academic and career interests, decisions of educational and career choices, and achievement of academic and career success. This dissertation focuses on the third feature in conceptualizing the study shown in Figure 2. Built on three variables—self-efficacy beliefs, outcome expectation, and goals—SCCT reckons that people perform at a higher level in activities in which they have strong self-efficacy based on their individual beliefs, and if they have the skills and conducive environment to perform such activities.

According to SCCT, undergraduate learning experiences increase self-efficacy, which can influence the perceived outcomes of the engineers' experiences and, in turn, influence their outcome expectations after a rotational onboarding program. For example, students who chose cooperative education throughout their undergraduate studies might have developed a higher self-efficacy about their abilities as new engineering graduates and report smaller gains in knowledge and skills from their ROP than those without a co-op assignment or internship.

As shown in Figure 2.3, the conceptual framework for this dissertation combines ideas from the framework of Volkwein et al. (2014) and the framework of Terenzini and Reason (2005), and from SCCT. From Volkwein et al., this dissertation framework incorporates the influence of ABET EC2000 on undergraduate experiences, which are divided into two components: Program Context and Peer Environment. The Peer Environment component corresponds to the Student Experiences component of Volkwein et al. From Terenzini and Reason, the Program Context comprises four parts: Leadership; Organizational Structures, Policies, and Practices; Academic and Co-Curricular Programs, Policies, and Practices; and Faculty Culture. In addition from Terenzini and Reason, the Peer Environment component has three parts: Classroom Experiences, Out-of-Class Experiences, and Curricular Experiences. As in SCCT, the undergraduate learning experiences influence the self-efficacy of engineering students. Upon graduation, early-career engineers enter Employer Onboarding, which has four parts: Networking, Corporate Culture, Technical Elements, and Professional Elements.

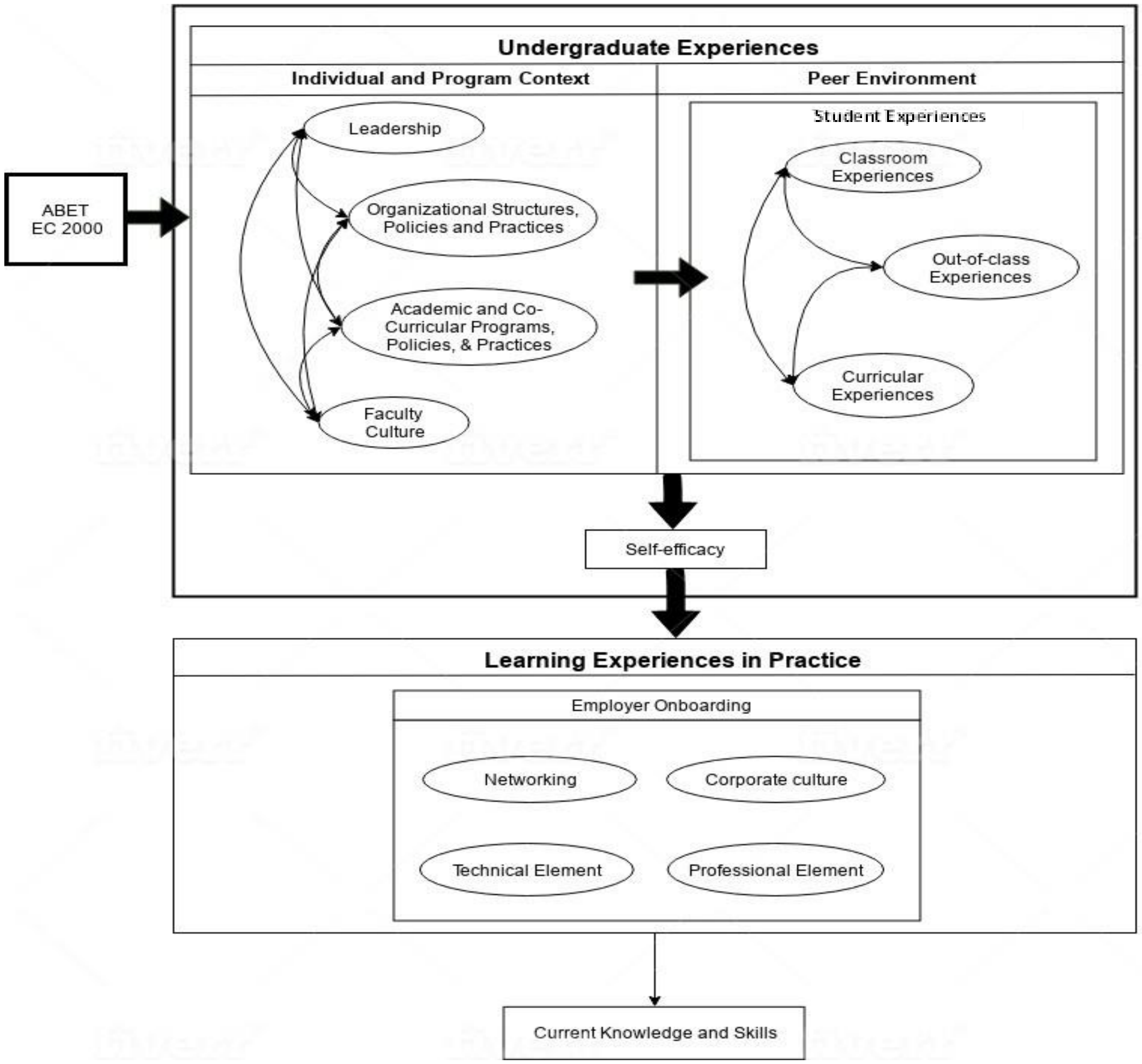


Figure 2-3. Conceptual framework for dissertation.

The conceptual framework for this dissertation implicitly captures these five assumptions:

a) Engineering students' experiences are strongly influenced by the ABET accreditation requirements.
b) Universities design their engineering programs and offer curricular and co-curricular programs to help students achieve ABET outcomes.
c) Students meet these outcomes through various means such as curricular and co-curricular activities like cooperative education and internship experiences, service-learning experiences, and capstone design.

d) These experiences provide opportunities for work readiness developmental activities in ABET-accredited programs.

e) Some employers in engineering practice offer rotational onboarding programs to enhance the knowledge and skills of new engineering graduates for traditional roles in their organization.

Conceptualized with the ABET outcomes as a backdrop, this conceptual framework describes how the university and onboarding program experiences of early-career engineers impact their career and success in engineering practice. This conceptual framework informs the design of this study and the interpretation of the results. From the framework, the researcher uses learning outcomes that align with the 11 ABET outcomes to define the knowledge and skills that early-career engineers first acquire in undergraduate studies and develop further in professional practice. The researcher also uses this framework as a lens for the survey instrument and interview protocol that collected data about how these engineers developed professional competencies through undergraduate experiences and in engineering practice.

CHAPTER 3. METHODS

3.1 Explanatory Mixed-Method Study

This chapter discusses the rationale for using a mixed method study approach and provides details of the context of this study design, including information on participants, survey instrument, reliability and validity, and trustworthiness. The overall goal of this dissertation study is to investigate the knowledge and skills gain of early-career engineers who participated in an ROP. The sample data included direct-hire engineers as a comparison group for the dissertation study. Furthermore, this study is designed to understand how early-career engineers' experiences at the university might have contributed to their perception of knowledge and skill gain. To accomplish this, the researcher decided that a mixed methods approach would be appropriate for this dissertation study because the first research question is a quantitative question designed to compare the knowledge and skill gain of the ROP and direct-hire engineers. On the other hand, the subsequent three research questions are qualitative research questions designed to further understand the experiences of the ROP and direct-hire engineers. This mixed method research approach uses both quantitative and qualitative approaches for data collection and analysis in one study (Plano Clark, 2005; cited in Azorin & Cameron, 2010). The general premise of the mixed method approach is that the use of both qualitative and quantitative methods may provide a more comprehensive understanding of a phenomenon than using either approach alone (Creswell and Plano Clark, 2007; cited in Azorin & Cameron, 2010).

Specifically, the Explanatory Sequential Mixed Method Study (SMM) (See Figure 3.1) is used in this dissertation study. The Explanatory SMM study starts with a quantitative phase and then collects qualitative data to explain the quantitative results and to describe the views of the study's participants in detail (Creswell, 2012). Explanatory SMM has been used in social science studies in various ways. For example, this approach was used in research on two types of teacher-workplace commitments (organization commitment) and student learning commitments in 63 urban elementary and middle schools using a survey and a follow-up case study (Kushman, 1992). In engineering education research, Brawner, Camacho, Lord, Long, and Ohland (2012) used an explanatory SMM study to analyze why undergraduate female engineers were attracted to industrial engineering. The study used a longitudinal dataset of 10,671 students, a focus group of

20 students, and content analysis from a university website. Waller (2016) also used the explanatory SMM study design to examine the interpersonal relationship statuses of 582 first-year engineering students in residential learning communities, using a web-based survey for the first phase of his dissertation research, and 12 student focus groups for the second phase of the study.

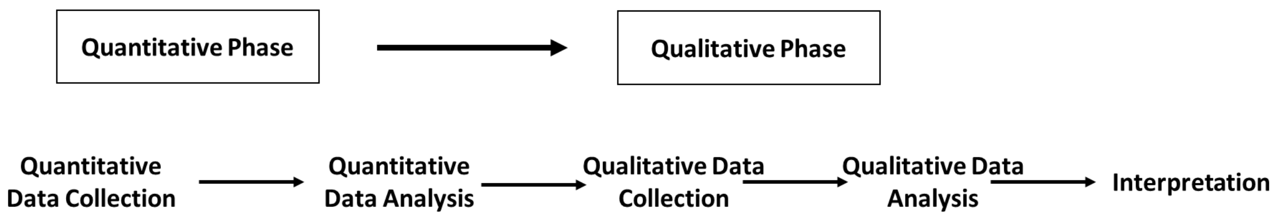


Figure 3-1. Illustration of the structure of a typical sequential explanatory mixed methods study. Terrell (2012)

Previous mixed methods studies in engineering education examined the experiences of students. By contrast, this dissertation study explores early-career engineers who have experienced training in engineering practice. This training often involves a cohort of early-career engineers learning together at different times while also staying connected as a group through social activities. This dissertation study uses a non-experimental design with a survey instrument to provide quantitative data (Creswell, 2012). A phenomenological approach was chosen as the methodology for the qualitative phase of this dissertation study.

According to Creswell (2014), phenomenological research is a research methodology where the researcher describes the lived experiences of individuals about a particular phenomenon as described by the participants. Phenomenological research considers how the individual perceives, describes, feels about, judges, remembers, and talks about their experiences with others (Patton, 2015). This approach also looks at the experiences of many individuals through the identification of shared experiences in order to make meaning of them. Phenomenology has deep roots in philosophy and psychology (Creswell, 2009) and can be used to explore phenomena such as pregnancy, survival, and relationships. Additionally, it can be applied to exploring a particular program as the phenomenon. This dissertation uses a phenomenological approach in exploring an ROP as the phenomenon and direct-hire engineers who did not experience the phenomenon of an ROP by studying how knowledge, skills, and past experiences of engineers related to their onboarding experience in engineering practice.

Phenomenology has been used for studies in engineering as well as developmental programs. For example, Bush (2013) used a phenomenological approach to explore the lived experiences of five black women who were currently employed as engineers. Similarly, Somerville-Midgette (2015) used phenomenology to study the persistence of six African American women who had had over 4.5 years of experience in the engineering industry. Smith (2012) explored the interest and persistence of 17 women majoring in engineering. These previous research studies investigated the experiences of engineers in practice and undergraduate engineering students, which are two populations that are similar to the target population of this dissertation study.

After the researcher analyzed the survey data, she conducted semi-structured interviews to collect data from a sample of engineers who had taken the survey. Table 1 depicts the overall process of this dissertation study:

Table 3-1. Phases, process, procedure, and product of study (Adapted from Creswell, 2012)

Phases of Study	Process	Procedure	Product
Phase 1: QUAN Phase	Data Collection	• Survey instrument • Undergraduate experience • ROP experience	• Survey respondents n=117

	Data Analysis	• Survey data cleaning
		• Test hypothesis using the following methods:
		  • Wilcoxon signed rank test
		  • Mann-Whitney U test
			• Descriptive statistics
			• Inferential statistics

Transition from QUAN phase to QUAL Phase		• Determine participant to recruit • Refine qualitative research questions based on QUAN findings	• Interview protocol • Recruitment materials
Phase 2: QUAL phase	Data Collection	• Send emails to recruit participants • Send/Receive signed consent forms • Recorded interviews (Phone Interview)	• Interview transcripts (n = 25)
	Data Analysis	• Thematic analysis of qualitative data	• Deductive coding • Inductive coding • Find themes
Integration of QUAN and QUAL Results		• Interpretation of findings • Explanation of findings (Using both data sets)	• Discussion • Connection to past research • Implications of findings • Future research

3.2 Population

For this dissertation study, the researcher chose a retrospective design because of its advantages over two alternatives: a longitudinal design and a cross-sectional design. In a longitudinal design, the process entails the collection of data about the same participants over a period of time (CLOSER, 2019). To achieve this, more time would be required to complete the research study than the time appropriate for an average dissertation study. In a cross-sectional study design, data collection would involve using the survey or interview protocol to collect data from a different sample of participants at a specific point in time. For example, a cross-sectional study would require surveying engineering graduates who have accepted employment for an ROP but have not yet attended. This category of engineers will be difficult to reach because engineering graduates who got accepted into an ROP program at their employer's organization and chose to defer their employment to a later start date are no longer at the university but not yet at a place of employment. This gap between graduation and employment makes it challenging to get contact information from human resources and universities that might most not have that information. Therefore, the retrospective approach was preferred for this dissertation study.

All participants in this dissertation study are early-career engineers who graduated between 2012 and 2017 with a bachelor's degree in engineering. Some of these engineers had participated in ROPs. All of these ROPs had required two or more rotational assignments before the final placement. All engineers worked in different capacities in practice such as design engineers, service engineers, manufacturing engineers, quality engineers, and product development. For engineers who participated in an ROP, the companies had a structured rotational program with a specified duration of time. To distinguish between the two groups in the study, engineers who did not participate in an ROP are considered direct-hires. For the qualitative phase of the study, purposeful sampling (Creswell, 2012) was used to select participants who were representative of the population.

3.3 Finding Participants

To gain access to early-career engineers for the study, the researcher followed the suggestions of Chen et al. (2010). These suggestions are highlighted as bullet points in this section.

- Establish partnerships with alumni associations, organizations, and individuals with insight and existing relationships with alumni.

The researcher contacted the office for the Center for Career Opportunity at Purdue University to access the network of employers that have partnered with the university. The researcher also contacted the alumni associations of three universities: Purdue University, University of Michigan-

Dearborn, and Temple University. Furthermore, the researcher leveraged professional organizations such the national office of the Society of Women Engineers (SWE), the Institute of Electrical and Electronics Engineers (IEEE) Young Professionals, and the professional chapter of the National Society of Black Engineers (NSBE) through platforms such as LinkedIn and GroupMe, and via emails and a follow-up with phone calls in some cases to responsible parties (See Appendix B). The researcher followed up with her professional network to directly reach potential participants. Furthermore, the researcher attended a National Association of Colleges and Employers (NACE) conference in New Orleans to network with representatives of universities and employers, and offered them a one pager of the benefits of the study (See Appendix D).

- Consider how well the sample size represents the target population and strategies to increase the participant response rate.

- Explore other avenues besides email lists such as social media, networking sites, events, and disciplinary organizations in the recruitment plan.

Some of the organizations and alumni associations, such as SWE, NSBE, and the University of Michigan-Dearborn used social media to reach the engineers for this study. This strategy helped gain participation from the target population.

- Consider offering incentives, but there might be other motivators for alumni to participate.

Three raffle draws of $250 were held for survey participants and $25 Amazon gift card was offered for every interview participant.

- Consider the timing of the survey invitation and reminders for better outcomes.

The interviews were scheduled using a scheduler with time slots available during a typical lunch break (between 11:00am and 1:00pm EST) and after business hours (after 4:00pm EST) to give busy professionals options to choose from that fit their schedules.

- Be patient in drafting the text for the survey invitations, reminders, and other communications. Iterate as much as possible for clarity. (Chen et al., 2012, p. 11-12).

Although efforts were made to encourage corporate-level participation through the human resource departments of several engineering and manufacturing companies through email and phone calls, none of the 68 companies the researcher attempted to contact participated in the study. Instead, participants were successfully reached through other means.

3.4 Phase 1: Quantitative Phase

In the quantitative phase, the researcher focused on research question RQ1. This research question is designed to answer the first research question which compares the experiences of ROP and direct-hire engineers using a survey instrument. The question posed is designed to compare the responses of the engineers based on 11 outcomes. The research question is,

- What are the differences in the perceived level of knowledge and skills gained between the university experience and experiences of ROP and direct-hire early-career engineers?

3.4.1 Survey Instrument

The survey instrument used for this study had been developed for the Prototype-to-Production (P2P) study (Lattuca & Terenzini, 2014), a large study on the effects of ABET's outcomes-based EC2000 accreditation criteria and information gathered from the Engineer of 2020 National Advisory Board. The P2P study was designed to understand the alignment of current undergraduate engineering programs with the characteristics of *The Engineer of 2020: Visions of Engineering in the New Century* (2004). There were six surveys in total, one survey for each of the six target populations. One of these surveys, which targeted engineering alumni, assessed the effectiveness of current engineering programs to prepare engineers for the future. The other five surveys for the other five populations were administered to current engineering students in a four-year institution, current students in a two-year institution/community college, faculty members, engineering program chairs, and administrators (Lattuca, Terenzini, Knight, & Ro, 2014). This dissertation study used the alumni survey instrument because it encompasses the retrospective nature of this study's research design. The survey was used to compare the level of knowledge and skills gains at the university level and the respondents' current skills level in practice. Interested readers are encouraged to peruse the full report from the longitudinal study report by Lattuca et al. (2014). The alumni survey instrument of Lattuca et al. (2014) was designed to compare the experiences of early-career engineers in their senior year in college to their current experiences in the workforce retrospectively. However, this dissertation study explored the undergraduate experiences of the engineers and their onboarding experiences in engineering practice.

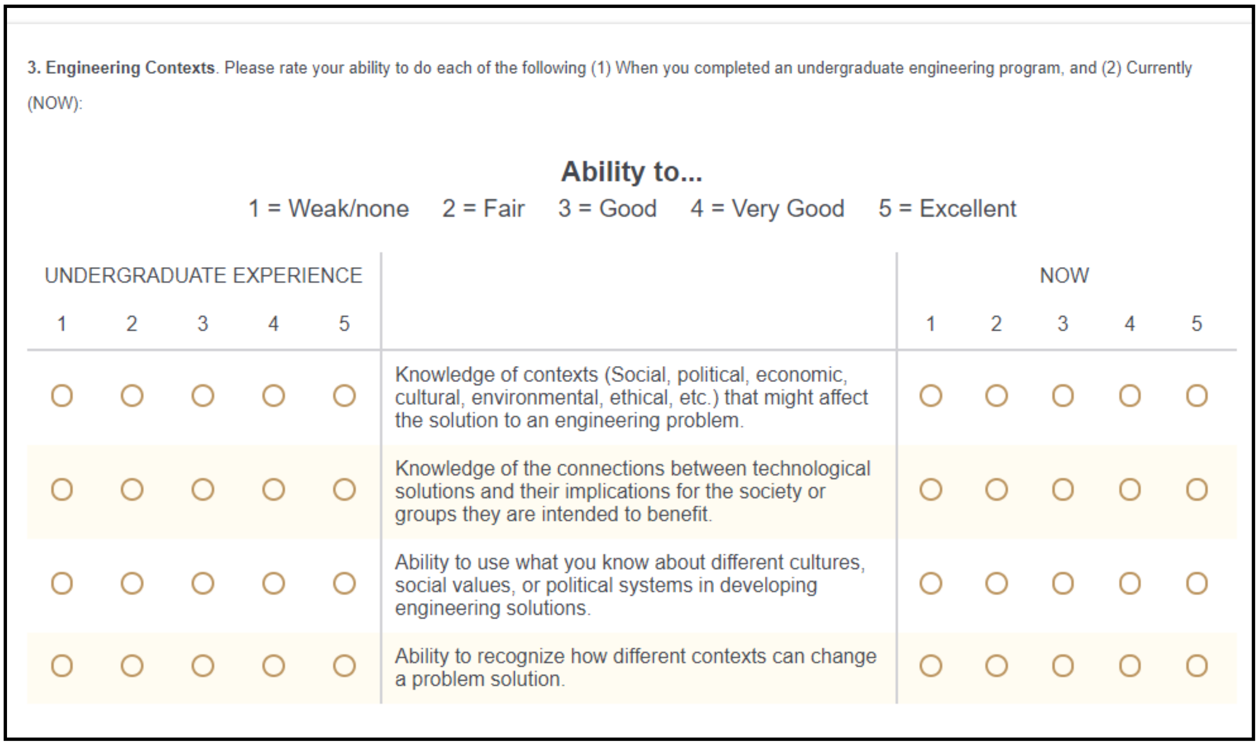
The P2P survey instrument was based on ABET outcomes criterion 3 for engineering programs. If in fact these criteria are met, then it is logical to hypothesize that new engineering graduates are prepared for work in engineering practice. Because the dissertation study population consists of engineers who graduated from ABET-accredited programs, it is expected that these engineers would have achieved each of the ABET outcomes at some level of proficiency during their undergraduate studies.

The survey instrument used in this study has 75 items, divided into 12 sections (see Appendix F). The final section asks questions about the duration of time the participants spent in non-academic experiences such as study abroad, internships, and volunteering activities. Each of the other 11 sections measures one learning outcome. For example, for the Engineering Contexts learning outcome, the corresponding section of the survey has four items, as shown in Table 3.2. These 11 learning outcomes do not correspond exactly to the 11 outcomes in ABET's criterion 3. Yet, the nature of the questions is consistent with the ABET outcomes. For example, the *Topics in Engineering* section in this survey has an item that asks about the emphasis on ethical issues in practice. This item is covered in ABET outcomes 3f – to have an understanding of professional and ethical responsibility. The survey instrument contains items on design, project management, engineering context, communication, teamwork, leadership, interdisciplinary skills, problem definition, recognizing perspectives, professional skills, and problem-solving skills. Furthermore, most of the survey items can be mapped back to the 11 ABET outcomes. The survey instrument is appropriate for this dissertation study because it measures competencies that are similar to the ABET outcomes, but it also includes items on project management and leadership, which are not among the ABET outcomes. In addition to the 12 sections, the survey contains background and demographic items such as ethnicity/race and gender, graduation year, and the participants' current role at their workplace.

Table 3-2. Survey Learning Outcomes and Sample of Survey Items

Learning Outcomes of Each Section	**Number of Survey Items**	**Example of Survey Item**
Define Problems and Generate Design Solutions	10	Evaluate design solutions based on a specified set of criteria.
Manage a Design Project	5	Monitor the design process to ensure goals are being met.
Engineering Contexts	4	Ability to use what you know about different cultures, social values, or political systems in developing engineering solutions.
Communication	6	Communicate effectively with clients, teammates, and supervisors.
Teamwork	4	Work with others to accomplish group goals.
Leadership	4	Develop a plan to accomplish a group’s or organization’s goals.
Interdisciplinary Knowledge and Skills	8	In solving engineering problems, I often seek information from experts in other academic fields.
Recognizing Perspectives	6	I usually know when my own biases are getting in the way of my understanding of a problem or finding a solution.
Topics in Engineering	9	How much did the courses in your undergraduate engineering program emphasize how theories are used in practice and how important are they now?
Professional Skills	6	How much did the courses in your undergraduate engineering program emphasize leadership skills and how important are they now?
Problem Solving	6	How much did the courses in your undergraduate engineering program emphasize systems thinking and how important are they now?

For example, one survey item in the section on Engineering Contexts asks participants to rate their knowledge and ability to recognize how different contexts can change a problem solution. The respondent must select from a scale of 1 – 5 for each survey item. A selection of 1 (Weak/None) means that the respondent perceives weak or no knowledge or ability to recognize how different contexts can change a problem solution. A selection of 5 (Excellent) means the respondent has an excellent ability to recognize how different contexts can change a problem solution. Each respondent was invited to answer the same question twice, once for their undergraduate experience and once for "Now" – the respondents' current skills level (See Figure 3.2).



3. Engineering Contexts. Please rate your ability to do each of the following (1) When you completed an undergraduate engineering program, and (2) Currently (NOW):

Ability to...

1 = Weak/none 2 = Fair 3 = Good 4 = Very Good 5 = Excellent

UNDERGRADUATE EXPERIENCE						NOW				
1	2	3	4	5		1	2	3	4	5
○	○	○	○	○	Knowledge of contexts (Social, political, economic, cultural, environmental, ethical, etc.) that might affect the solution to an engineering problem.	○	○	○	○	○
○	○	○	○	○	Knowledge of the connections between technological solutions and their implications for the society or groups they are intended to benefit.	○	○	○	○	○
○	○	○	○	○	Ability to use what you know about different cultures, social values, or political systems in developing engineering solutions.	○	○	○	○	○
○	○	○	○	○	Ability to recognize how different contexts can change a problem solution.	○	○	○	○	○

Figure 3-2. Sample: The four items in the "Engineering Contexts" section

According to the survey platform Qualtrics, the approximate time for survey completion was 14 minutes. The survey duration agrees with studies of undergraduate students that suggest that the ideal duration of a survey study is 14 minutes or less to achieve good response (Asiu, Antons, & Fultz, 1998; Handwerk, Carson, & Blackwell, 2000). The survey instrument was available for 90 days from the date of initial distribution to allow busy engineering professionals to complete it as their schedule allowed.

An initial email was sent to professional organization representatives, university alumni associations, and company representatives to introduce the study, and to solicit these entities to gauge their interest. Where there was interest, a link to the survey was sent with the IRB approved information. In some cases, a social media post was agreed upon which was sent out through Twitter and LinkedIn (See Appendix E Social media post). For organizations that participated by email, two reminder emails containing instructions to take the survey were sent to participants over the course of 90 days.

3.4.2 Quantitative Data Collection

In the late fall of 2018, the researcher administered the survey online, as Baruch and Holtom (2008) showed that in organization related studies, electronic data collection yields a higher response rate than mailing surveys. For example, in the PEARS pilot study, Chen et al. (2012) sent solicitation email messages to 1,896 university alumni and received 543 responses, a response rate of 28%.

For this dissertation study, all participants received an introductory email message that included a link to the survey. Once the participant clicked on the survey link, the first screen of the online survey had information about the purpose, the estimated time to complete the survey, and the consent indication. A participant who did not indicate consent by clicking the "Accept" button was not allowed to take the survey. Once the participant consented to the survey, the survey began with questions on the 11 outcomes followed by the demographic questions such as gender, race, and the type of school attended. The survey included instructions to help guide participants through every section (See Appendix B).

All 117 respondents worked in the engineering industry. Sixty-seven of the engineers worked for several companies that have ROPs as part of their onboarding process for new engineers, with a minimum of two rotations in the program preceding final placement. The other 50 engineers worked for employers without a rotational onboarding program (direct-hire engineers). The survey respondents consisted of 35% female and 65% male. The most represented group was Caucasian respondents at 71.8%, while the least represented group was Hispanic/Latino participants. All of the major engineering discipline categories were represented, and all respondents graduated from their undergraduate studies between 2012 and 2017. Below is the table of attributes of the survey participants in Table 3.3.

Table 3-3. Table of attributes of the survey participants

		# of Respondents	%Total	%ROP	%Direct-hire
	Direct-hire	50	42.7		
	ROP	67	57.3		
	Gender				
	Female	41	35.0	34.3	36
	Male	76	65.0	65.7	64
Race/Ethnicity					
	African American	7	6.0	6.0	6
	Asian/Pacific Islander American	15	12.8	10.4	16
	Caucasian/White	84	71.8	73.1	70
	Hispanic or Latino/a American	5	4.3	3.0	6
	Others	6	5.1	7.5	2
Major					
	Aerospace Engineering	11	9.4	10.4	8
	Biomedical Engineering	6	5.1	3.0	8
	Chemical Engineering	13	11.1	10.4	12
	Civil Engineering	3	2.6	4.5	0
	Electrical and Computer Engineering	15	12.8	15.0	11
	Environmental Engineering	1	0.9	0	2
	Industrial and Systems Engineering	17	14.5	13.4	16
	Materials Science and Engineering	4	3.5	3.0	4
	Mechanical Engineering	41	35.0	34.3	36
	Others	6	5.3	6.0	4
Year of Graduation					
	2012	17	14.5	10.4	20
	2013	15	12.8	16.4	8
	2014	25	21.4	22.4	20
	2015	18	15.4	17.9	12
	2016	18	15.4	13.4	18
	2017	24	20.5	19.4	22

3.4.3 Quantitative Data Cleaning

A total of 346 engineers started the survey. The researcher eliminated the survey response from one engineer who had not checked "Yes" on the initial consent form. The researcher eliminated responses from 120 engineers who had not answered at least 75% of the questions; the eliminated responses were only 2% to 42% complete. From the remaining 225 responses, the researcher eliminated responses from 85 engineers who had spent less than six minutes on the survey. The rationale for this elimination was that Qualtrics estimated that completing the survey would take 14 minutes, and the researcher decided that engineers would need at least half of this nominal time, that is, at least seven minutes, to respond thoughtfully. The researcher then eliminated responses from seven engineers who indicated that they did not work for a product development or manufacturing company. Finally, the researcher eliminated responses from 15 engineers who had graduated before 2012. After these steps, responses from 118 engineers remained. To further ensure the validity of the survey responses, a survey item was put in place to verify if the participants were paying attention to the survey items. To ensure that the engineers were paying attention, the researcher included an item in the Engineering Contexts section that asked the engineer to choose "Very Good." Only one engineer failed to choose "Very Good," and that response was eliminated. This left a total of 117 survey responses. According to answers to question 34, 67 engineers had participated in an ROP and 50 had not.

One change was made to the survey. Due to the ambiguous wording of the item on the length of time participants spent in an ROP, question 34b was eliminated as a bad item because it did not specify the word “Rotational” but rather simply asked for the duration of their onboarding program.

3.5 Phase 2: Qualitative Research Design.

3.5.1 Pilot Study

Pilot-test Interview Questions Development

The initial semi-structured interview questions were designed to follow the guidelines for a phenomenological study as described by Jones, Torres, and Arminio (2014). The initial interview questions as shown in Table 3.4 evolved after going through an iterative process and were eventually piloted.

Table 3-4. Adapted from Jones, Torres, and Arminio (2014).

TYPE	**SAMPLE QUESTIONS**
Background	How many years have you been working in engineering practice? What was your reason to accept an offer for an ROP versus direct employment?
Behavior or Experience	Can you describe your experiences at the beginning of the ROP? How was the transition from being a student to the ROP? Tell me about some of your positive experiences during the program. Tell me about some of the most challenging experiences during the ROP.
Opinion or Value	Of your experiences at your university, which one do you most value? Which of your university experiences (classroom and non-classroom) do you believe was the least important to your ROP experience?
Knowledge	What percentage of those in your cohort come from a similar background as you? How did this influence your experience of the ROP?
Feeling	What feelings come up for you when discussing your undergraduate experience? How did you feel when you started the onboarding program? What did you feel when you left the program in relation to expertise, competence, and preparedness?
Sensory	Did you have periodic meetings with members of your cohort? Describe for me in as much detail as you can what the cohort meetings were like.
Probing	Can you give me an example of a technical challenge you were asked to address during your program that you were unsure how to address? How did you navigate it? What was that experience like for you? How so?

Pilot study participants

For the pilot study, the researcher interviewed three engineers. The interviewed engineers were chosen for the pilot study from the list of engineers who in the survey responses indicated that they would like to participate in an interview, but did not meet the criteria for the study because two of the engineers graduated before 2012, one had participated in an ROP, and the other was a direct-hire. The third engineer was a PhD student who had internships but did not work in engineering practice. The interview for the three engineers was a phone interview and was recorded. An email was sent to the engineers inviting them for the interview and a time slot was scheduled at their convenience.

Pilot study analysis and revisions

Each pilot interview was recorded and two were transcribed. The following are the outcomes of the pilot study:

- During the first pilot interview, the researcher realized that some of the interview questions were asking the same things and that the point of the RQ2 was to understand the experience of diverse people and how that diversity might have contributed to their experiences as an undergraduate student and at work in engineering practice. This question needed to be clarified.

- Responding to the diversity question seemed uncomfortable to the participant as initially stated. The researcher adjusted the question to clarify the intent of the question. For example, modified, "How would you describe the diversity of the employees at your company?" to "If you were to describe your colleagues at work, how would you describe the general composition at your employer's organization?"

- The researcher also considered and added short background information about herself before the interview commenced to make the participants feel more comfortable relating to her as someone who had also spent some time in engineering practice.

- Moved section 3 to section 2 (See Appendix A) to allow the participants to get comfortable sharing their experiences so that the diversity questions transition seamlessly and help participants see the connection to the research study about undergraduate experiences and early-career experiences in engineering practice.

- Questions about perception of undergraduate experiences were also clarified. For example, one of the questions asked, "What feelings come up for you when discussing your undergraduate experience?" This was modified to ask, "Reflecting back on your first 2 years in engineering practice *(If participated in an ROP, ask using ROP instead of "first 2 years in engineering practice),* what would you say about your undergraduate experience and preparation for work in engineering practice?"

After the pilot study, the final version of the interview protocol was used for this dissertation study (See Appendix A).

3.5.2 Qualitative Research Question:

The qualitative phase of the sequential explanatory mixed method research study is designed to answer the second, third, and fourth research questions:

> RQ 2: How do the backgrounds of early-career engineers, such as demographic factors and university environment, relate to their ability to adapt in engineering practice?'

> RQ3: How do the academic and non-academic experiences of early-career engineers relate to their ability to perform in engineering practice?
>
> RQ4: What are the similarities and differences in the experiences of ROP and direct-hire early-career engineers?

The study was conducted through semi-structured interviews to understand the engineer's experiences during their undergraduate studies and during their onboarding experience in engineering practice.

According to Patton (2015), a general phenomenological perspective can be employed in qualitative research studies to investigate individual experiences. In a qualitative study, researchers can intentionally select respondents within the population to get a deeper understanding of the phenomenon under study (Creswell, 2012). The use of purposeful sampling ensured that different voices were incorporated in the study. A scheduler (Doodle.com) with available interview times was sent to each respondent and as they scheduled, the researcher received notification of the email address of the respondent which was then mapped back to her participant list for tracking. After reviewing the list of scheduled participants, the researcher closed the scheduler after the second reminder and purposefully sent a reminder and a scheduler link to the African Americans on the list who did not respond to the initial email to encourage participation with minimal success.

3.5.3 Qualitative Data Collection

Among the 117 engineers in the final sample of the quantitative phase, 78 indicated that they would be willing to participate in an interview. An email was sent out to the 78 participants who indicated interest in participating. Out of the 78 who showed interest, 29 scheduled an interview initially. Out of the 29, two of the engineers graduated before 2012 and one was a PhD student. These three engineers were interviewed for the pilot study. Three other engineers could not be interviewed due to schedule conflicts and a total of 23 interviews were initially conducted. One engineer recommended a fellow engineer to be interviewed after their interview was conducted, and that engineer was invited and accepted. Lastly, to include more diverse voices in the interviews, a targeted email was sent to those who identified as a minority from the survey list. One engineer from this group scheduled and was interviewed.

Before the interview, all participants were provided with an approved Institutional Review Board (IRB) consent form to review, sign, and return via email. The participants were also given a general overview of the interview before the interview began (See Appendix A for interview protocol). At the end of the interview, participants were offered a $25 gift card for participating. These gift cards were given electronically via email at the end of the interview. Each gift card given was recorded and documented according to IRB rules. An audio recorder was used during the interview process. The recorder was also supplemented with notes taken during the interviewing process.

3.5.4 Qualitative Data Cleaning Procedure

During the interview, the researcher made notes around the time personal information such as first name and last name, reference to a friend by the first name or first and last name, and marital status was mentioned. To eliminate these identifying details, the researcher listened carefully during the interview and while listening to the audio again, eliminated the section from the audio. Most of the information was removed from the beginning of the interview when the researcher asked participants to tell a little bit about themselves. Furthermore, out of the 25 interviews conducted, one interviewed engineer was eliminated because they did not answer the questions in a manner that conveyed that they understood the posed questions. This interviewed engineer responded to questions with responses that suggested they were unaware of the premise of the study and gave responses that did not relate to the posed questions in many instances. Of the 24 remaining engineers, 14 had participated in an ROP and 10 were direct-hire engineers as shown in Table 3.5 below.

Table 3-5. List of interviewed engineers by pseudonyms

Pseudonym	Gender	Race/Ethnicity	Year of Graduation	ROP/Direct-hire
Nicole	Female	Caucasian/White	2012	Direct-hire
Billy	Male	Hispanic or Latino/American	2012	Direct-hire
Rita	Female	Asian/Pacific Islander American	2015	ROP
Diego	Male	Caucasian/White	2014	ROP
Craig	Male	Caucasian/White	2014	Direct-hire
Hanna	Female	Asian/Pacific Islander American	2014	Direct-hire
Lauren	Female	Caucasian/White	2014	ROP
Aerin	Female	Caucasian/White	2012	Direct-hire
Walt	Male	Caucasian/White	2016	Direct-hire
Bailey	Male	Caucasian/White	2015	ROP
John	Male	Caucasian/White	2017	Direct-hire
Ann	Female	Caucasian/White	2017	ROP
Ronnie	Male	Caucasian/White	2014	Direct-hire
Blue	Male	African American	2013	ROP
Lina	Female	Caucasian/White	2015	ROP
Bryan	Male	Caucasian/White	2016	Direct-hire
Kyle	Male	Caucasian/White	2014	ROP
Joe	Male	Caucasian/White	2017	ROP
Erine	Male	Caucasian/White	2014	Direct-hire
Mallory	Female	Caucasian/White	2013	ROP
Mark	Male	Caucasian/White	2014	ROP
Von	Female	Caucasian/White	2015	ROP
Kelly	Female	Caucasian/White	2014	ROP
Luke	Male	Caucasian/White	2015	ROP

3.5.5 Interview Questions

Semi-structured interviews were conducted to provide data to enrich the study. Semi-structured interviews give interviewers the opportunity to stray from a set protocol and provide the opportunity to ask follow-up questions and probe deeper into specific areas of the interview for further insight (Brand & Kasarda, 2014; Hutchison, Follman, Sumpter, & Bodner, 2006). The interview questions were informed by the conceptual framework developed by the researcher in section 2.8. Specifically, the questions were developed by using questions that probe at the student experiences, both academic and non-academic, within the ABET EC 2000 learning outcomes context. The SCCT model of Lent, Brown, and Hackett (2002) was used as a lens to develop interview questions that invited the engineers to discuss the relationship between their undergraduate experiences and their ROP experiences, the university environment. It also allowed for probing questions that could offer the interpretive meaning of the experiences early-career engineers had while at the university and during their ROP or first two years in engineering practice. For example, one of the interview questions asks, *What about your academic experiences at the university did you find helpful in your transition into engineering practice?* The aim of this question was to ask the participants to reflect on their academic experiences during their undergraduate studies and describe events, activities, and encounters that might have contributed to their experiences in engineering practice.

The interviews were conducted by phone, and each took approximately 45 minutes. At the end of each interview, the participant was invited to select a pseudonym to respect their identities when quoted and protect their confidentiality during the interview process. All interviews were recorded and transcribed to capture the participant’s responses accurately.

3.5.6 Qualitative Data Analysis

To analyze the interview data, the researcher followed the six-step guide to thematic analysis described by Braun and Clarke (2006) to ensure that the findings of the study represented the voices of the engineers in the study.

Step 1: Familiarizing yourself with your data

To familiarize herself with the interview data, the researcher first reviewed her personal notes of each interview at least once. Next, the researcher listened to the audio recordings and transcribed the data. Next, she reviewed the audio and transcripts to verify the transcriptions were as accurate as possible. Subsequently, the researcher began highlighting patterns as she read the transcriptions and listened to the audio.

Step 2: Generating initial codes

The initial codebook for deductive analysis was used for the first round of coding (See Deductive Codebook in Table 3.6). The data was then coded again to identify new codes that emerged beyond those that mapped back to the conceptual framework followed. The researcher used the students' experience as undergraduates as described by Terenzini and Reason (2005) for the first round of coding, mapping these initial codes to the research's conceptual framework, particularly those codes that stood out in relation to the early-career engineer's undergraduate and onboarding experiences. During this phase, the transcriptions were then imported into the NVIVO 12 data analysis software tool to arrange and organize the codes.

Following this first round of coding, the researcher continued to code the data inductively for other themes that emerged beyond those supported by the conceptual framework. Explicitly, the researcher coded themes that emerged as key contributors to early-career engineer preparedness for engineering practice as specified in the working conceptual framework in Chapter 2 using thematic analysis as recommended by Creswell (2012). The voices of the engineers represented in this dissertation study were added to the inductive themes when three or more engineers responded to questions with similar ideas.

Table 3-6. Deductive Codebook based on Terenzini and Reason (2005)

Academic Experiences	Definition	University Experiences	Influence Statement
Classroom Experiences	Classroom experiences are characterized by formal and informal learning. They consists of the type of educational activities students encounter, the type and frequency of feedback they receive from their instructor, and the strength of their teacher's instructional abilities.	• Service-Learning Project • Project Based-Learning projects • Senior Capstone • Laboratory Experiments • Lectures • PBL projects	**Kelly:** "The JDQ program had a lot of like group work and report writing and learning, learning about a subject and then applying that knowledge very quickly to solve an extensive problem. So definitely group and lab work in school prepared me for that you know."
Curricular Experiences	Curriculum experiences are described by the student's overall educational coursework, the selection of academic majors, the characteristics and type of socialization students engage in the field, and the degree of exposure to other academic experiences related to the general or major field curriculum.	• Internships • Co-op Experience • Study Abroad • Learning community • Undergraduate Research	**Von:** "Yes, I interned for two summers at [Deleted]. I would say R&D in [Deleted] and, I guess in the nonwovens department. So, we weigh all of the material that goes into making diapers for them, and I did a lot of, yeah, it was like, it was a lot of tensile testing."
Out-of-class Experiences	Out-of-class experiences are experiences that include factors that have the ability to shape student's success from a social, attitude, and behavioral perspective. These factors include on/off campus living arrangements, student work on/off campus, and co-curricular activities hours worked on or off-campus, involvement co-curricular activities, and time spent supporting their family.	• Engineering clubs • Social clubs • Work on/off campus • Community service • Living/Learning Communities	**Hanna:** "I was part of the [Deleted] orientation program So, I was a part of that program and I was the team leader and the following year I was a supervisor for the program and then that really helps me with, um, if not be afraid of talking to people who don't know and because people are looking up to you in that leadership role."

Step 3: Searching for themes

In this step, the researcher sorted all generated codes into themes and organized all related coded data excerpts within the identified themes. Following this step, the researcher began to consider the relationships between the codes and themes, searching for overarching themes about the contribution of the university and ROP experiences on a participant's perceived preparedness for work in engineering practice. When the researcher could not categorize a code, she did not discard it but instead saved it in NVIVO for future reference for possible themes in the future as recommended by Braun and Clarke (2006).

Step 4: Reviewing themes

In this step, the researcher examined the initial themes from Step 3, looked for ideas supported by sufficient data and themes that aligned with other themes, and hence decided to combine them into another theme. For example, codes titled "Impact of ROP," "Perception of Onboarding Strategy," and "ROP Similarities to Undergraduate Education" were combined under one theme - *Early-career engineers consider the structure, learning opportunities, and professional and social networking opportunities of an ROP as essential in transition into engineering practice*. Furthermore, "School Demographic," "Work Demographics," and "Impact of Diversity in Undergraduate Experience" were combined under a group of themes titled *Diversity Themes.* In this step, the researcher also categorized miscellaneous themes within other related themes and made the decision to discard those that were outside the scope of her research question. Once this was completed, the researcher re-read the data set to ensure that the themes aligned with the research questions and confirmed that there were no other codes that were missed during the initial coding. This process was iterative and on-going until there was a satisfactory thematic map.

Step 5: Defining and naming themes

In this step, the themes from the transcribed data were organized to tell a coherent story of the findings from the interviews. The researcher was explicit about the interesting ideas within the themes and why they are important to the narrative she seeks to tell of the experiences of early-career engineers as they connect to the research question. In this phase, the researcher covered a detailed analysis of sub-themes that had been identified, checking that there was minimal overlap amongst themes.

Step 6: Producing the report

At this stage, all themes and subthemes had been identified. The narrative was then written to convey a coherent story that speaks to the results of the findings logically in this report. The researcher quoted excerpts from the interviews to support the claims in the themes. Finally, the researcher used the themes to answer the research questions.

3.6 Reliability and Validity

For the quantitative phase, the researcher utilized the survey instrument development process described by Volkwein et al. (2004). A scale of four to ten items for each learning outcome from the alumni survey instrument was used to enhance the psychometric reliability of the survey instrument. The scale development was also done to alleviate the cost of developing a capital-intensive, time-consuming, and objectives-based test of skills and knowledge. The measures developed require participants to self-report on their perception of knowledge and skills gained during their undergraduate studies and in their current position (Volkwein et al., 2004).

This dissertation study relies on self-reported data from early-career engineers as the sole source of information. Although standardized measures of learning might be preferred, there is no known standardized method of measuring knowledge and skill gain. Therefore, the validity of the results for this dissertation study depends on self-reports of ability such as professional skills, communication skills, and teamwork skills. Self-reports provide a reasonable substitute for direct measures if approached with care (Latucca, Knight, Ro, & Novoselich, 2017). Furthermore, Pike (1995) found that self-reports may be used to measure educational outcomes and university experiences to the extent that the findings are used as indicators for program improvement and not as a substitute for standardized test scores. Still, self-report is not without criticism. Findings from Bowman’s (2010) study of the comparison of longitudinal assessments with students’ self-report measures suggest that longitudinal measures of gains in learning are not associated with self-report measures of change due to factors like human error in judgment. These errors can be reduced by requesting information known to the respondent, asking clear and concise questions, asking the respondent questions about recent activities, and asking questions that do not compel the respondent to answer in a socially acceptable manner (Latucca, Knight, Ro, & Novoselich, 2017). Although the survey instrument for this dissertation study was used in a similar study and was found to answer the key research questions posed for the study, the researcher reviewed the survey items and responses extensively to verify that all items were understood as intended by the participants to ensure the validity of the results.

Additionally, the Cronbach's alpha was calculated for each of the 11 sections of the survey instrument. In this dissertation study, the Cronbach's alpha has a range of 0.83 and 0.90 for the Undergraduate survey and a range of 0.78 and 0.88 for the Now survey separately. For each survey, the researcher used only the survey responses from engineers who had answered every item: 110 for the Undergraduate survey and 113 for the Now survey. The overall reliability of all the surveys for the Undergraduate and Now surveys was 0.78 and 0.90 respectively. This coefficient is considered acceptable in social science research because a reliability coefficient of 0.7 or higher is considered satisfactory (Hakan & Seval, 2011). All learning outcome scales had acceptable internal reliability for both the Undergraduate responses and the Now responses. Table 3.7 shows the Cronbach's alpha reliability coefficient of all 11 Learning Outcomes and confirms the internal consistency of the survey instrument.

Table 3-7. Cronbach's Alpha for Knowledge and Skill Gain Items for Undergraduate and Now Items

Learning Outcome	**Number of Items**	**Undergraduate (N=110)**	**Now (N=113)**
Define Problems & Generate Design Solutions	10	0.88	0.88
Manage a Design Project	5	0.83	0.78
Engineering Contexts	4	0.90	0.85
Communication	6	0.83	0.79
Teamwork	4	0.84	0.84
Leadership	4	0.84	0.79
Interdisciplinary Knowledge & Skills	8	0.86	0.80
Recognizing Perspectives	6	0.83	0.79
Topics in Engineering	9	0.87	0.85
Professional Skills	6	0.83	0.78
Problem Solving	6	0.87	0.83

In addition to the mixed method approach, a triangulation with content analysis from the early-career engineers' employer websites was used to further understand the context of their ROPs' settings. This process was similar to the study by Brawner et al. (2012) where triangulation was used to triangulate results of a mixed method research study. Many employers offer an ROP program and prior to the beginning of the survey administration, 50 employer organizations were reviewed to understand the requirements for applicants, program offerings, benefits, and description of program learning objectives for their ROP to be able to analyze the qualitative interviews within context. The procedure for analysis of this process can be found in Babajide, Al Yagoub, and Ohland (2019).

3.7 Data Trustworthiness

During the qualitative analysis phase, the written transcripts from the interviews were sent to the interviewees to give them an opportunity to verify, accept, or decline information written in the transcript. Two of the interviewed engineers sent back minor updates to their transcripts. Furthermore, the researcher's research advisor and co-advisor reviewed codes and themes along with excerpts from the data. Additionally, using a journal helped maintain an adequate record of reflection notes on what the researcher gathered from every interview.

3.8 Positionality Statement

The researcher is a female engineer who has spent over 12 years working in engineering practice as a design engineer, manufacturing engineer, manager, and consultant. When she started her career, she wasn't sure what engineering meant in practice beyond what she was taught in the classroom setting. After one year in engineering practice, the researcher joined an ROP with an employer in the automotive industry. The researcher spent almost three years rotating through different product development and manufacturing departments. Over the years she had wondered about her cohort, the excitement, and the zeal they possessed to want to help develop the next generation of cars.

To reduce bias in the interviewing process and in the report writing of this dissertation study, the researcher used memoing during the entire study. Specifically, memoing was used after every interview and during analysis to bracket out personal experiences and keep the focus on the data without bias. Also, the researcher did not disclose her participation in an ROP during the interviews; however, she disclosed it to a few interviewed engineers after the interview ended.

CHAPTER 4. RESULTS

4.1 Quantitative Data Collection and Analysis

In the quantitative phase, each survey respondent rated themselves on each of the 11 learning outcomes both after their undergraduate experience and at their current level (Now). For each outcome and each respondent, the researcher calculated an Undergraduate score and a Now score by averaging the responses to the survey items for that outcome. For example, the respondent's Undergraduate Communication score was the average of the responses to the six items on the Communication subscale (See respondents' scores in Appendix G). For each outcome, the researcher defined the *gain* for that individual to be the difference between the individual's Now score and the individual's Undergraduate score. For example, for the Communication learning outcome, if the individual's Now score was 4.83 and Undergraduate score was 4.00, then the Communication gain was 0.83.

Furthermore, for the ROP data set, a total of three answers were missing from three respondents for questions in three different learning outcomes. These cases were simply omitted in the analysis. For the direct-hire data set, a total of six answers were missing from five respondents across three learning outcomes. In addition, one respondent omitted five learning outcome question blocks. Figure 4.1 and Figure 4.2 present the comparison of the Undergraduate scores and the Now scores for ROP and direct-hire engineers based on a 5 point Likert scale from the survey responses.

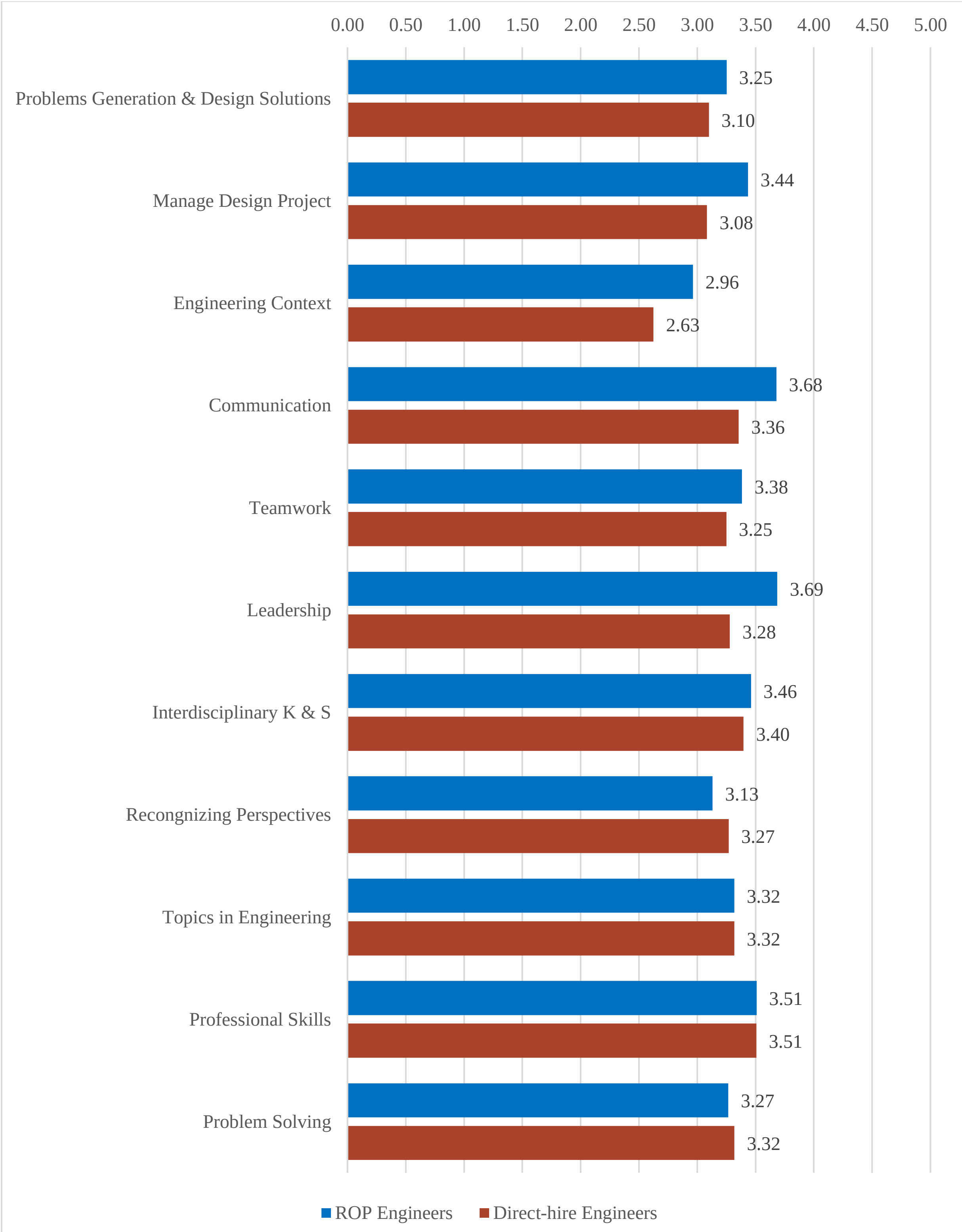


Figure 4-1. Comparison of Undergraduate Scores Between ROP and Direct-hire Engineers

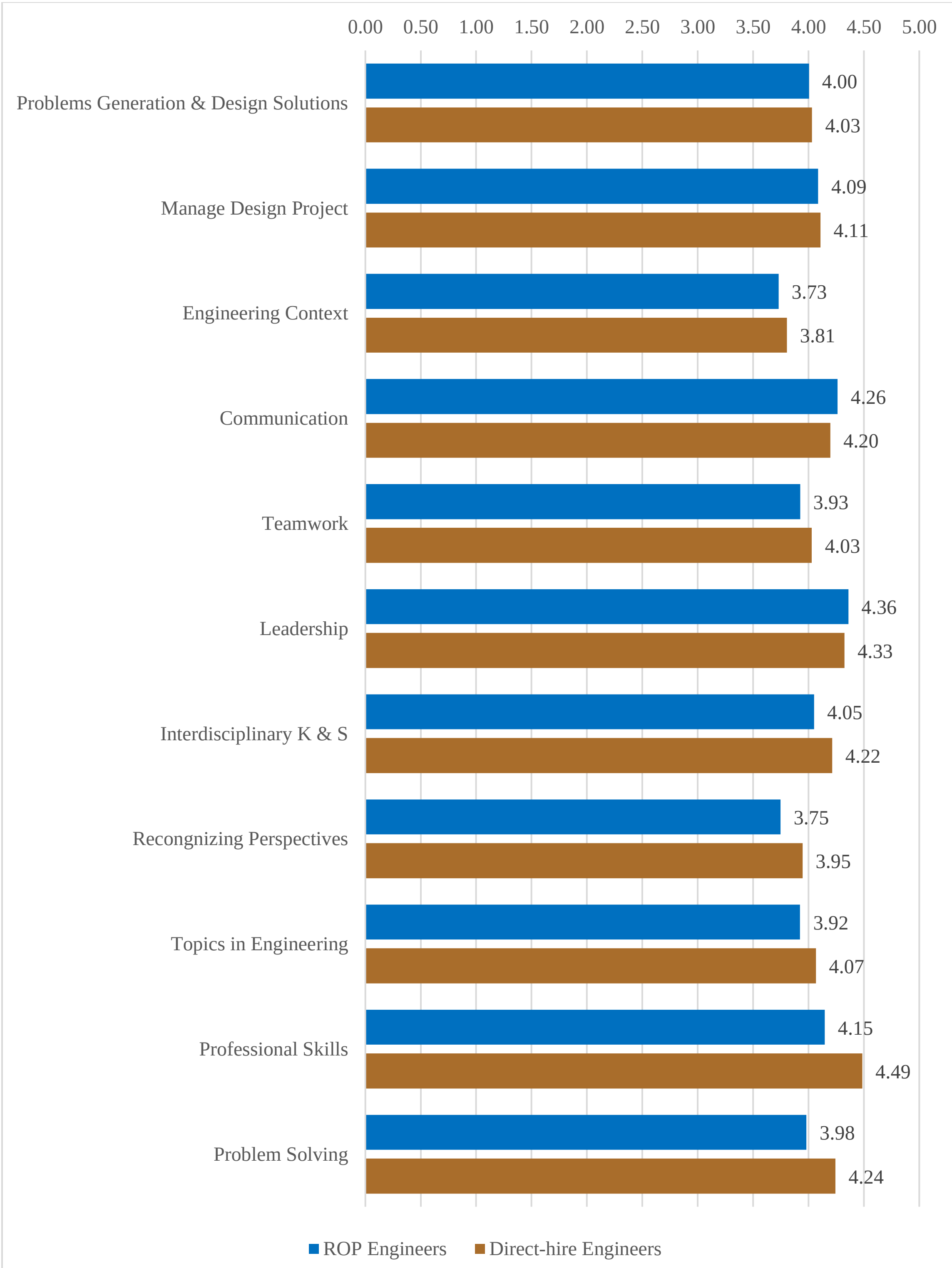


Figure 4-2. Comparison of Now Scores Between ROP and Direct-hire Engineers

4.1.1 Choosing the Statistical Tests

For each learning outcome and each group (ROP and direct-hire), the researcher checked whether the distribution of scores satisfied the Shapiro-Wilk test for normality. The distribution of the direct-hire Now scores for outcomes Define Problems and Generate Design Solutions, Manage a Design Project, Communication, Leadership, Interdisciplinary Knowledge and Skills, Topics in Engineering, and Professional Skills did not meet the assumption of normality using a p-value of 0.05. The distribution of these learning outcomes was positively skewed to the right, but there was no ceiling effect (See Appendix H for table of normality test result). Because the Wilcoxon signed-ranks test does not assume normality, the researcher applied it to all 11 learning outcomes to determine if there was a difference in the Undergraduate scores and the Now scores for each outcome. The researcher conducted the Wilcoxon signed-ranks test twice: first for the ROP group and second for the direct-hire group. To compare the gains, the researcher applied the Mann-Whitney *U* test to compare the gains for the ROP group with the gains for the direct-hire group. The effect size for the Wilcoxon signed-ranks and Mann-Whitney *U* test was calculated using the formula $r = Z/\sqrt{n}$ where r is the effect size, Z is the Z score from the Wilcoxon signed-ranks Test, and n is the sample size. Typically, the effect size is considered small when $r = 0.10$, medium when $r = 0.30$, and large when $r = 0.5$ (Cohen, 1988). Lastly, the null hypothesis for the ROP and direct-hire group test was that there is no difference between the median Undergraduate score and the median Now score.

4.1.2 Analysis for the ROP Group

Table 4.1 presents the results of the Wilcoxon signed-ranks test on the data from the ROP group. For every learning outcome, the difference between the median Undergraduate score and the median Now score was significant ($p < 0.05$), with a large effect size ($r > 0.5$). For example, for the Communication outcome, the median Undergraduate score was significantly lower than the median Now score (Z = 6.57, $p < 0.01$) with an effect size of $r = 0.80$. These results indicate that the engineers perceived that their levels of knowledge and skills now were much higher than at the end of their undergraduate studies.

Table 4-1. The Wilcoxon Signed-Ranks Test Result for ROP (n=67)

Learning Outcome	**Median**		***Z***	***T***	***p***	***r***
	Undergraduate	**Now**				
Define Problems and Generate Design Solutions	3.10	4.00	6.95	2135.5	< 0.01	0.85
Manage a Design Project	3.20	4.20	6.93	2074.5	< 0.01	0.85
Engineering Contexts	2.63	3.75	6.69	1770.0	< 0.01	0.82
Communication	3.67	4.33	6.57	1859.0	< 0.01	0.80
Teamwork	3.25	4.00	6.20	1703.0	< 0.01	0.76
Leadership	3.25	4.50	6.59	1653.0	< 0.01	0.81
Interdisciplinary Knowledge and Skills	3.38	4.13	6.75	2049.0	< 0.01	0.82
Recognizing Perspectives	3.33	3.83	6.38	1579.0	< 0.01	0.78
Topics in Engineering	3.11	4.00	5.45	1753.5	< 0.01	0.67
Professional Skills	3.50	4.50	6.07	1841.0	< 0.01	0.74
Problem Solving	3.33	4.33	6.34	1932.0	< 0.01	0.78

4.1.3 Analysis of Direct-hire Group

Table 4.2 presents the results of the Wilcoxon signed-ranks test on the data from the direct-hire group. For every learning outcome, the difference between the median Undergraduate score and the median Now score was significant ($p < 0.05$), with a large effect size ($r > 0.5$). For example, for the Communication outcome, the median Undergraduate score was significantly lower than the median Now score ($Z = 5.57$, $p < 0.01$) with an effect size of $r = 0.79$. These results indicate that the engineers perceived that their levels of knowledge and skills now were much higher than at the end of their undergraduate studies.

Table 4-2. The Wilcoxon Signed-Ranks Test Result for the direct-hire Table (n=50)

Learning Outcome	**Median**					
	Undergraduate	**Now**	***Z***	***T***	***p***	***r***
Define Problems and Generate Design Solutions	3.30	4.20	5.34	1148	< 0.01	0.76
Manage a Design Project	3.40	4.20	5.57	1049	< 0.01	0.79
Engineering Contexts	3.00	3.75	4.94	917	< 0.01	0.70
Communication	3.67	4.33	5.57	1049	< 0.01	0.79
Teamwork	3.25	4.00	5.04	960	< 0.01	0.71
Leadership	3.63	4.50	5.11	755	< 0.01	0.72
Interdisciplinary Knowledge and Skills	3.63	4.13	5.23	905	< 0.01	0.74
Recognizing Perspectives	3.17	3.83	4.95	777	< 0.01	0.70
Topics in Engineering	3.56	4.11	3.55	798	< 0.01	0.50
Professional Skills	3.67	4.50	4.03	840	< 0.01	0.57
Problem Solving	3.50	4.00	3.79	852	< 0.01	0.54

4.1.4 Comparison of ROP Gains and Direct-hire Gains

According to the Shapiro-Wilk test, with a *p*-value of 0.05, the distributions of gains did not appear to be normal. Therefore, the researcher used the Mann-Whitney *U* test, which does not assume normality, to check the difference between the gains of the ROP and direct-hire groups for each learning outcome. As an additional benefit, the Mann-Whitney *U* test is reliable when the sample sizes are unequal. Table 4.3 presents the results. The median ROP gain was significantly higher than the median direct-hire gain ($p \leq 0.05$) for five learning outcomes: Engineering Contexts, Topics in Engineering, Professional Skills, Problem Solving, and Leadership. For these five outcomes, the effect sizes ranged from $r = 0.19$ to $r = 0.24$, indicating that the differences in gains were small to medium. For the other six learning outcomes, the differences in gains were not significant at the 0.05 level. For the ROP group and direct-hire group comparison analysis for the Undergraduate and Now Scores independently, see Appendix J.

Table 4-3. Mann-Whitney U Test for comparison between ROP and Direct-hire (n = 67) for ROP and (n = 50) for Direct-hire

Learning Outcome	Median		U	Z	*p*	*R*
	ROP Gain	**Direct-hire Gain**				
Define Problems and Generate Design Solutions	0.90	0.90	1473.5	1.11	0.27	0.10
Manage a Design Project	1.00	0.80	1326.5	1.93	0.05	0.18
Engineering Contexts	1.12	0.75	1275.5	2.21	0.03	0.20
Communication	0.66	0.66	1641.5	0.19	0.85	0.02
Teamwork	0.75	0.50	1359.0	1.76	0.08	0.16
Leadership	1.25	0.87	1297.0	2.10	0.04	0.19
Interdisciplinary Knowledge and Skills	0.74	0.50	1368.0	1.70	0.09	0.16
Recognizing Perspectives	0.50	0.66	1612.5	0.35	0.73	0.03
Topics in Engineering	0.89	0.55	1265.0	2.26	0.02	0.21
Professional Skills	1.00	0.67	1272.5	2.22	0.03	0.21
Problem Solving	1.00	0.50	1212.5	2.56	0.01	0.24

4.2 Qualitative Analysis

The qualitative analysis of this dissertation study is divided into eight main themes. Three themes are focused on diversity in the background and environment of early-career engineers. Two other themes describe the knowledge and skills that all interviewed engineers developed during their undergraduate experiences. One theme describes the ROP experiences, professional skills, and technical skills. Another theme addresses the lack of business acumen, and the last theme describes the interviewed engineers' perspective on empathy.

Throughout this chapter, the researcher follows a standard convention of using bracketed ellipses "[. . .]" to denote omitted text. Also, to eliminate identifying information, the researcher replaced each name of an employer and each name of a university by a three-letter pseudonym.

4.2.1 Diversity Themes

The interviewed engineers discussed experiencing diversity in different forms during their undergraduate experience and in engineering practice. They also discussed the lack of gender diversity in their engineering programs during their undergraduate studies and in engineering practice. Although the engineers perceived they gained exposure to people from diverse backgrounds, races, ethnicities, and cultures at the university level, the findings suggest that once they transitioned into engineering practice, the lack of gender diversity became even greater.

Theme 1: Early-career engineers encountered engineering classes and workplace environments with substantially more men than women.

The interviewed engineers described their workplace and engineering course environments as having fewer women than men and limited ethnic diversity. When asked about the general composition of his engineering classes, Diego said,

> **Diego:** So, I would say, uh, it was mostly, and this may come to no shock, it was mostly white men. I would say it was probably close to maybe 80% white men. Then there were, they were maybe about 20% women. Um, it, and this is an aero, aeronautical and astronautical and we, I don't know about the others.

When asked about the general composition of his colleagues in engineering practice, he said,

> **Diego:** At my department. Yeah. So my department is still mostly white men. Um, there are, I would say the other kind of a next big, you know, majority would probably be white women, but that is probably closer to maybe 10 to 15% of the population.

Although it is not a novel finding that the engineering field is less diverse from a gender perspective (Blust, 2001), some of the interviewed engineers experienced a more gender-balanced environment in their engineering program; however, when asked to describe the general composition of their colleagues at work, many engineers described a comparable context as Rita:

> **Rita:** It's very unique in that the company is like 90% chemical engineers and that includes people at the top of your business, your vice president, everyone sort of works their way up through the engineering organization. So, I would say they're literally about 80 to 90% chemical engineers, maybe 10% mechanical engineers. And whatever's left is like HR. So very strongly engineering, definitely less women. It's probably more like 30, 70 for women to men. So that was different going into the working environment [.…] I feel like it [Undergraduate Experience] was really nice because you know, a lot of women and I'm like, this is great. There are women

> engineers. And then when I went out into practice I'm like, nope, they're not apparently.

ROPs on gender diversity- Unlike direct-hire engineers, ROP engineers found their ROP cohort to be balanced from a gender perspective, but in some cases noticed less diversity as they ventured into departments for rotational assignments. Although the findings suggest that ROP and direct-hire engineers both experience changes in the diversity of their workplace, ROP engineers experience this phenomenon differently. ROPs provide two distinct demographic structures to early-career engineers. During each job rotation, ROP engineers participate in two different communities: their ROP cohorts and their departments. When asked to define his employer's ROP structure, Joe said,

> **Joe:** So there's really two parts to that question. So, my rotational program cohort is, we're a bit of an outlier, so my class per se is 16 people or yes, 16 people and there are five guys and 11 girls […] So my rotational program actually has pretty good diversity, both in race gender. Um, now the actual workplace in West Michigan, […] I have one single female coworker. She's from Cameroon, on my immediate team, I should say. She's from Cameroon and she's only temporary. She's an intern…

Although most engineers felt there were fewer women in engineering practice, some of the ROP engineers felt there was an even gender split. When asked to describe the general composition of her ROP cohort, Mallory said,

> **Mallory:** Yeah. From when I started the, all the other people that were in the rotation program as well. We actually had over 50% female that, that started the same year that I did. I believe that there was 11 of us, I think that it was 6 females and 5 males, if I'm remembering correctly. Give or take, so just over 50% female.

Mallory’s experience comprised her ROP cohort experience. What she described suggests that she experienced a gender-balanced environment at multiple occasions in her engineering practice. Another engineer, John, talked about working on a gender-balanced multidisciplinary team that included food scientists:

> **John:** Um, describing the people I work with. So, the first thing that comes to mind to split between engineers and food scientists, we have, it almost feels like we have slightly more, um, I'm trying to, there are a lot of people that are from other countries that have that now work in [City] who had worked throughout BMP LTD being a global company that they'll move around. And so I do notice at work it feel like there are slightly more, international people…I feel like at work it's a pretty even split between men and women…

Although many engineers reported a predominance of men in their engineering courses and engineering practice, a small minority of engineers believed their ROP cohort was gender-balanced. A small minority of engineers also worked on gender-balanced multidisciplinary teams that included other groups such as the food scientists that John described. Mallory and John's experiences with gender parity suggest that even though there are still more men in engineering disciplines and practice, they had a greater proportion of women in their workplace. It is noteworthy that one company where some of the interviewed engineers worked has an initiative to have 50% of the technical workforce as women in their organization by 2020. From the higher institution perspective, there are programs and policies at many universities aimed at increasing gender parity in the engineering field.

Theme 2: Early-career engineers experienced less age diversity during their undergraduate experiences than in engineering practice

Another form of diversity the engineers discussed was age diversity. Both ROP and direct-hire engineers identified a visible age gap between engineers in practice and students with whom they interacted during their undergraduate studies. When asked about the differences between his undergraduate and early-career experiences, Erine, a direct-hire engineer said,

> **Erine:** So, obviously the age gap, both of my past two roles has been with people that pretty much everyone's at least 10 years older than me. So that's definitely a huge difference. And when I was in college everyone is your age. Now everyone's got kids and stuff and you know, I'm young, still single, that's different.

When asked about the general composition of their colleagues at work, Joe, Kyle, and John said,

> **Joe:** Um, so actually age is also a discrepancy there too, uh, the, the median age of my team is probably average age is probably in the forties now. The average age of my onboarding class, low twenties, like 22 probably. Well my particular class now probably more like 24 'cause we are 2 years in. But yeah.

> **John:** There's definitely more of an age spread at work than in Undergrad. Undergrad, for the most part, felt like it was people within two or three years of me how that works, you know, and I think I'm one of the youngest people in the building working with people that have been up there. Actually, we just recognize[d] somebody on Thursday, he has been working in our building in R&D for 40 years.

> **Kyle:** Yeah. I mean it is, it is interesting how it's laid out. So, one thing that they talked about all the time and like the, you know, you got a week-long orientation at SBD LTD first, it's not really specific for engineers, it's more like about the company and that kind of stuff. That they talked constantly about how, the median

> age for employees that work for SBD LTD is, you know, around 55 or 60, it skews much older. And then, if you look at, you know, if you try to put it on a bell curve or something like that, we'll get a histogram out of it that it's almost like bimodal. So you get a very small portion of people that are like around 30 or a little bit younger. And then there's like a, you know, it kind of dips down and there's hardly anyone that works there between the ages of like 35 and 50, and then all of a sudden it spikes back up.

> **Rita:** I would say in terms of age, ACE LTD was also more like, you know, very varied. So there are a lot of people who had been there for a very long time. And then there were some newer people like me.

As John and Rita stated, the age gap between early-career engineers and senior engineers in the workplace was one of the differences that interviewed engineers perceived at the beginning of their career. The age gap in engineering practice was discussed by both direct-hire and ROP engineers. Yet, because of the program structure, ROP engineers worked with other engineers of a similar age in their ROP cohorts but worked with much older engineers in their rotational assignments.

Theme 3: The diverse university environment helps early-career engineers develop the ability to work globally and become culturally aware in engineering practice

Although the engineers' university experiences with cultural diversity occurred primarily outside engineering classes, when these engineers worked on global teams in engineering practice, their university experiences with multiculturalism enabled them to work effectively on those teams. In the interviews, the engineers discussed how their exposure to working with international students from diverse cultures and backgrounds helped them become more culturally aware, better communicators, and effectively able to span boundaries at work. When asked, *How did the diversity while you were an undergraduate student influence how you adjusted to your new environment as an early-career engineer in practice?* Mallory and Kyle, both ROP engineers, said,

> **Mallory:** Yeah, I think, you know, definitely having the experience of all different types of people. You know, at EDU, from, you know what I mean, the town that I grew up at, and you know, pretty small. So being like going to EDU and having a lot of different experiences of different people kind of, it definitely set me up well to be at TGK LTD because you know, you know TGK LTD is a global company and then you'd have a different, you know, manufacturing and technology centers and everything, all over the globe. So, I interface a lot of people from Brazil, Poland and Italy, India, China. So, you know, having those experiences beforehand, you know, makes it easier in terms of, you know, understanding the different cultures and having already been exposed to that. So, you didn't have to get, you know,

> relearn or kind be exposed, to that for the first time and work, you know you're also trying to figure out what your job is and all that sort of stuff.
>
> **Kyle:** Yeah, so I think, because there was such a, a diverse mix [in] undergrad like, I mean it, it definitely helps with, you know, talking to the research people because there were so many international people there. Sometimes we'll get people with, everyone is proficient in English, but varying degrees of accents. So, picking up on that and being able to communicate with them and talk to them about topics that are kind of universally relevant. So, I, I think it, it definitely helped with that.

Because engineers were exposed to different cultures, values, and languages as undergraduates, they developed efficacy in collaborating with those who did not necessarily look or speak like them in engineering practice. Mallory expressed her ability to communicate with a multicultural team in engineering practice due to undergraduate experiences.

Summary of Themes 1, 2, and 3

Engineers described experiencing different types of diversity, especially cultural and ethnic diversity, during their undergraduate studies. Because the engineers were asked to describe diversity during their undergraduate experience and at their workplaces, without identifying or limiting the term "diversity," many engineers did not highlight or explicitly speak of minority groups such as African Americans, Hispanics, or Latinos. Still, in some instances, they talked about the predominance of white males both in their engineering courses and in engineering practice. Apart from the predominance of white male students in engineering courses, most engineers believed that their undergraduate experience prepared them for a culturally diverse environment in engineering practice. Furthermore, when engineers experienced an ROP, they developed social relationships with other early-career engineers of similar ages, in the early to mid-20s. These relationships helped them work with engineers in their age group and other engineers in departments where they were often the youngest members.

Additionally, the multicultural nature of the university environment afforded students opportunities to develop their cultural awareness and comfort working on global teams. Although some of the engineers in this study had participated in a study abroad experience, many others mentioned other factors, such as the university environment outside of their engineering classes, as the key to their exposure to many cultures, races, and ethnicities. While the engineering courses lacked gender diversity for most interviewed engineers, the overall experience during undergraduate studies made it easier for the engineers to relate with different races, culturally diverse groups, and the global nature of their employer's organization.

4.2.2 ROP Themes

Theme 4: Early-career engineers consider the structure, learning opportunities, and professional and social networking opportunities of an ROP as essential in transition into engineering practice.

ROP Program Structure – The interviewed engineers discussed some of the features and benefits of the ROP, such as technical initiatives, rotations, professional networking with colleagues, and social networking with peers. The lengths of their ROPs varied from two to four years. The lengths of their individual rotations varied from four months to one year. Typically, an ROP that lasted over two years involved life-long learning with courses and seminars. Some long ROPs enabled engineers to acquire a master's degree.

Subtheme 4a - The structure of ROPs provides an opportunity for early-career engineers to transition into work in engineering practice with activities that are similar to their undergraduate experience.

The engineers who had participated in an ROP perceived that the program helped them to comfortably move into a greater level of responsibility over time in engineering practice through activities that were similar to university experiences. As new engineers, the ROP engineers believed that the structure of the program gave them a guided transition into engineering practice. When asked to reflect on his onboarding program experience and talk about his preparation for work in engineering practice, Diego said,

> **Diego:** I'd say, with the JDQ program, it was very, it was very good. So you, like I said, it's three years and the first year you're very, you know, very green. And I think that there's a lot of, um, a lot of opportunity for mentorship your first year. I don't think that you could just be thrown in your first year and performed at a level that you have to do on your, you know, your off program role, but then your second year comes along and you have more responsibility and the less, you know, oversight. And then the third one comes along and it blends really nicely I think into your off program position.

According to Diego, the ROP structure provided engineers with a progression in learning and experiences as they transitioned into engineering practice. Through different rotations, the engineers gained experience in different functional areas within their organization. In addition, the program often had group project assignments comparable to what the engineers had experienced at university. When asked if there were any similarities between their ROP experience and undergraduate experience, Linda and Bailey reflected,

> **Linda:** For the onboarding process for what it was, you know, we worked and had, you know, our working times and then we had our social time. So, you know, whether it was, you know, going through the lean management class, like going to your 9:00 am, you know, for a dynamics class we went through the motions of, you know, doing the working thing in the working sessions, stuff like going to class. But then, you know, we had breaks for lunch and so, you know, that was where we were put in groups and you know, it was a social time just kind of like where I was, you know, meeting friends for lunch at EDU and, you know, catching up with old friend**.**

> **Bailey**: I think working in teams to solve the theoretical problems. So [inaudible 26:54] case study in our onboarding, eight weeks and where we thrust with a problem and then you put together your best [inaudible 27:01], there's no right answer or wrong answer. It's collecting a bunch of information and putting together in the best possible scenario. So, that was kind of similar in that regard. [inaudible 27:15] In our senior design project, there's no right or wrong answer, and we definitely didn't get to the right answer but you had to show your steps and how you got there. And you had to be able to prove out this is what I think, that this is what we solved for and this is what we did. Here's why so that kind of helped me in our case studies. It wasn't solving the problem, it is about showing your work. How you did it and why you did it that way and then proving that it is the best solution.

Linda and Bailey described how their ROPs resembled their undergraduate experience, such as problem-solving and working on project teams in addition to their regular departmental responsibilities. These similarities mirrored some of their undergraduate activities such as senior design and social time.

Lastly, several interviewed engineers benefited from the opportunity to obtain an advanced degree during their ROP. Without being prompted, ROP engineers offered details about their employer's paid master's program initiative. For instance, while introducing himself, Joe said,

> **Joe:** So you need basically get to rotate through three different roles a year, a yearlong rotation each, and also you get your master's degree paid for. So, I'm actually going for my master’s in computer science right now, be done. Um, end of this year or next year.

Mallory, who had experienced a different program from Joe, discussed in detail her experience with her ROP and the process of gaining an advanced degree:

> **Mallory:** After the two years of rotation TGK LTD actually sponsors you to do your master's degree. And the way that it's set up right now is that you actually get to return. For me, return to EDU. For some people, it's going to EDU for the first time. But to return to EDU for me to do your masters non-thesis for full time for two semesters. So, I look to do that for the third year. And, so basically through that I was taking three classes and then one credit of research where one class of research, so three credits of research each semester and the research itself was linked to a TGK LTD project. So, I actually worked in the LPC lab for that and then, also did, basically before that, did two semester worth of classes. Did 2 classes online so I was able to finish the whole program and then after that, based on the openings that are available in the company at the time, you're pretty much placed into a role that fits the openings as well as what your interests are.

These interview excerpts indicate that the engineers benefited from completing master's degrees during their ROP programs. Since their employers covered the tuition and paid them full salaries during their graduate studies, they overcame the barriers of time and cost, which can discourage engineers from pursuing advanced degrees (Bone, 2001).

Subtheme 4b - ROPs helped early-career engineers develop their network with other engineers and find resources while rotating through different departments.

Rotating through several departments helped the interviewed engineers to develop a network of people and resources that they used after the program ended and they began in permanent roles. When Kelly was asked about how she felt regarding her preparation to take on a permanent role after her ROP, she said,

> **Kelly:** Maybe I've just been very fortunate, but I've always worked on teams that are really good at bringing new people up to speed and getting them working on like small tasks independently as soon as possible and helping them kind of build up to the larger tasks, but the thing that I thought was most useful in the rotational program was just getting to work on a variety of teams, and so now when I encounter a problem, you know, it's easy for my teammates to say, oh well, you know, I don't know, like I don't know who I would even talk to in this scenario, but because I've actually worked on the different teams, I either already know the answer, know where to find the answer or know who the expert is, which is a hard skill to learn if you haven't, you know, worked in a wide spectrum of teams.

Mallory, another ROP engineer said,

> **Mallory:** So because of the onboarding program, I think one of the biggest things that I got from that, having a broad understanding of TGK LTD as a company and being able to pull best practices from the different areas that, I've worked in to make the place, you know, the specific group that I'm working in right now or was working earlier to make that better. Because, you know, even though it's one

> company at different groups, they have slightly different ways of doing things or different software a different process. And to be able to see like, okay, well this works really well here. Let's see if it could also work in this area. And then also it really helps you to have a good network with inside the company because you meet so many people in such a short time. So, you kind of always in different areas. Have somebody that you know or somebody that, you know, or could go to, who you know, has experience in whichever area that you need advice.

Similarly, when describing his perception on the network across departments, Luke said,

> **Luke:** Because you're going through so many different departments, I mean, I know people all over the company because I worked in all these different areas and everywhere you're working, if you worked there for eight months, are going to be a lot of people in that area. So, you have all these committees, all these connections across all different places.

Mallory and Luke benefited from the network that they had developed during their rotations. The advantage of rotating through different groups helped them connect with other engineers and identify experts within functional groups. Especially in large organizations where there could be several engineers responsible for different areas of a product, having a network of people within several departments and having a general knowledge from other functional groups helped the engineers navigate through working on interdisciplinary teams.

Subtheme 4c - ROPs helped early-career engineers develop their network with other early-career engineers.

Many ROP engineers built a social and professional network within their ROP cohort. These relationships gave them a support system that facilitated their adjustment into engineering practice. When speaking about her ROP experience at the beginning of her career, Von said,

> **Von:** So it's kind of a really nice network to have at your fingertips [… they become some of] your closest friends just because they're moving often just like you are and you're together all the time. And I'm at these conferences, so that was a really nice way to transition out of college into the workforce to have kind of a, a community that you could lean on even if, even if you weren't working directly with them, you could ask them for help and things like that. So it was, it was a good experience overall.

When asked to reflect on his ROP program and preparation for a full-time role after the program, Luke said,

> **Luke:** So, I think some of the biggest valuable pieces of that has been, uh, networking both amongst the [ROP Engineers] because you're like that, that first,

> like that plant rotation I talked about at the beginning, that ends up being a common experience that we've all had. And so, whenever you meet at like a random event, right? The other [ROP Engineers], you kind of have almost a war story swapping experience for it. You'd be like, what did they make you do for Berlin? I was installing windshield washer fluid bottles for four weeks.

The engineers discussed networking opportunities available during their ROP. Von described her experience within the ROP as having a “community” that she could depend on as she navigated her career in engineering practice. Similarly, Luke talked about how the ROP program enabled him to network with his peers.

Walt was a direct-hire engineer who had the opportunity to experience an ROP but opted not to participate due to his involvement in several internships at his current employer. He explained the importance of networking within the field of engineering. He desired to be part of the networking distribution list so that he could participate in the ROP community without the rotations offered by his employer. During his interview, he stated his reason why. Walt said,

> **Walt:** Basically like the thing is, so kind of like I said, so when I hired in, I was just out of college and everyone else, you know, I would say 95% of the people that NHR LTD hired out of college go into the track rotation program. And like I said, they had those, you know, career development seminars and the social aspect. A lot of what I was after, kind of was the social aspect, but also the the professionalism and the seminars, but it was one of those ones where it's like, the group that I hired into the demographic was so much older. Like I was the youngest, by like 10 or 12 years. And so, you know, it's like, oh, hey, it's Friday, let's all go out for drinks after work. And everyone's like, oh no, you know, I've got to go home to the wife and kids you know, and like I've got to go pick them up so. So, yeah. And so it's like, you know, and then I'd like to invite a couple of people out and, they're like, oh, I can't go out. We've got, you know, this track event tonight. And I'm just like, I feel like it had I been able to be in the track, email distribution, even though I wasn't a big track. I don't want to say student track employee, I guess is what you could call, uh, I, I feel like that would have happened, would have helped, you know, what they were teaching from that professionalism standpoint. But also I think it would have helped me be able to kind of meet new people faster because like I said, it was, you know, my group was older, I was younger, I was a recent college graduate and so were a lot of the people that live in Michigan. But when my group wasn't interacting with them, it was hard to find them.

Although Walt did not participate in an ROP, being part of an organization that offered the program made him realize, like many other engineers, the importance of the professional and social network as one of the advantages of participating in an ROP. Although he missed out on the experience, he valued the educational and social networking opportunities with other young engineers.

Furthermore, in contrast to the experiences of those who participated in an ROP, direct-hire engineer Hanna felt that she was thrust into a permanent role at the onset of her career and had to navigate her network coming from an undergraduate experience where she had developed friendships over four years. While speaking about the differences between her undergraduate experience and the beginning of her time in engineering practice, Hanna said,

> **Hanna:** Essentially the work I did was completely different so going from taking courses that you're required to take that could be in many different subjects. I went to a very focused jobs where I had a specific job duty. Another difference was being an undergrad and especially being in biomedical engineering where the class size is pretty small you kind of, or you go through your 4 years with the same people so you learn how they work in teams, or what kind of work they put out. While you're at a job, you kind of meet those people for the first time so you have to learn how they work and what their style of working is. And how they work on a team so that was just a whole new experience of having to do that all over again when I spent the last four years with people I had already know who were my friends at that point.

Hanna's perception of her experience is an example of how the absence of a structured transitional process can affect how early-career engineers develop their network. The lack of a networking element suggests a difference in how ROP and direct-hire engineers responded to questions about their onboarding experiences in engineering practice from a network development perspective.

Summary of Theme 4

The ROPs were structured to provide experiences that helped the interviewed engineers transition into engineering practice while navigating two environments. One of these environments was with their peers in their ROP cohort, and the other was within the departments where they rotated and began their final placement after the program. The ROP engineers benefited from networking with their cohort, attending seminars, working on projects in teams, and completing advanced degrees. The way ROP engineers described the community of their peers suggests that ROPs provided a space for the interviewed engineers to experience their transition into engineering practice with a group of peers they can relate to as they progressed in their career. Therefore, the main experiences that the interviewed engineers perceived as key to their transition into engineering practice were the professional development activities, the social and professional networks with other members of their cohort and in the departments they rotated, and the educational opportunities that the ROPs offered.

Although most ROP engineers described positive experiences and benefits from their ROPs, one engineer believed that the structure of her ROP program did not encourage her to stay with the employer. When asked to describe her ROP experiences, Lauren said,

> **Lauren:** The structure was not great, it was structured and the stuff that you had to go through an interview and the program existed, but once you started the rotation it was really like you were just in a new job almost like you just took a new position or role rather than kind of a rotation program where you grew, there wasn't a lot of focus, at least in my experience, rotating to a different position and kind of getting a full view of the company, there weren't really strict guidelines on timeframes and there wasn't as much training that was associated with the rotation program as I would have liked, it was kind of sporadic and not very in depth.

When asked to expand on her perception of the ROP she experienced later in the interview, she said,

> **Lauren:** I started on my first day with work at my desk to start, it wasn't a slow transition into the environment, and I think I, I've seen and I've heard, companies do things different ways, and I, I really think that kind of slow transition where you know, you have two weeks of training or, you're kind of with a group that spends a month learning about the company and learning about their role, rather than just jumping into the work. I think it's really beneficial, and I think if I had had that, there's a chance that I could have stayed at the company longer.

The structure of the ROP Lauren experienced directly related to her decision to leave the employer, suggesting that the structure and delivery of the program are important to experiences of early-career engineers when they transition to practice and retention of engineers. The researcher noted, though, that the majority of the ROP engineers reported that they experienced a well-structured program that provided them with different benefits.

4.2.3 Technical and Professional Skills Themes

The findings from this dissertation study suggest that the ROP engineers and direct-hire engineers gained technical and professional skills during their undergraduate experience. Both groups discussed curricular and extracurricular activities that helped them gain technical and non-technical skills. However, engineers who participated in an ROP believed their undergraduate experiences enhanced their ROP experience.

Theme 5: Undergraduate experiences gave early-career engineers fundamental technical skills.

Academic activities are part of the fundamental aspects of the undergraduate experience. In the classroom, students learn theoretical concepts and practice solving problems. When asked about the technical skills he gained while he was an undergraduate student, Mark said,

> **Mark:** Well, I work at a transmission company, so I think one of the big ones is going to be the, just the general mechanics towards inertial, torque, speed, power, all those are very fundamental to what we do and what I am exposed to on a daily basis.

In engineering practice, Mark was frequently able to use the fundamental knowledge that he had learned as an undergraduate.

Some classes have a laboratory component to help students understand theoretical concepts using practical activities in laboratories, sometimes incorporating project-based team activities that require collaboration. Many of the interviewed engineers discussed how their exposure to different laboratory experiments and safety standards in their engineering classes helped them transition into technical roles that built on the foundational knowledge they gained while at university. While discussing the technical skills she believed she gained while at university, Hanna, a direct-hire engineer, attributed the majority of her technical skills gain to her laboratory experiences:

> **Hanna:** So, I would say pretty much all my technical skills came from the University, I wasn't very familiar with most lab equipment and most, I guess what I currently use now is manufacturing equipment, but it's still currently use in the lab, you know I worked very similar with microscopy and cell culture um, or different mechanisms like assays or anything that a biologist I wasn't very familiar with it. So, all my technical skills came from all the labs that I did.

Hanna's undergraduate lab experiences helped her feel comfortable using laboratory equipment in engineering practice.

Another technical skill the interviewed engineers discussed was their problem-solving skills. When asked about the technical skills they felt that they gained at university, Linda, Blue, and Erine discussed their abilities to analyze a technical problem and find possible solutions:

> **Linda**: Definitely good analytical side of analysis, so not just like mathematical competency, but you know, understanding and analyzing a technical problem. So, you know, looking at a piece of machinery learning, being able to follow a process through [25:58 inaudible], I'm just thinking through like how things work, especially coming from mechanical engineering, and then just um technical stuff, cause that's the most technical it can really get, but you know, data analytics skills too. So, you know, sort of excel or you know, working with Matlab, really to

> analyze and create meaning to data from why reports or what not. So being able to take data and make it meaningful was also a technical skill that was definitely useful, but I think EDU does very well.
>
> **Blue:** One, being able to really think about the problem. I think EDU does an exceptional job on the technical side of teaching you how to frame the problem… And then you learn the EDU way of going the extra step of coming up with possible solutions to identified problem.
>
> **Erine:** Um, I think a couple of the main ones I would think would be the programming and kind of data analysis and stat, statistics are some of the main things I've brought into the professional world. So as far as technical skill goes, yeah, those are some of the main things that I remember just learning a few different languages, a few different classes and learning that kind of logic, so I use some of that in my professional career as well as analyzing the data and seeing trends wherever it may be like shipping trends and stuff.

Linda and Blue were able to not only develop the ability to analyze technical problems, but also to brainstorm possible solutions. Many of the interviewed engineers learned how to use different types of software suites to analyze data and find possible solutions to technical problems during their undergraduate studies.

The interviewed engineers explained how they could apply what they had learned as undergraduates to their early-career experiences. They were also able to connect between technical experiences while at university and in their early-career experiences in engineering practice. When asked if he had a technical challenge at the beginning of his career in engineering practice and how he navigated it, Kyle said,

> **Kyle:** So, one of the first projects, the first major project that I've worked on at YRT LTD, in the labs, and they were having an issue where they weren't confident in their tape tests. So, this is on, but our scenario, they did both a galvanized and Galvan neal, at their galvanizing line. And a with that each coil had to have a tape test where you, been, a small sample and, put tape over it, take that tape off and put it on a piece of paper and see how dark the powder band does. And they weren't confident that, all of the operators were judging appropriately. So, it's a pretty subjective test. And, you know, you do have a scale that you can compare it to that says, okay, here's what dark looks like. You put it on a number scale between one and five, depending on what kind of, what's the, who the customer is and, and what kind of processing it's been through. Different levels are acceptable. So sometimes be four as a failure, sometimes we'll be five with the failure. And so, I had to do a Geo R&R study, which I learned about kind of briefly in Undergrad, but it was definitely not a focus.

When asked about the technical knowledge he believed he gained during his undergraduate studies, Luke said,

> **Luke:** I guess one of them that was a little bit outside of the realm of what I really was formally educated on one of those, my second rotation actually, um, I said I had to do some Android development stuff and that's something that I had never had to do before. Uh, and it wasn't like, you know, just, you know, make an APP. It was a, here is our entire system, but we've already been using for stuff and we want you to one; make these improvements to it; build something to demonstrate what it can do. Uh, and that was definitely something that I hadn't ever done before. I mean I programmed before because my Undergrad was computer engineering, but, um, it wasn't entirely kind of foreign, uh, environment.

Kyle and Luke gave examples of how they were able to expand on their undergraduate technical knowledge in engineering practice and apply that knowledge to work on more complex software and processes. Many engineers stated that during their undergraduate experiences, they acquired most of their technical skills and built on those skills in engineering practice. When asked about the technical abilities he believed he had acquired while studying undergraduate, Walt said,

> **Walt:** I think SERVICE ED has to do with a lot of that, I know, you know, I know like, no, I didn't get as much necessarily like class experience just because I was always taking SERVICE ED for two credits, but it's still, it was still given, you know, so that kind of cut out a couple of classes. But, I think just the, being able to go into, um, into a workforce already having the whole like design experience and uh, you know, problem-solving and the proc- and the design process and all of that. Having done that so many times, um, just for all the different projects in SERVICE ED and you know, it wasn't just. You know everyone is like, you have your senior design, that's your one real big design projects and you know, start to finish. And then that's it. Whereas I was doing that for eight semesters.

When Luke was asked about skills that are helping him in his career now, he said,

> **Luke:** So I mean, I think that like design thinking gets thrown around a lot, but I mean to me that's, that's, I kind of attribute that to like prototyping kind of skills, which definitely came up through my undergrad. We're gonna kind of start at the end here. And then that, I think most of that came from like senior design and SERVICE EDU just because it, those were like the, the biggest times it felt like a, where I was actually directly like making something, uh, I am a very like hands-on kind of person, less on like theory. Uh, and so I think that that those experiences, well, you know, building a prototype for, uh, my SERVICE EDU team and all the work that goes into, you know, figuring out how it needs to work, if that would actually be a useful for the business partner and putting together just, you know, slapping together some kind of proof of concept prototype for it. And that's really what senior design is as a whole. Right? It's, it's coming up with an idea and spending an entire semester just putting everything together for it and testing it,

> breaking it and fixing it. So those are things that I use in pretty much all of my work experience rotation wise so far.

Walt and Luke gained problem-based learning experiences in design classes. Some of their design experiences came from their service-learning community experiences. It is noteworthy that Walt participated in service-learning for eight semesters during his undergraduate studies. Working on design projects teams for such an extensive time period gave him an opportunity to hone his design and problem-solving skills and practice the use of the design process. He believed he used these skills and knowledge early in his career in engineering practice. Luke also talked about how the use of the design process, designing, proof of concept, and testing during his undergraduate studies is helping him in his career now.

Even though all interviewed engineers mentioned that they acquired technical skills during their undergraduate experience, two engineers felt that they did not use any of their technical skills in engineering practice. Although they discussed working in engineering practice, they described working in roles that did not require a lot of the technical skills that their undergraduate courses offered. When asked, *Which of your undergraduate experiences, academic or nonacademic do you believe was the least important after your rotational onboarding program?* Ann and Aerin replied.

> **Ann:** A lot of, I felt like a lot of our classes, um, like the examples we did in classes and like our senior design lab were really geared towards people who were going to be like design engineers. And I, um, that's not what I'm doing. So, I guess, I don't know, it’s, it's kind of tricky because of the options that you have as an engineer, like if I had decided maybe to go into design, it would have been helpful. But since I'm more in a, a process engineering role, it, it doesn't really apply to what I do. I don't, I'm not designing any systems I need, just need to understand what we have in place already. Really.

> **Aerin:** If I had to go with engineering type classes or work. Um, I'd say really just because I personally don't use them. The ones that are the least helpful were like the heat and mass transfer and that sort of thing. But that's just because of the engineering class that I took I haven't needed them.

The different types of roles presented to the engineers in engineering practice ranged from technical research and development where they were involved in innovative design to project management functions. Some interviewed engineers also worked in the manufacturing sector as process and quality engineers and project managers. Ann and Aerin’s experiences in practice highlight the fact that not all engineers go into technical roles, but the non-technical skills they develop during their undergraduate years enhance their experience in engineering practice.

Theme 6: Undergraduate experiences helped early-career engineers develop their professional skills

Throughout their undergraduate years, the interviewed engineers had acquired knowledge and skills in various forms and were able to use these knowledge and skills in engineering practice. The engineers discussed how their undergraduate experiences helped them develop professional skills like communication, leadership, problem-solving, and teamwork. The classroom experience enabled the engineers in this study to work in teams, assume leadership roles, and exercise their communication skills.

Subtheme 6a: Academic activities helped early-career engineers develop professional skills.

Classroom activities play a critical role in developing the engineers' skills and knowledge. While discussing the skills she believed she gained while at university, Hanna, a direct-hire engineer, attributed her improvement in writing scientific papers to her time spent experimenting and writing laboratory reports:

> **Hanna:** So, all my technical skills came from all the labs that I did. And then along with that, I got a lot better at writing papers so that was one of my weak points in high school. Um, but because my program, like has a huge emphasis on lab reports and working as a team to write papers and write scientific papers. Um, I think that was one of the best technical skills that I learned that I still currently today, and aside from that, better, becoming better at public speaking.

Another engineer, Erine, perceived that teamwork, presentation skills, communication, and problem-solving skills that she learned during her undergraduate experience are helping her in her career now:

> **Erine:** The team-building and presentations and just problem solving in general. Um, there's a, just, that's all. I got a lot of practice at EDU. A lot of different project classes and I also did SERVICE ED so that was extra project work too so that definitely really help 'cause you work in teams a lot in my career so far and learning how to work with people, communicate. And the problem solving that was a big one and then time management too. It's a big engineering coursework at EDU it's not the easiest thing to do. As most people see it.

When asked about the skills she believed are helping her in her career now and where she believes she learned them, Lauren, an ROP engineer said,

> **Lauren:** I think my skills that are helping me most are kinds of a project management skills, which I feel like a lot of friends that I have an engineering would not agree with, but the roles that I've taken on has definitely been in that project management, scope and much less than the technical engineering scope, so all those group projects and senior design and big presentations. I think that's what has benefited me the most since undergrad.

Hanna, Erine, and Laura expressed that the classroom component of the undergraduate experience helped them learn and practice several professional skills that they believe are helping them in their careers now. Hanna's laboratory classes helped her improve her communication skills and team working skills. Erine's service-learning class helped her develop the same skills as Hanna and, additionally, time management and problem-solving skills. Finally, in addition to communication and team working skills, Lauren learned project management skills from her group projects and senior design experiences. Project management became important for Lauren as she mentioned that her current work requires this skill.

Subtheme 6b: Extracurricular activities helped early-career engineers develop professional skills.

The interviewed engineers expressed that their extracurricular activities also helped with their professional skills development. These extracurricular activities included sports, tour guides, and clubs, which helped develop their networking, communication, time management, and leadership skills. When asked about the non-academic experiences that he found helpful in his transition into engineering practice, Bailey replied,

> **Bailey:** I was very involved in the glee club, pretty much, so that taught me a lot about, I got really good experience in networking. As well as time management, obviously with how busy things are.

When asked about the non-academic experiences that he found helpful in his transition into engineering practice, Kyle said,

> **Kyle:** Hmm, so I think, so nonacademic, especially my junior and senior years, I, was on a few different, you know, intramural, played a few different intramurals, intramural sports and you know, led a few of those groups. So, I think that that was a, also a valuable part of my undergrad experience. taking the leadership that I got from doing that, you know, organizing these groups of people to play an organized sport and get them to practice and, go on to win games and things like that, even if

> they have varying levels of experience with the sport. That's something that also kind of translated to, after graduation.

When asked a similar question as Kyle about her non-academic experiences, Linda said,

> **Linda:** I was also involved with SWE on campus and served on the executive board for two years as their competition chair to enter the competition at nationals. And so I work to kind of develop what that would look like. And so really just taking nothing and made something out of it. And then forming that team and leading that team to the first competition, um, with LTQ LTD as our sponsors. So from a technical standpoint, project management and then, leading the team on a leadership side.

Bailey felt his participation in the glee club helped him develop his networking skills. The ability to juggle multiple activities between academic commitments and club activities helped him develop his time management skills. Kyle felt that he learned leadership from participating in and leading his team while playing intramural sports. Also, Linda felt that her involvement with the Society of Women Engineers (SWE) and serving on the competition board help her learn how to build teams, lead teams, and manage projects.

Subtheme 6c: Cooperative education and internship experiences helped early-career engineers develop professional skills.

Co-ops and internships enhanced the engineers' understanding of work in engineering practice while also enhancing their technical and professional knowledge and skills. Out of the 24 interviewed engineers, 22 had participated in a co-op or internship during their undergraduate studies. The experiences ranged from one year to every year while at university. Many interviewed engineers discussed the importance of these experiences in shaping the way they viewed their undergraduate classroom experiences, and how these co-op and internships enhanced their understanding of their engineering courses. When asked to discuss the tasks she was assigned during her internship during her undergraduate experience, Kelly said,

> **Kelly:** Yeah, I was assigned to the nuclear methods team. So, they basically write, maintain, update, revise, assist with all of our computer codes that we use for simulation and analysis. So at the time they were taking one of those codes through a qualification process and I got to help with the testing of it.

Kelly's internship experience helped her gain further understanding of nuclear engineering and develop technical skills by getting some exposure to testing computer codes used in the field.

When discussing non-academic experiences that she found helpful during her transition into engineering practice, Linda said,

> **Linda:** But working for DENT LTD uhm was, you know, an interesting thing where I actually learned the chemical engineering side of things and some mechanical being food processing and you know working with the biology department and the chemistry department, and R & D facility to pick up, you know, what qualification testing and validation testing for different pieces of equipment looks like, what good documentation and templates look like and the facility, and how to write technical reports on a corporate level versus, you know, your lab report for fluids, and then I learned how to read P&IDs [Piping and Instrumentation Diagrams]and do a lot of different lab tests as well at that internship. So that was definitely heavy on the technical side.

Linda's internship experience helped her develop her technical skills by learning about what validation testing entailed. From a professional skill perspective, she learned how to work on multidisciplinary teams and communicate to a corporate audience. When speaking of his co-op experience, Ronnie said,

> **Ronnie:** I think like the Co-op program like that, that was a very useful experience just for instance I didn't end up working in the power electronic industry, but it still um really helped me to understand like how uh, how to work with other people and to understand just how teams and projects are organized uh and how to, successful techniques in order to get people to work together and complete things.

Although he does not work in the industry he interned in, Ronnie was able to learn how to manage teams and gain knowledge of project management in engineering practice. The time spent in cooperative experiences and internships was helpful to most interviewed engineers. They were able to gain experience working in engineering practice while attending classes toward their engineering degree.

Subtheme 6d - The knowledge and skills gained from the university helped engineers succeed in their ROPs.

All of the interviewed engineers believed that their undergraduate experiences gave them the foundational knowledge that they needed to begin their career in engineering practice. Furthermore, many of the engineers acknowledged that nothing could have prepared them for all the requirements for their particular position in engineering practice. Although most engineers felt they had the basic knowledge to build upon as they began their career, it was important to look at the experiences of ROP engineers specifically. When asked to reflect on her ROP experience in comparison to her undergraduate experience and share her thoughts on her preparation for work in engineering practice, Von said,

> **Von:** I think that they did a very good job. I think um EDU made you, they had us do a lot of presentations where we had to present as a team present individually. Um, and I think that that's really like the bread and butter of what you do. Um you're always presenting yourself out in the company. And I think it's good that they had us dress up for presentations and things. The little things that make you look more formal and put together. Um, I think that EDU, EDU did a very good job of setting us up for success.

When asked about the undergraduate experiences that she found helpful in her transition into engineering practice, Kelly said,

> **Kelly:** The JDQ program had a lot of like group work and report writing and learning, learning about a subject and then applying that knowledge very quickly to solve an extensive problem. So definitely group and lab work in school prepared me for that you know, I wasn't unaccustomed to having to crank out a tough lab report under a short amount of time and that was definitely helpful. You know, I think we all know that group work is a part of everyday life and is important, but that just go that you're always developing, and so I think, you know, group work in college really or in undergrad, helped prepare me for JDQ as well.

Von and Kelly valued the communication and teamwork skills that they had developed as undergraduates because they found these skills to be important in engineering practice. From a technical perspective, when asked if she felt she had any knowledge gap when she started her career, Rita said,

> **Rita:** I work at ACE LTD and they do a lot of refining processes, but I didn't know the specific process that I, that I was, you know, meant to be an expert in. So that was definitely a huge gap and that was the main thing that I had to develop. But at the same time, you know, I understood process and hearing somebody who I understand controls engineering, things like that. So it was more just learning the new processes, then applying those things that I already knew to it. So, it was a bit of a skill gap but not terrible. Um, I would say the same thing, in my current job, you know, I didn't understand the exact software, they are on. So, you have to learn the job specific skills. But, um, the concept from undergrad where you know, the same.

Having the basic knowledge of different technical concepts from their undergraduate studies made it easier for ROP engineers to transition into technical roles. These technical roles expanded their fundamental knowledge of technical concepts. As the engineers progressed into their full-time positions, the ROP experience gave them the opportunity to build on what they learned in the laboratory, classroom, project-based classes, and extracurricular activities they participated in as undergraduates.

Summary of theme 6

Both ROP and direct-hire engineers believed that they gained fundamental technical and non-technical knowledge and skills during their undergraduate studies. The interviewed engineers learned professional skills such as time management, communication, leadership, and networking from both their extracurricular activities and academic activities. As they navigated their new departments and worked on challenging projects, they were able to draw on some of the technical knowledge and professional skills from their undergraduate studies in their new environment. Furthermore, the engineers were able to learn and adapt to more complicated systems than those they had used while they were at university. Interestingly, some interviewed engineers who did not have a computer engineering background expressed expanding the software knowledge and skills learned in their first-year engineering programs at the undergraduate level in their professional practice. Although the amount of exposure and opportunity for technical and professional development for the ROP engineers was different, direct-hire engineers also had experiences that suggest that they did not lack significant technical and professional skills in preparation for professional practice.

4.2.4 Other Themes

Theme 7: Early-career engineers believed they did not develop business skills through their engineering program but found these skills to be important now in engineering practice

When asked if they felt they perceived a knowledge or skill gap at the beginning of their career in engineering practice, some of the engineers identified a lack in business acumen from their undergraduate engineering experience. The engineers desired more general knowledge of basic business administration and understanding of how the business aspect of an organization affected their roles and responsibilities as engineers. Furthermore, they desired to have enough business knowledge to communicate the value of their work to the organization at large and understand how their designs and projects affected the organization from a financial perspective.

When asked if they felt they had a knowledge gap from their undergraduate experience after starting work in engineering practice, Linda and Bailey, both ROP engineers, felt that they had a gap in their business acumen skills:

> **Linda**: I think the biggest gap was actually the business acumen, and I think that kind of thing that is, it could develop over time, but the inner workings of how companies on the business side work. I did take and get my minor and OLS [Organization Leadership and Supervision] and then entrepreneurship, so I tried to fill in some of the gaps with that, but the concept of cash flow and you know, corporate strategy and accounting and um, what marketing really does in the company I'm just learning all the other parts because all of my roles that I've had have been fairly cross functional, and so it took some question asking and research to understand the purpose and you know, the areas that all of those other places take into account from a company perspective, and how they all work together to do the same goal, and so that was probably the biggest adjustment since I had the technical knowledge, but not the business acumen.
>
> **Bailey:** I think there was a general knowledge gap around general business acumen. I didn't know how businesses work and how they run.

In addition to perceiving a lack of business skills, when asked about competencies and skills he believes are helping him now, ROP engineer Blue said,

> **Blue:** Competences, I think base level what my school gives me yes, those skills that I'd had to pick up on, I wish that, the school needs to add to our curriculum. In addition to merging the technical stuff with the business skill, I have been doing a lot more work lately studying up on the business side. As such, I'm able to communicate the value of my work to leadership and to business leaders.

Although some early-career engineers perceive a skill gap in business acumen, John, a direct-hire engineer, believed he gained fundamental knowledge of business during his undergraduate experience. Yet, he pointed out the difficulty in navigating the political nature of dealing with other departments outside of engineering:

> **John:** I think we did learn a lot with regards to business concepts. We briefly covered the financial models, gain back capital, stuff like that in Undergrad, definitely a lot more important now in the industry than what I learned in Undergrad. For example, if I'm working on a technical problem where I want to increase product quality, that might lead to more waste i.e. more product that you have to throw away. So, from an R & D quality perspective, that's what we want to do, but then the operations team is going to come back and say that will cost us way too much money. We never went over such conversations in undergrad – where you have two people from different professions, with different goals in mind.

The business skill gap was explained in different ways by the interviewed engineers. Linda presented her gap as trying to understand what other functional areas, such as marketing, do for the organization and how those functional areas relate to her work as an engineer. Bailey felt he needed an understanding of how businesses worked in general, while Blue felt he needed business acumen to be able to communicate with managers the value of their work. Additionally, John described a gap in his ability to acknowledge other competing functional areas that might present constraints for his goals as an engineer when dealing with cross-functional teams.

Theme 8: The undergraduate experience developed empathy in early-career engineers

The interviewed engineers perceived that the student diversity in their undergraduate experiences made them conscious of other people's perspectives, respectful of other people's approach to communicating, and able to conduct themselves based on cultural norms. When asked, *How did the diversity, while you were in Undergrad, influence how you adjusted to your new environment as an early career engineer?* Luke, Linda, and Bailey responded to this question as expressed in the following excerpts. Luke considered the interaction with the diverse students at his university as giving him a "background" in interacting with those who did not necessarily look like him. He said,

> **Luke:** I think it was, it was definitely kind of helpful to have had some, uh, background with, with people that weren't like, just like m[e] so for like perspective, like my high school was a Midwest high school. It was pretty much all white kids, so there wasn't a whole lot of diversity there. And so I think that through kind of the university, that definitely gives me an opportunity to meet and work with a lot of people that I wasn't really used to working with. So, it was uh, definitely helpful if for, well for a lot of reasons […] Which ends up being very translatable when you come out to industry, especially when, um, not only do you have a lot of people that you're working directly with sitting right next to that are different, but like we have portions of our company that we interface with that sit in China or uh, like Eastern Europe is a not-insignificant portion of our company is that are very different from southeast […] Uh, and in those kinds of situations it's, it's even more vital because communicating something wrong, is the difference between something getting done and something getting done wrong and having to be redone.

Luke described how his undergraduate experiences have helped him to develop sensitivity to the way people communicate from an international perspective. Next, Linda discussed how the diversity in her undergraduate experience facilitated her transition into engineering practice and transformed her consciousness in communicating with people based on background factors. She said,

> **Linda:** I think it made it pretty easy, honestly, because I was used to such diversity and, and just to see it by the aspect of things that when I, you know, got to SGY LTD is, I had to work with a variety of different backgrounds and experiences. It helped me navigate through how to do it most successfully. Build those relationships to make it meaningful. So that really taught me how to kind of approach different people in different ways, because I learned how to talk to my vice president the same way I would talk to an operator on the floor and not in a matter of one deserve more respect than the other, but the way I communicated messages deferred, and being able to work with it and our diverse student body, at EDU, I kind of after my project work or just casual conversation to kind of pick up on personality cues based on either cultural experiences or, just, you know, the culture that they came from or you know, even the states that people grew up and if you grew up on a farm versus grew up in Chicago, you know, you're going to have different habits and everything, and so getting those experiences in college helped me navigate those different experiences and personalities.

Linda described how her undergraduate experience made her conscious of people's backgrounds and being able to interact with others accordingly. Lastly, Bailey tied the diversity experience at the university he attended to his ability to be empathetic towards others based on their background. He said,

> **Bailey:** I think that, it opened my eyes to see people and the world differently. Again, I think working with people from the floor, from different places who have, varying experiences, you kind of learn to be a little more sympathetic towards some, based on the backgrounds and it also kind of gives you, I think empathy is the right word. I don't think sympathy is the right word. Empathy is the right word where did you feel more? No, I don't think sympathy. Empathy. Where you feel, I can feel what other people feel and understand where they're coming from and not only, not only, you know, catering my reaction to them based on that. But also catering my expectations towards them as well. Even in my new role. It's an important thing, it gave me a high level of emotional intelligence where I think that, I became more aware of how people view me and how people reacted to what I say or do things. And so that was kind of the start. I think as I've grown in my career, I've learned more and more each year and how it works. And you're never, done learning about emotional intelligence and trying to kind of building on that. But that was how I [inaudible 34:07] the building blocks for that.

Luke, Linda, and Bailey described how their undergraduate experience enhanced their ability to empathize in engineering practice. Their descriptions suggest that they have been able to use empathy to function both locally and globally with sensitivity not only to global cultural differences, but also to varied socioeconomic backgrounds in the engineering workplace that sometimes span between the technical workforce and operators in manufacturing facilities.

Table 4-4-4 below shows which the themes in this chapter relate each research question. The next chapter explains these relationships in detail.

Table 4-4. Mapping of Qualitative Analysis Themes to Research Questions

Research Question	Themes
RQ 1: What are the differences in the perceived level of knowledge and skills gained between the university experience and experiences of ROP and direct-hire early-career engineers?	**Subtheme 4a -** The structure of ROPs provides an opportunity for early-career engineers to transition into work in engineering practice with activities that are similar to their undergraduate experience. **Subtheme 6d -** The knowledge and skills gained from the university helped engineers succeed in their ROPs.
RQ 2: How do the backgrounds of early-career engineers, such as demographic factors and the university environment, relate to their ability to adapt in engineering practice?	**Theme 1 -** Early-career engineers encountered engineering classes and workplace environments with substantially more men than women. **Theme 2 -** Early-career engineers experienced less age diversity during their undergraduate experiences than in engineering practice. **Theme 3 -** The diverse university environment helps early-career engineers develop the ability to work globally and become culturally aware in engineering practice. **Theme 8 -** The undergraduate experience developed empathy in early-career engineers.
RQ 3: How do the academic and non-academic undergraduate experiences of early-career engineers relate to their ability to perform in engineering practice?	**Theme 5:** Undergraduate experiences gave early-career engineers fundamental technical skills. **Theme 6:** Undergraduate experiences helped early-career engineers develop their professional skills**.**
RQ 4: What are the similarities and differences in the experiences of ROP and direct-hire early-career engineers?	**Theme 4:** Early-career engineers consider the structure, learning opportunities, professional and social networking opportunity of ROPs as beneficial in transition into engineering practice.
	Theme 5: Undergraduate experiences gave early-career engineers fundamental technical skills.
	Theme 6: Undergraduate experiences helped early-career engineers develop their professional skills.

CHAPTER 5. DISCUSSION

This chapter connects the quantitative results and qualitative themes with the research questions of this dissertation study. Specifically, this section includes a review of the findings on the influence of demographic factors on knowledge and skill gain, the perspective of the study participants on their knowledge and skill acquisition, and findings on the outcomes of ROP. Furthermore, the researcher compares the findings of this dissertation study with the existing literature on demographic factors, the undergraduate experience, and onboarding programs. Lastly, this chapter contains the limitations of this dissertation study, and provides recommendations and implications for employers, educators, and engineering education researchers.

5.1 Summary of Findings of the Dissertation Study

The purpose of this dissertation is to offer a perspective into the ROPs offered by many employers in engineering practice by exploring early-career engineers' perceptions about their knowledge and skills, and the factors that contributed to those perceptions. The study also explores the undergraduate experiences of early-career engineers that they believe informed their perception of their ROP experiences. For this dissertation study, an explanatory mixed-methods study was conducted using two groups: ROP engineers and direct-hire engineers. First, a quantitative study was conducted (N = 117) using a survey instrument. Second, from the pool of surveyed engineers, 24 participants were interviewed for the qualitative part of the study. The next four sections address the research questions of this dissertation study.

RQ 1: What are the differences in the perceived level of knowledge and skills gained between the university experience and experiences of ROP and direct-hire early-career engineers?

The findings from the quantitative phase suggest that all engineers in this study perceived large improvements between their undergraduate levels and current levels of knowledge and skills in all 11 learning outcomes. When the researcher compared the ROP engineers and direct-hire engineers, she found significant differences between the two groups in the magnitudes of the gains on five learning outcomes. In particular, the ROP engineers perceived significantly greater gains than the direct-hire engineers on Problem Solving, with a medium effect size (r = 0.24). To explain this difference on Problem Solving, the researcher found potential reasons in the analysis of the interview data. As described by Bailey (Subtheme 4a) and Kelly (subtheme 6d), ROP engineers worked with their cohorts on multiple projects that required them to solve difficult problems. By contrast, the direct-hire engineers may have had fewer opportunities to work on multiple projects in different groups.

RQ 2: How do the backgrounds of early-career engineers, such as demographic factors and the university environment, relate to their ability to adapt in engineering practice?

The backgrounds of the interviewed engineers in this dissertation study are expressed within the context of factors such as gender, age, and undergraduate experiences. The interviewed engineers described their perception of their transition into engineering practice from various perspectives—specifically, how their undergraduate experience with diverse cultures, genders, and learning environments influenced their knowledge and skill gain in engineering practice.

The cultural, ethnic, and gender diversity experiences in both academic and non-academic environments as described in themes 1, 2, and 3 are experiences that are contextualized as part of the background of the interviewed engineers. Some of these experiences discussed in this dissertation were classrooms, learning communities, living-learning communities, and extracurricular activities. The way the engineers experienced these environments during their undergraduate studies could influence their knowledge and skill gain while at university.

The findings of this dissertation study are consistent with findings from recent research on university climate. According to Lin, Salazar, and Wu (2018), the diversity climate within a university is a predictor of graduates' overall academic experience. Even though the participants noticed predominantly male attendance in engineering classes, they were also aware of the overall diversity at their universities as they engaged in other activities outside of the engineering program. Although the engineers experienced diversity during their undergraduate experience as a whole, the low number of women in engineering classes and workplaces was similar to the general norms. Even though the number of women earning a degree in engineering has increased in recent times, there is still more work to be done to gain gender parity in the engineering field. To offer a perspective on some of the improvements made over the years, the number of women who earned a bachelor's degree in engineering has increased from 17.8% in 2009 to 19.9% in 2015, and women make up 21.4% of students enrolled in engineering programs (Yoder, 2015). Yet, women comprise only 12% of engineers in practice (Corbett & Hill, 2015), and in this dissertation, 35% of the engineers were women. Besides the gender differences in engineering, the early-career engineers expressed that they had experienced cultural diversity that contributed to their positive experience during their undergraduate studies.

Even though the cultural diversity that engineers experienced while in their undergraduate studies helped them adjust to new environments in engineering practice as described in theme 3, the interviewed engineers discussed the age gap between them and their colleagues in theme 2. According to Schiff (2003), the age gap could result in disagreements between senior employees and new employees in the workplace that reduce retention of early-career engineers if not handled with care. In contrast to direct-hire engineers, ROP engineers experienced two workplace environments: their ROP cohort, in which the other engineers were similar in age, and their rotational assignment departments, in which the other engineers were significantly older. Moreover, the participants described the structure of the ROPs in a way that suggests that the programs are designed to maintain an environment that mimics the university environment, allowing the engineers to relate to peers in a structured program and create an environment that can foster an easier transition into engineering practice.

Many of the interviewed engineers also attributed their improvement in empathy to their undergraduate experiences as described in theme 8. They described being conscious of their communication because of their awareness of the diverse backgrounds their colleagues might have, from urban to rural differences, and international and cultural differences. The interviewed engineers also discussed making a conscious effort to communicate with everyone equally and with respect, irrespective of their socioeconomic status. The findings from this study align with those of Strobel, Hess, Ran, and Morris (2013), who explored how empathy is operationalized in academia and in engineering practice. In their study, practicing engineers described the role of empathy in communicative behavior consisting of the show of respect, being attentive to others, and the ability to communicate sensitively with diverse people.

RQ 3: How do the academic and non-academic undergraduate experiences of early-career engineers relate to their ability to perform in engineering practice?

Undergraduate Experience Perspective - The results of this mixed-methods study suggest that the acquisition of technical and professional skills by early-career engineers begins at university and continues to develop as they work on different projects and in teams in engineering practice. Many of the engineers perceived that their academic and non-academic experiences helped them develop foundational knowledge and skills, as described in themes 5 and 6. These skills include design, communication, teamwork skills, and contextual and interdisciplinary competencies. These findings align with Terenzini and Reason's (2005) framework that attributes student success to academic experiences, the peer environment described as the student's classroom, and out-of-class and curriculum experiences. From a programmatic standpoint, Terenzini and Reason (2005) suggested that academic and co-curricular programs, policies, and practices all affect students' academic success. Here, Terenzini and Reason's (2005) conclusions also agree with the findings of this study. For example, many participants had engaged in extracurricular activities, including a glee club, intramural sports, and professional student organizations offered by their universities, and identified that they contributed to their professional knowledge and skill gain.

Early-career engineers who participated in activities that developed professional skills such as communication, leadership, problem-solving, and teamwork are more likely to succeed and experience fulfillment in engineering practice than those who did not experience such activities. Brunhaver and Gilmartin (2013) determined that entry-level engineers rated professional skills such as those mentioned above as critical to their job in practice. The findings of this research are no different. Yet, this study also aligns with what is known about the positive influence of both academic and non-academic activities on the development of professional skills in early-career engineers. The extracurricular activities described by the participants helped them develop skills such as leadership, communication, and teamwork. Past research by Shuman, Besterfield-Sacre, and McGourty (2005) on ABET professional skills concluded that skills can be taught through different means such as service-learning experiences, which some of the participants participated in during their undergraduate studies.

The finding in Subtheme 6b is consistent with previous research by Foreman and Retallick (2012), which suggested that students who spend more than one hour per week in extracurricular activities, such as student organizations, scored higher in leadership skill development than those who did not. Furthermore, a research study by Knight and Novoselich (2017) was conducted at 31 colleges and universities, based on 5,076 undergraduate students from 150 undergraduate engineering programs to understand how their pre-college and university and engineering programs contributed to their perception of their leadership skills. Findings from the study suggest that curricular and co-curricular activities contribute to increased leadership skills for engineering students. Additionally, they are consistent with the qualitative phase of this dissertation, as the results suggest that early-career engineers perceived that they gained leadership skills through their curricular and extracurricular activities. Nonetheless, Knight and Novoselich emphasized that leadership skills in the curriculum have the greatest effect on student performance, arguing that these skills in the curriculum enable students to understand leadership concepts in a structured manner and enhance the student's confidence in their leadership skills. The support for leadership concepts in the curriculum can be justified by the fact that all students would experience the curriculum, while some may elect not to participate in other activities outside the classroom (Knight & Novoselich, 2017). It is noteworthy here that the new ABET Learning Outcomes Criterion (5) which will replace the Learning Outcome (d - an ability to function on multidisciplinary teams) now explicitly states that the students must be able to exhibit the "ability to function effectively on a team whose members together provide leadership…" (ABET, n.d.).

In addition to out-of-classroom experiences, the participants also attributed the development of their professional skills to their academic experience, which helped them cultivate similar skillsets including time management, project management, and the ability to work under pressure. Ro and Knight (2016) conducted a study of 4,901 students from 120 engineering programs in the United States. Their quantitative study assessed the relationship between gender and engineering students' experiences and learning outcomes considered critical for career success by exploring how curricular instruction and co-curricular activities affect student learning outcomes. Their findings suggest that there is a correlation between frequent participation in group learning and students' perception of their design skills, teamwork, and leadership skills (Ro & Knight, 2016).

The findings of Ro and Knight (2016) are in line with those of this dissertation. In the quantitative phase, the results showed that 37% of the engineers surveyed participated in at least two out of the three activities: humanitarian engineering projects, non-engineering community service/volunteer work, or student design projects beyond the classroom. Furthermore, in the qualitative phase, theme 5 of this dissertation study suggests that academic experiences helped early-career engineers develop their professional skills. Most of the interviewed engineers participated in one or more activities such as service-learning, senior design projects, and extracurricular project teams, and reported learning design skills, teamwork, and leadership skills during their undergraduate experience.

RQ 4: What are the similarities and differences in the experiences of ROP and direct-hire early-career engineers?

In this dissertation study, university academic and extracurricular experiences positively influenced the perceived technical and professional knowledge and skills gained of the interviewed engineers, as discussed in themes 5 and 6. It is important to note, though, that this dissertation study is based on self-reported data; thus, the self-efficacy beliefs of the interviewed engineers from a technical and professional standpoint are different. This is because the knowledge and skill gains for the ROP engineers are significantly higher than direct-hire engineers in five out of 11 learning outcomes from the quantitative analysis, with a small to medium effect size on all five learning outcome categories (See Table 4.3). In the qualitative analysis, the results offer a plausible explanation of the small to medium effect size. For example, in the case of leadership, teamwork, and problem-solving skills, the medium effect size can perhaps be explained by the additional activities that ROP participants engage in beyond their regular work-related activities as described in theme 4.

Some of the ROP participants worked on project teams with their peers and participated in rotations that allowed them to take on leadership roles from the beginning of their careers, as described in theme 4. The findings also suggest that the ROPs included classroom and project work that was similar to the activities that the engineers had participated in when they were undergraduates. Participation in more academic-style activities while in an ROP could have potentially accounted for the small to medium effect size between ROP and direct-hire engineers for the Problem-Solving learning outcome (See Table 4.3) because ROP participants reported doing similar activities such as taking courses and working on design challenges while in the ROP.

Two ideas that advance the literature on what is now known about the ROP for engineers in practice come from the findings of the ROP program structure and the potential influence of the program on the development of a community, as described in theme 4. Previous studies examined different aspects of ROP programs. For example, Kuok and Bell (2005) looked into ROP structure such as assignment, length of rotations, and requirements. Furthermore, Dailey (2016) investigated how new employees use communication in the socialization process. Themes 5 and 6 of the qualitative phase of this dissertation study offer a potential explanation to Dailey's (2016) conclusions from an engineering practice perspective. They also extend the findings of Dailey (2016) and Korte, Brunhaver, and Sheppard (2015) beyond networking of early-career engineers among themselves and with upper management because they focus on the undergraduate experiences and workplace experiences of engineers from a technical and professional perspective, with consideration for their background. Additionally, the results of this study add to the body of work on transitional experiences of early-career engineers, how employers' onboard engineers, and the perceived benefits of the program.

The SCCT framework is used as a lens to explore how engineers' experiences during their undergraduate studies influenced their self-efficacy in their abilities and how this confidence affected their expected outcomes in an ROP. Although self-efficacy is typically measured with a multiple-choice instrument (Mamaril, Usher, Li, Economy, & Kennedy, 2016), interviews can also be used to gather evidence of self-efficacy. In this study, the interviewed engineers expressed self-efficacy in engineering tasks by connecting their current competencies in professional practice with their prior mastery experiences during undergraduate studies. Other researchers such as Revelo, Schmitz, Le, and Loui (2016) have also used interviews instead of multiple-choice instruments for measuring self-efficacy to explore student outcomes and self-efficacy of non-engineering students in a general education course on digital information technologies.

Importance of structure and peer network in transition **–** The SCCT model suggests that the support or barriers that participants might face during the program can affect their goals, action, performance, and attainment (Lent, Brown, & Hackett, 2002). This claim aligns with the finding in theme 4 of the qualitative phase of this study because participation in an ROP did not always translate to attainment of knowledge and skills. For example, an interviewed engineer, Lauren, identified in theme 4 that she believed that the program she hired into was ill-structured and did not perceive gains from the ROP experience. Still, the majority of ROP participants reported gains in their current levels of knowledge and skills as described in the quantitative analysis and further discussed in the qualitative analysis. This finding further aligns with the previous study by Kowtha (2008) that suggests well-organized and structured onboarding strategies help early-career engineers adjust to working in engineering practice at the beginning of their career and can promote retention within an organization.

In contrast to the direct-hire engineers' experience in practice, findings from this dissertation study suggest that the networking component of an ROP enriched the ROP engineers' practice. Findings suggest that the networking component of an ROP is an essential aspect of the program for most engineers, as described in theme 4. This finding confirms previous findings of the importance of networking in an ROP (Dailey, 2016). The ability to network with peers, work in peer groups, and develop a sense of community among other early-career engineers helped them adjust to their new environment in practice. For many in the ROP cohort, the ROP experience can be compared with a community of practice as described by Wenger (2011) for several reasons. First, the engineers are in a cohort of other early-career engineers who are also experiencing rotations within their employer's organization. Second, they participate in common activities, build relationships among the cohort, and provide help for each other within the community. Lastly, they share a common practice by participating in seminars, classes, and projects together, and engaging in collective activities outside of their regular assigned rotations. Thus, the structure of the program fosters a community of practice among ROP participants.

5.2 Recommendations for Undergraduate Engineering Programs

This study adds to the body of knowledge pertaining to early-career engineers' experiences by providing insights into the transition of engineers into professional practice. The findings from this study suggest three specific recommendations for undergraduate engineering programs.

First, by rotating through several departments, the ROP engineers experienced different types of work. As a consequence, they could make an informed choice for their final placements in departments. The opportunity to preview departments could also be implemented in undergraduate engineering programs: students could take courses in multiple engineering departments before they select a specific engineering major.

Second, the ROP engineers valued opportunities to network with engineers both within their cohort and across departments. Since these networking opportunities benefit early-career engineers, undergraduate engineering programs could incorporate modules that help students develop professional networking skills.

Third, the findings of this dissertation suggest that undergraduate engineering programs generally fail to develop students' business acumen. As described in theme 7, early-career engineers perceived they had less knowledge about business topics than other areas. Currently, some universities offer joint Engineering and MBA degree programs, and some universities offer credits in a joint effort between the school of engineering and international business centers to help students develop their business acumen skills (Shuman, Besterfield-Sacre, & McGourty, 2005). Even though some universities have a strong emphasis on business skills and entrepreneurship for their engineering students, many business courses are still mainly offered in the school of business at universities and not for engineering students (Kriewall & Mekemson, 2010). Undergraduate engineering programs can do more to incorporate business skills in the engineering curriculum. These business skills may help engineering students gain a better understanding of the economic impact of their work as practicing engineers, and how their work fits into the overall product development process and delivery to market. To help engineering students develop business skills, undergraduate engineering programs could create an integrated business and engineering course, and they could offer strategic business elective courses.

5.3 Recommendations for Engineering Practice

Considering the return on investment perspective for a rotational onboarding program, one cannot ignore the extensive time, effort, and financial resources that employers dedicate to developing such programs. Employers invest these assets in rotational onboarding programs, but there is limited prior research on the impacts of these programs; that is, on the return on this investment. Furthermore, from a retention perspective, the 2015 annual Recruiting Benchmarks Survey by the National Association of Colleges and Employers (NACE) reported that after five years, organizations with rotational onboarding programs for new graduates retained an average of 6% more employees than those without an ROP. To understand the factors that influence retention of ROP engineers, more research is needed.

For employers that do not have the financial budget to deploy an extensive onboarding program, the findings of this study suggest that they could implement some components of ROPs to improve retention and engagement of early-career engineers in an organization. Evaluating best practices and engaging and investing in engineering education research at universities could offer research-backed methods to assist employers in achieving better outcomes at the corporate level. This could eventually lead to a higher return on investment, greater retention, and overall better preparedness of engineers for permanent roles.

This dissertation study adds to the body of work that is just beginning to unpack the technical and professional skills early-career engineers develop while at university and how those skills are then used on the job during their transition to engineering practice. This study also gives a small window into the technical and professional skills early-career engineers believe they now use in practice. Because the findings of this study suggest that ROP and direct-hire engineers gain technical and professional skills from their undergraduate experience, program evaluations can be conducted to understand how the undergraduate experience fulfills some of the goals of an ROP to help employers reevaluate their programs.

Reevaluating onboarding programs can help employers better align with the current standards that universities have embraced in preparing early-career engineers for work in engineering practice. In return, reassessment of ROPs can potentially save time and resources in areas that might be considered redundant and help employers readjust the program goals to include other areas of learning and development. To this end, the researcher does not claim that ROPs are redundant; rather, a reevaluation of current strategies at an organization can potentially help the employer improve their program and manage expenditures.

5.4 Recommendations for Future Research

This dissertation study examines the onboarding of early-career engineers and how their undergraduate experiences may have prepared them for work in engineering practice or not. The future direction of this dissertation study will be to consider the next three or more years for direct-hire engineers, and three or more years post-ROP to explore if the ROP process has an effect on the retention of young engineers, especially women and minorities, in engineering practice. Another consideration for future work is to explore the second transition for ROP participants when they leave the ROP and take on permanent roles because that transition offers an insight into retention of early-career engineer in engineering practice. This future direction will expand what academia and employers know about the factors that promote retention of ROP engineers in practice.

Another aspect that can be further expanded upon from this dissertation study is understanding the different structures and durations of ROPs. The findings from the study suggest that there are various types of ROPs and the duration of time engineers spend in such programs differs. Most ROPs in this study lasted for an average of 9 months to 3 years. It is important to understand if there is an optimum duration of time for new engineers to gain experience in such programs.

Lastly, the findings of this study suggest most of the ROP and direct-hire participants gained fundamental technical and professional knowledge and skills that the ABET learning outcomes criteria specify for new graduates. More research needs to be done to understand how these findings on technical and professional knowledge and skill gain align with the vision of the ENG2020. As the year 2020 approaches, it is important to assess how university engineering curriculums have met the expectations of the ENG 2020 proposed vision (NAE, 2004) in preparing engineering students for work in practice.

5.5 Limitations of the Study

One major limitation is that there are many possible reasons for the increases in the levels of knowledge and skills for ROP engineers. For example, if an engineer started a two-year rotational program in 2013, completed the program in 2015, and answered the survey in 2018, then the increase in knowledge and skills cannot be attributed to the ROP alone. Furthermore, the interview protocol did not include specific questions to pinpoint the reasons for all of the differences in the learning outcomes gains between the ROP engineers and the direct-hire engineers.

This dissertation also has some research limitations. For instance, the use of recall has the potential to create recall bias. Recall bias is defined as the "systematic error due to differences in accuracy or completeness of recall to memory of past events or experiences" (Last, 2000, p. 153). This dissertation relies on participants' recall of their undergraduate and onboarding experiences as early-career engineers in practice. Previous studies have used recall, such as the study of Kelsey, Wall, and Pettibone (2005) on knowledge and skill gains of participants in a statewide agricultural leadership program. The results of this study suggest that participants might exaggerate their gains, thereby making retrospective recall potentially biased. Yet, according to Klein et al. (2015), the use of recall is a relatively accurate and acceptable approach to data collection and has been successfully applied in studies on student and employee experiences, especially when the respondents are the best source of information. For example, Korte, Brunhaver, and Sheppard (2015) asked participants to recall their onboarding experience as early-career engineers. Similarly, Lattuca, Terenzini, Knight, and Ro (2014) used a survey instrument that required participants between their senior year at university and their current role at their current workplace to recall their university and work experiences.

In addition, participants were asked to respond to survey items about their Undergraduate and current (Now) abilities on one survey instrument. Consequently, this arrangement has the potential to introduce a response bias; i.e., respondents might have answered the survey items in socially acceptable ways (Pettibone, 2004). If there was in fact a response bias, then there was a potential range of effects, such as ceiling and floor effects that might have been created by engineers' beliefs about acceptable responses. Yet, the quantitative data does not show any ceiling or floor effect in the way the ROP and direct-hire engineers responded to their Undergraduate and Now survey items as shown in the scores (See Appendix G ROP and direct-hire scores). As another potential response bias, older engineers might rate their current skills higher than younger engineers, to conform with expectations. To check for this bias, Appendix I presents the correlations between the year of graduation and the Now scores. For every learning outcome, the correlation is not significantly different from zero. The correlation results indicate that older engineers did not rate their current skills significantly higher than younger engineers.

Another limitation of this dissertation study is that the study population was initially anticipated to be from early-career engineers through their employing organizations in order to obtain a diverse cross-section of different undergraduate engineering programs. Yet, the data were collected through professional engineering organizations and university alumni associations. The survey sample data shows that most of the engineers in this study were of traditional age, full-time students who resided on or near the campus and, thus, were able to engage in a variety of extracurricular activities while at university. As such, there is potential for a large group of participants to have had similar experiences. Furthermore, this research is bound by the topic of rotational onboarding programs in engineering and manufacturing organizations and excludes the population of engineers that work in other professional fields.

There are also limitations in the quantitative and qualitative data collection process. In regard to the survey instrument, some of the survey items could have been clarified further to enable deeper analysis. For example, those who did not participate in an ROP could have been asked explicitly if they had any form of onboarding and to describe that experience. In regard to the interview protocol, asking for details of the participant's final placement after the ROP and if they stayed with the employer could have provided more details about their overall experience and retention in engineering practice. While the survey instrument was not designed as a self-efficacy survey, there are indicators of self-efficacy in the way the engineers described their experiences. Lastly, given the nature of the qualitative phase, the ability to generalize is limited because company business, size, and corporate objectives vary. Due to this variability in the qualitative data and the small sample size, the findings from this dissertation cannot be generalized (Creswell, 2013).

5.6 Conclusions

Previous studies on early-career engineers have mainly consisted of alumni studies that examined different aspects of their transition into professional practice. These previous studies included the process of socialization into professional practice, the skills and knowledge that early-career engineers perceived to be significant in practice, and their decisions about their career choice. By contrast, this dissertation study explores the differences perceived by early-career engineers between their undergraduate levels and their current levels of professional knowledge and skills. This study also examines the differences between engineers who had participated in an ROP and direct-hire engineers, and identifies factors that contribute to these differences. The findings of this study offer new insights for administrators and instructors in undergraduate engineering programs, for employers, and for engineering education researchers.

For administrators and instructors in undergraduate engineering programs, the findings of this dissertation study explain how undergraduate experiences influence the development of early-career engineers from a technical and professional perspective. As a consequence, these findings can help administrators and instructors by informing how the curriculum and instruction can be developed to better prepare engineering students for professional practice. Although the findings suggest that the university experience was positive for the participants, they also raise questions on how educators can include skills like business acumen in a more intentional way in the engineering curriculum.

For employers, the findings of this study suggest that by implementing some components of an ROP, a traditional onboarding program could significantly improve the learning and development of new employees and contribute to their success and retention. For example, the findings imply that all onboarding programs have the potential to help early-career engineers develop social and professional networks, which may have lasting benefits. Thus, even employers who do not offer programs as extensive as an ROP could prepare transitional school-to-work modules that incorporate some features of ROPs, such as opportunities to network with other new engineers of similar ages.

For engineering education researchers, this dissertation study can advance knowledge by informing the development of a framework that describes the transition of engineers from students to professionals. This framework goes beyond the SCCT model to explain how engineers' career-related interests develop by incorporating interventions such as ROPs that can influence this development. Moreover, this framework can help researchers understand factors that affect the perceptions of early-career engineers as they transition into full-time roles. More importantly, when discussing early-career engineers in future studies, engineering education researchers should identify the kind of onboarding program that the engineers experienced, as it could affect their perceptions of their knowledge and skills. For example, the PEARS research study explored the work experiences and perspectives of early-career engineers four years after graduation and identified the educational and workplace factors related to their initial career choices (Chen et al., 2012), but the PEARS study neglected the potential influence of the engineers' onboarding programs. If these engineers had participated in rotational programs and selected one as a final placement, that experience would have significantly affected the reasons for their career choices and their persistence in engineering.

In conclusion, engineering educators have come a long way in improving the quality of the experiences of engineering students. As the year 2020 approaches, the vision illustrated in the NAE report *The Engineer of 2020: Visions of Engineering in the New Century* (2004) is manifesting in the way the engineers in this study expressed their perceptions of their undergraduate experiences. To complement what educators are doing, employers are investing in programs that enhance the experiences of early-career engineers. Bridging the gap between academic experiences and professional practice is attainable if educators and employers work together, especially when more employers become intentional about partnerships with engineering education researchers.

APPENDIX A. INTERVIEW PROTOCOL

Research Questions

1. How are the knowledge and skills used by early-career engineers influenced by their backgrounds: specifically, by their demographic characteristics, by university environment, by community/relationships
2. How does the way early-career engineers perceive their undergraduate experience influence their knowledge and skills gained in engineering practice?

Interview Protocol
Interview #____________
Date/Time: ____________________
Participant Corresponds with #__________ in the Protocol List File

Introduction Script:

Hello, my name is Bunmi Babajide. I am a PhD Candidate at the school of Engineering Education at Purdue University. Thank you for your participation in this study. To begin with, I want to give you a chance to review the consent form. I have sent a copy to your email address for your review, if you have any questions, let me know.

The goal of the interview is to understand your unique experiences and perspectives related to your onboarding in engineering practice as an early-career engineer. There are no right or wrong answers to these questions and no right or wrong perspectives. My main goal is to simply understand what *you* think and feel about your experiences.

A little bit about myself, I worked in engineering practice for over 10 years before I decided to go back to get my doctorate degree. As someone who has always been curious about the experiences of engineers, the topic of onboarding and transition into engineering practice has always been my interest. Furthermore, how our backgrounds play a role in how we acquire skills and knowledge.

Some of these questions may require you to reflect to a time in the past and you might need some time to consider the question. If you wish to not answer a particular question, that's fine. We can always come back to it later or skip it entirely. Further, in an attempt to understand your perspectives as accurately as possible, I may ask what seems like a very simple, obvious, or repetitive question. Please forgive this as it's part of the interview process for this type of study.

I will begin by asking you a little bit about your background. We will then discuss your undergraduate experiences, early-career experiences, current experiences at work, and end with discussing similarities between your undergraduate experiences and early-career experiences.

Your participation is voluntary, and you can stop at any time. I also want to remind you that this is a confidential interview and your participation and responses will be de-identified and held in strict confidence. We will not reveal it in any form to others outside of the research team, especially anyone in your company.

Do you have any questions before we begin?

Section 1. Background Questions:

• Thank you for completing the survey prior to this study. I see from your responses that you have degrees in specify degree. Could you talk a little about that?

- How did you decide to pursue that degree?

o I see that you are working in [specify field], how did you decide to work in that field?

• What is your role in your most recent position?

- Could you specify the company you currently work for?
- *For those who answered yes to participating in a Rotational Onboarding Program:* From your Survey response, I see that you indicated that you participated in a Rotational Onboarding Program, tell me more about the program

NOTE: **During the rest of this interview, we will be discussing your undergraduate experiences and perception of your knowledge and skill gain during your early-career. While it might be easier to consider only your academic experiences during your undergraduate studies, it is important to consider all your experiences as an undergraduate, both academic and non-academic, and both on-campus and off-campus throughout this interview process.**

Protocol # ___________________________

Section 2a. Exploring Experiences and Skill Gain – Undergraduate Experiences

- From your survey response, I see that you had [Undergraduate Experience (Internship/Coop, study abroad, etc.] Tell me about those experiences
- What are some of the technical skills you believe you gained while you were at the university?
- What about your academic experiences at the university did you find helpful in your transition into engineering practice?
- What about your non-academic experiences at the university did you find helpful in your transition into engineering practice?
- Which of your undergraduate experiences (academic and non-academic) do you believe was the least important to your after your first 2 years at work? *(If participated in a ROP, ask using ROP instead of "first 2 years at work").*
- Of your experiences as an undergraduate, which ones do you most value now?

Section 2b. Exploring Experiences and Skill Gain – Engineering Practice

- Can you give me an example of a technical challenge you were asked to address at the beginning of your career that you were unsure how to address? How did you navigate it? What was that experience like for you? How so?

Follow-up Questions:

  - *What was the outcome?*
  - *What would you say made a difference in the outcome?*
  - *How did that experience make you feel about your university environment and preparation for engineering practice?*
  - *Reflecting back on this experience and maybe others during those first few years, did your undergraduate experience influence how you approached it? How so?*
- Are there any similarities in tools you used as an undergraduate student and the ones you use now? Give me some examples
- What would you say were your biggest adjustments from a technical perspective during the first 2 years of your career *(If participated in a ROP, ask using ROP instead of "first 2 years of your career")?*
- Which competencies or skills do you believe are helping you in your career now?
  - Where do you believe you learned them?
- Were there any similarities between your early experiences at work as a new engineer and some of your undergraduate experiences? Tell me about them?

Section 3. Exploring Background and Influence

- From your survey response, I see that you went to a [Type of University], if you were to describe the student body of the university you attended, what would it look like?

Follow-up:

- Where their part-time students? Transfer students? Mainly residential?
- What did the composition of your class look like?
- If you were to describe your colleagues at work, how would you describe the general composition at your employer's organization?

Follow-up Question:

Protocol # ___________________________

   - The people you worked with, what did they look like?
   - How did you develop your network at work?
- Did you have mentor(s)?

Follow-up Questions:
   - *Were they male/female?*
- Did you at any point feel you had a knowledge or skill gap at the beginning of your career?

Follow-up Question:
   - *Where their people or groups that helped you? Tell me more about it.*

Section 4. Summative Questions

- Reflecting back on your first 2 years in engineering practice *(If participated in a ROP, ask using ROP instead of "first 2 years in engineering practice),* what would you say about your undergraduate experience and preparation for work in engineering practice?
- Is there anything else that you want to add about your undergraduate or work experiences?
- Is there anything you feel I should've asked that I didn't ask about?
- Follow up with any aspects that they did not talk about earlier.

Concluding Questions

- What are your questions for me?
- Would you like to choose a pseudonym for me to use during analysis and in any publications?
- Thank you very much for your time! I appreciate it.

APPENDIX B. SAMPLE EMAIL TO SWE

Reply all | Delete | Junk | Block | ···

PhD Student Question: Onboarding in Engineering Dissertation

BO

Babajide, Olubunmi
Mon 10/8/2018 10:19 AM
[redacted]

Good day [redacted],

My name is Bunmi Babajide, I am a PhD student at Purdue University's College of Engineering. I am in the School of Engineering Education and I am currently working on collecting data for my dissertation. As an ex SWE student chapter president at Temple University, I am aware of the strong community at SWE and would like to speak to you about how I can potentially leverage the SWE community for my research survey.

My topic of interest is around knowledge and skills acquisition in Rotatational Onboarding Program in Engineering and Manufacturing practice. I am interested in the transition experiences of early-career engineers into engineering practice and as I prepare to recruit participants from engineering/manufacturing industry, I am looking to connect with people and organizations like SWE that might have reach within this space to help with connecting with employers and potential participants.

I recently finished a manuscript looking into 50 Rotational Onboarding Programs in engineering with a goal to understand recent trends in industry requirements and program goals to help academia understand what industry is looking for in new graduates and how they can better align from a curriculum perspective.

The goal is to send out an IRB approved survey link to employers for distribution in their organization or preferably directly to engineers with less than approximately 6 years of experience.

There will be a whitepaper published for this study and I will be happy to work on this in partnership with SWE Learning for all the female engineers related data. If this might be of interest, I will like to connect with you to discuss further. I look forward to hearing from you.

Regards,

APPENDIX C. EMAIL TO INTERVIEW PARTICIPANTS

Reply all | Delete | Junk | Block | ···

Dissertation (Onboarding Program Interviews)

BO

Babajide, Olubunmi

Tue 4/16/2019 8:29 AM

[redacted]

Dissertation (Onboarding Program Interviews)

Thu 4/18/2019 3:45 PM - 4:30 PM

Phone Interview/Discussion

No conflicts

This phone discussion will be a short interview to understand further your experiences while at the University and during your onboarding program in engineering practice.

Thank you so much for your support through this process of data collection for my dissertation!

\---

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Doodle Reference - DO NOT DELETE

doodle-uid=aoMMylYugk-5cb5ca9fc172a70001eb2acd3bipjur9r13aylpyitaksyan9k39suxi

Reply all Delete Junk Block ···

Dissertation Interview Today

BO

Babajide, Olubunmi
Mon 4/15/2019 7:19 AM
[redacted]

Interview_Consent_Form_[redacted]
269 KB

Good morning [redacted]

I look forward to speaking with you today at 3:45pm EST.

I will be available via my phone number: [redacted] I can also call you at that time if you prefer.

Please sign this consent form (could be signed via pdf editor if you prefer) and send to me at your convenience. It contains similar information as the survey consent form you took prior.

Thanks again. I look forward to speaking with you tomorrow.

Regards,
Bunmi Babajide
PhD Candidate
Purdue University
School of Engineering Education
www.onboardingprograms.com

Reply all Delete Junk Block ···

Invitation to Participate in Short Interview

BB

Bunmi Babajide <Bunmi@purdue.edu>
Mon 3/4/2019 10:45 PM
[redacted]

Thank you for taking the time out to respond to the inital survey for my dissertation study. You have indicated that you are interested in participating in the interview process. Thank you!

To get started, I will like to simply check in to see if you are still interested in the short interview to help me with my data collection about your experiences transitioning into engineering practice.

If you are still interested, please respond to this email with a "Yes, please contact me for the interview".

I will imagine this will be a short phone interview at your convience.

Initial Survey you responded to:
Take the Survey

I look forward to hearing from you!

Thank you,
Bunmi Babajide
PhD Candidate
Purdue University

Follow the link to opt out of future emails:
Click here to unsubscribe

APPENDIX D. EMPOYER LETTER

PURDUE
UNIVERSITY

Research Project Proposal: Onboarding Early-Career Engineers: ***Knowledge & Skill Acquisition in Rotational Programs***

Executive Summary:

How effective is your onboarding program in bringing new engineering graduates on board? And once they're trained – and becoming valuable to your organization – are you retaining them? The purpose of this study is to explore the impact of the rotational development program experiences on early-career engineers. Precisely, to compare skills and knowledge gain between rotational onboarding program in engineering and manufacturing industries in the United States and the undergraduate university experience. This will be achieved by exploring how the in-classroom and out-of-classroom experiences as perceived by the early-career engineers influence the outcomes of their rotational onboarding program experience.

This study is designed to characterize the experiences of early-career engineers while also offering in-depth perception of the effectiveness of onboarding programs. Furthermore, it will focus on understanding how the Rotational Onboarding Program experiences compare to the Undergraduate experiences in regards to the knowledge and skills Early-Career Engineers gain and the types of factors that contribute to the perception of both experiences.

Characterizing these experiences is important because it has potential to increase academia awareness of what industry is currently doing from a technical and professional perspective to prepare engineers for permanent roles in industry. It could also help to understand how well these form of onboarding meets new graduates' needs, inform organizations on program activities that are redundant from university experiences that could be eliminated. Furthermore, it could assist academia in gaining insight on student preparation in ways that fulfill industry standards, benefit academia understanding of industry expectation of entry-level roles, and understand how diversity plays a role in onboarding early-career engineers.

This study has potential benefits for organizations that are interested in understanding the perception of the technical and professional content of their program. Some of these benefits include: Identifying gaps that may exist, understanding actual perceived outcomes of the program from a technical and professional skills perspective, and gain insight on overlapping objectives between university and industry preparation. The findings could be used to restructure or revamp the current program and eliminating wasteful spending in areas that might be considered redundant from undergraduate experiences or deemed ineffective.

Companies who participate in the online survey activity of this study could receive the following incentives based on the level of participation:

- Full whitepaper report
- Presentation of overall research findings to upper-management (In-person/WebEx)
- Organization-specific results summary
- Access to future research on best practices

To participate in this study, please contact Bunmi Babajide for more details at Bunmi@Purudue.edu or [redacted]

About the Researcher: Bunmi Babajide is a Ph.D. student in Engineering Education at Purdue University. Her professional background includes experiences in management consultant with Booz Allen Hamilton, management at Caterpillar Inc., Area Lead at Cytec Engineered Materials, and as an alum of the Rotational Leadership program at Ford Motor Company (FCG Program).

APPENDIX E. LINKEDIN SURVEY INVITATION

You are invited to participate in a research study titled ***Onboarding Early-Career Engineers: Knowledge & Skill Acquisition in Rotational Onboarding Programs.*** This study is designed to compare the skills and knowledge that early-career engineers gain in their experiences as undergraduates with their onboarding experiences as new employees. Kindly take the survey and share link with your network. Each person taking the survey has a chance to win two $250 Amazon gift cards. There will be 2 raffle drawings for this study. The first raffle drawing will be on **January 31st, 2019.** Each person who refers a person who takes the survey will receive an additional chance to win the $250 Amazon gift card for each person referred as an incentive to forward the survey invitation to your friends who fit the criteria for the study. One additional chance for each participant. Simply have your friends input your email address at the end of the survey. **If you decide to participate in this anonymous survey, it will take approximately 15 minutes to complete using the link attached.** https://goo.gl/8S3ZVv

APPENDIX F. QUALTRICS SURVEY INSTRUMENT

PURDUE
UNIVERSITY

Consent Form

RESEARCH PARTICIPANT CONSENT FORM
Protocol #1809021095

Onboarding Early-Career Engineers: Knowledge & Skill Acquisition in Rotational Programs

School of Engineering Education
Purdue University

What is the purpose of this study? The purpose of this study is to explore the impact of the professional development experiences on early career engineers. Specifically, this survey will investigate the relationship between undergraduate experiences and rotational onboarding programs in the development of the skills and knowledge of early-career engineers in engineering and manufacturing industries in the United States.

What will I do if I choose to be in this study? You will be asked to answer a series of questions about your experiences as an undergraduate student and about your experiences in your onboarding program with your employer.

How long will I be in the study? The survey will take approximately 15 minutes.

What are the possible risks or discomforts? The risks are minimal, no greater than everyday life. There is a risk of breach of confidentiality, but measures to minimize this risk can be found in the confidentiality section.

Are there any potential benefits? There are no direct benefits. However, the potential benefit is for the engineering community at large--both academics and practitioners--to understand the knowledge and skills that early career engineers gain from university experiences and from onboarding programs.

Will I receive payment or other incentive? There is no compensation for the survey study.

Will information about me and my participation be kept confidential? You will not be asked for your name, and we will not collect any identifiable information. The data will be stored in a password protected computer. The project's research records may be reviewed by the College of Engineering at Purdue University, and by departments at Purdue responsible for regulatory and research oversight. This data may be used for future research purposes.

What are my rights if I take part in this study? Your participation in this study is voluntary. You may choose not to participate or, if you agree to participate, you can withdraw your participation at any time without penalty or loss of benefits to which you are otherwise entitled.

Whom can I contact if I have questions about the study? If you have questions, comments or concerns about this research project, you can talk to one of the researchers, Bunmi Babajide, Bunmi@purdue.edu

- ○ Accept
- ○ Decline

Demographic Data

Engineering Rotational Onboarding Program Survey

This survey is part of a research study to help understand the transition of early career engineers into industry. It contains questions that invite participants to reflect on their undergraduate experience and also current job experiences.

Total Duration of this survey is approximately 15 minutes.

PERSONAL INFORMATION

Have you in the past or do you currently work for a product development/manufacturing company?

- ○ Yes
- ○ No

Did you participate in a form of rotational onboarding program with your current or previous employer?

- ○ Yes
- ○ No

What was the total duration of the onboarding program? (Including all rotations)

- ◯ 1 to 3 months
- ◯ 4 to 9 months
- ◯ 10 to 12 months
- ◯ 13 to 18 months
- ◯ 19 to 24 months
- ◯ 25 to 36 months
- ◯ Over 36 months (How many months) ____________

What year did you start your onboarding program?

- ◯ 2000-2008
- ◯ 2009
- ◯ 2010
- ◯ 2011
- ◯ 2012
- ◯ 2013
- ◯ 2014
- ◯ 2015
- ◯ 2016
- ◯ 2017

Instructions

Instructions: **in the following section, you will be asked to think about your level of ability in college at the time of graduation and your current level of ability. If you're unfamiliar with , or have had no experience with, any of the following, select the "Weak/none" option.**

Define Problems and Generate Design Solutions.

1. Define Problems and Generate Design Solutions. Please rate your ability to do each of the following (1) At the end of your <u>entire experience</u> as an undergraduate student (UNDERGRADUATE EXPERIENCE), and (2) Currently (NOW):

Ability to...

1 = Weak/none 2 = Fair 3 = Good 4 = Very Good 5 = Excellent

UNDERGRADUATE EXPERIENCE						NOW				
1	2	3	4	5		1	2	3	4	5
○	○	○	○	○	Define design problems and objectives clearly and precisely.	○	○	○	○	○
○	○	○	○	○	Ask questions to understand what a client/customer really wants in a "product."	○	○	○	○	○
○	○	○	○	○	Undertake a search (literature review, databases, benchmarking, reverse-engineering, etc.) before beginning team-based brainstorming.	○	○	○	○	○
○	○	○	○	○	Take into account the design contexts (social, cultural, economic, environmental, political, ethical, etc.) and the constraints they may impose on each possible solution.	○	○	○	○	○
○	○	○	○	○	Generate and prioritize criteria for evaluating the quality of a solution.	○	○	○	○	○
○	○	○	○	○	Brainstorm possible engineering solutions.	○	○	○	○	○
○	○	○	○	○	Apply systems thinking in developing solutions to an engineering problem.	○	○	○	○	○
○	○	○	○	○	Develop pictorial representations of possible designs (sketches, renderings, engineering drawings, etc.).	○	○	○	○	○
○	○	○	○	○	Evaluate design solutions based on a specified set of criteria.	○	○	○	○	○
○	○	○	○	○	Produce a product (prototype, program, simulation, etc.).	○	○	○	○	○

Manage a Design Project

2. Manage a Design Project. Please rate your ability to do each of the following (1) At the end of your <u>entire experience</u> as an undergraduate student (UNDERGRADUATE EXPERIENCE), and (2) Currently (NOW):

Ability to...

1 = Weak/none   2 = Fair   3 = Good   4 = Very Good   5 = Excellent

UNDERGRADUATE EXPERIENCE						NOW				
1	2	3	4	5		1	2	3	4	5
○	○	○	○	○	Break down a design project into manageable components or tasks.	○	○	○	○	○
○	○	○	○	○	Identify team members' strengths/weaknesses and distribute tasks and workload accordingly.	○	○	○	○	○
○	○	○	○	○	Recognize when changes to the original understanding of the problem may be necessary.	○	○	○	○	○
○	○	○	○	○	Monitor the design process to ensure goals are being met.	○	○	○	○	○
○	○	○	○	○	Put aside differences within a design team to get the work done.	○	○	○	○	○

Engineering Contexts

3. **Engineering Contexts.** Please rate your ability to do each of the following (1) At the end of your entire experience as an undergraduate student (UNDERGRADUATE EXPERIENCE), and (2) Currently (NOW):

Ability to...

1 = Weak/none   2 = Fair   3 = Good   4 = Very Good   5 = Excellent

UNDERGRADUATE EXPERIENCE						NOW				
1	2	3	4	5		1	2	3	4	5
○	○	○	○	○	Knowledge of contexts (social, political, economic, cultural, environmental, ethical, etc.) that might affect the solution to an engineering problem.	○	○	○	○	○
○	○	○	○	○	Knowledge of the connections between technological solutions and their implications for the society or groups they are intended to benefit.	○	○	○	○	○
○	○	○	○	○	If you can read this, select 4 - Very Good	○	○	○	○	○

UNDERGRADUATE EXPERIENCE 1	2	3	4	5		NOW 1	2	3	4	5
○	○	○	○	○	Ability to use what you know about different cultures, social values, or political systems in developing engineering solutions.	○	○	○	○	○
○	○	○	○	○	Ability to recognize how different contexts can change a problem solution.	○	○	○	○	○

Communication

4. Communication. Please rate your ability to do each of the following (1) At the end of your entire experience as an undergraduate student (UNDERGRADUATE EXPERIENCE), and (2) Currently (NOW):

Ability to...

1 = Weak/none 2 = Fair 3 = Good 4 = Very Good 5 = Excellent

UNDERGRADUATE EXPERIENCE 1	2	3	4	5		NOW 1	2	3	4	5
○	○	○	○	○	Write a well-organized, coherent report.	○	○	○	○	○
○	○	○	○	○	Make effective audiovisual presentations.	○	○	○	○	○
○	○	○	○	○	Construct tables or graphs to communicate a solution.	○	○	○	○	○
○	○	○	○	○	Communicate effectively with clients, teammates, and supervisors.	○	○	○	○	○
○	○	○	○	○	Communicate effectively with non-technical audiences.	○	○	○	○	○
○	○	○	○	○	Communicate effectively with people from different cultures or countries.	○	○	○	○	○

Teamwork

5. Teamwork. Please rate your ability to do each of the following (1) At the end of your entire experience as an undergraduate student (UNDERGRADUATE EXPERIENCE), and (2) Currently (NOW):

Ability to...

1 = Weak/none 2 = Fair 3 = Good 4 = Very Good 5 = Excellent

UNDERGRADUATE EXPERIENCE						NOW				
1	2	3	4	5		1	2	3	4	5
○	○	○	○	○	Help your group or organization work through periods when ideas are too much or too few.	○	○	○	○	○
○	○	○	○	○	Develop a plan to accomplish a group's or organization's goals.	○	○	○	○	○
○	○	○	○	○	Take responsibility for a group's or organization's performance.	○	○	○	○	○
○	○	○	○	○	Motivate people to do the work that needs to be done.	○	○	○	○	○

Leadership

6. Leadership. Please rate your ability to do each of the following (1) At the end of your entire experience as an undergraduate student (UNDERGRADUATE EXPERIENCE), and (2) Currently (NOW):

Ability to...

1 = Weak/none 2 = Fair 3 = Good 4 = Very Good 5 = Excellent

UNDERGRADUATE EXPERIENCE						NOW				
1	2	3	4	5		1	2	3	4	5
○	○	○	○	○	Work with others to accomplish group goals.	○	○	○	○	○
○	○	○	○	○	Work in teams of people with a variety of skills and backgrounds.	○	○	○	○	○
○	○	○	○	○	Work in teams where knowledge and ideas from multiple engineering fields must be applied.	○	○	○	○	○

UNDERGRADUATE EXPERIENCE 1	2	3	4	5		NOW 1	2	3	4	5
○	○	○	○	○	Work in teams that include people from fields <u>outside engineering</u>.	○	○	○	○	○

Interdisciplinary Knowledge and Skills

7. Interdisciplinary Knowledge and Skills. Indicate your level of agreement with the following (1) When you were an undergraduate student (YOUR ENTIRE UNIVERSITY EXPERIENCE), and (2) Currently (NOW):

Agreement with...

1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree

UNDERGRADUATE EXPERIENCE 1	2	3	4	5		NOW 1	2	3	4	5
○	○	○	○	○	I value reading about topics outside of engineering (history, business, politics, the cultures of other parts of the world, etc.).	○	○	○	○	○
○	○	○	○	○	I enjoy thinking about how different fields approach the same problem in different ways.	○	○	○	○	○
○	○	○	○	○	Not all engineering problems have purely technical solutions.	○	○	○	○	○
○	○	○	○	○	In solving engineering problems I often seek information from experts in other academic fields.	○	○	○	○	○
○	○	○	○	○	Given knowledge and ideas from different fields, I can figure out what is appropriate for solving a problem.	○	○	○	○	○
○	○	○	○	○	I see connections between ideas in engineering and ideas in the humanities and social sciences.	○	○	○	○	○
○	○	○	○	○	I can take ideas from <u>outside engineering</u> and synthesize them in ways that help me better understand or explain a problem.	○	○	○	○	○
○	○	○	○	○	I can use what I have learned in one field in another setting or to solve a new problem.	○	○	○	○	○

Recognizing Perspectives

8. Recognizing Perspectives. Indicate your level of agreement with the following (1) When you were an undergraduate student (YOUR ENTIRE UNIVERSITY EXPERIENCE), and (2) Currently (NOW):

Agreement with...

1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree

UNDERGRADUATE EXPERIENCE						NOW				
1	2	3	4	5		1	2	3	4	5
○	○	○	○	○	I often step back and reflect on what I am thinking to determine whether I might be missing something.	○	○	○	○	○
○	○	○	○	○	I frequently stop to think about where I might be going wrong or right with a problem solution.	○	○	○	○	○
○	○	○	○	○	If asked, I could identify the kinds of knowledge and ideas that are distinctive to different fields of study (chemistry, psychology, literature, etc.)	○	○	○	○	○
○	○	○	○	○	I recognize the kinds of evidence that different fields of study rely on.	○	○	○	○	○
○	○	○	○	○	I'm good at figuring out what experts in different fields have missed in explaining a problem or proposing a solution.	○	○	○	○	○
○	○	○	○	○	I usually know when my own biases are getting in the way of my understanding of a problem or finding a solution.	○	○	○	○	○

Topics in Engineering

9. Topics in Engineering. Overall, (1) how much did the courses in your undergraduate engineering program emphasize each of the following and (2) how important are they in your work now?

Emphasis on...

1 = Little/none 2 = Slight 3 = Moderate 4 = High 5 = Very high

UNDERGRADUATE EXPERIENCE 1	2	3	4	5		IMPORTANCE NOW 1	2	3	4	5
○	○	○	○	○	Ethical issues in practice.	○	○	○	○	○
○	○	○	○	○	The importance of life-long learning.	○	○	○	○	○
○	○	○	○	○	Examining my beliefs and values and how they affect my ethical decisions.	○	○	○	○	○
○	○	○	○	○	The value of gender, racial/ethnic, or cultural diversity.	○	○	○	○	○
○	○	○	○	○	Working with people who differ from me in gender, race/ethnicity, or cultural background.	○	○	○	○	○
○	○	○	○	○	Creativity and innovation.	○	○	○	○	○
○	○	○	○	○	Current workforce and economic trends (globalization, outsourcing, etc.)	○	○	○	○	○
○	○	○	○	○	Emerging technologies.	○	○	○	○	○
○	○	○	○	○	How theories are used in practice.	○	○	○	○	○

Professional Skills

10. Professional Skills. Overall, (1) how much did the courses in your undergraduate engineering program emphasize each of the following and (2) how important are they in your work now?

Emphasis on...

1 = Little/none 2 = Slight 3 = Moderate 4 = High 5 = Very high

UNDERGRADUATE EXPERIENCE 1	2	3	4	5		IMPORTANCE NOW 1	2	3	4	5
○	○	○	○	○	Professional skills (knowing codes and standards, being on time, meeting deadlines, etc.).	○	○	○	○	○
○	○	○	○	○	Written and oral communication skills.	○	○	○	○	○
○	○	○	○	○	Leadership skills.	○	○	○	○	○

UNDERGRADUATE EXPERIENCE						IMPORTANCE NOW				
1	2	3	4	5		1	2	3	4	5
○	○	○	○	○	Working effectively in teams.	○	○	○	○	○
○	○	○	○	○	Working with multinational groups or teams.	○	○	○	○	○
○	○	○	○	○	Project management skills (budgeting, monitoring progress, managing people, etc.).	○	○	○	○	○

Problem Solving

11. Problem Solving. Overall, (1) how much did the courses in your undergraduate engineering program emphasize each of the following and (2) how important are they in your work now?

Emphasis on...

1 = Little/none 2 = Slight 3 = Moderate 4 = High 5 = Very high

UNDERGRADUATE EXPERIENCE						IMPORTANCE NOW				
1	2	3	4	5		1	2	3	4	5
○	○	○	○	○	Understanding how a solution can be shaped by environmental, cultural, economic, and other considerations.	○	○	○	○	○
○	○	○	○	○	Understanding how knowledge from several fields can help solve a problem.	○	○	○	○	○
○	○	○	○	○	Applying knowledge from several fields to solve a problem.	○	○	○	○	○
○	○	○	○	○	Systems thinking.	○	○	○	○	○
○	○	○	○	○	Defining a problem.	○	○	○	○	○
○	○	○	○	○	Generating and evaluating ideas about how to solve an engineering problem.	○	○	○	○	○

Undergraduate Experience

UNDERGRADUATE EXPERIENCES

12. As an undergraduate student, approximately how many months did you spend participating in each of the following:

	# of months
Undergraduate research activities	
Engineering internship(s)	
Engineering cooperative education expereince	
Study abroad or an international school-related tour(s)	
Working on humanitarian engineering projects (Engineers Without Boarders, etc.)	
Non-engineering related community service or volunteer work	
Student design project(s)/competition(s) beyond class requirements	

Block 17

What is your gender?

- ◯ Male
- ◯ Female

What is your racial or ethnic identification?

- ◯ Asian/Pacific Islander American
- ◯ African American
- ◯ Caucasian/White
- ◯ Hispanic or Latino/a American
- ◯ Native American
- ◯ Multiracial

- Foreign national (Green card holder)
- Naturalized U.S. citizen
- I do not wish to identify
- Others (please specify): ______

What year did you graduate from **undergraduate** studies?

- 2000 - 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017

What was your major?

- Aerospace Engineering
- Architectural Engineering
- Biomedical Engineering
- Chemical Engineering
- Civil Engineering
- Computer Engineering
- Electrical and Computer Engineering
- Electrical Engineering
- Industrial Engineering/Systems Engineering
- Mechanical Engineering
- Structural Engineering
- Others ______

What was your minor?

- None
- Computer Science
- Mathematics
- Others

Do you have a master's degree?

- Yes
- In progress
- No

Is your master's degree in engineering?

- Yes
- No

The organization I work for is in which of the following:

- Public sector
- Private sector
- Nonprofit
- others

The university I attended is considered which one of these?

- Commonwealth University
- HBCU
- Ivy League
- Private Univeristy
- State University/Land Grant University

○ others [ ]

What is the name of the company you work for?

[ ]

Where you **assigned** a mentor during your Rotational Onboarding Program?

○ Yes
○ No

General Questions

Are you currently enrolled in a graduate program?

○ Yes
○ No

What degree are you seeking?

○ MA/MS/M Eng
○ MBA
○ MD/DDS
○ JD
○ PhD
○ Others

In what filed will you earn your graduate degree?

○ Aerospace Engineering
○ Biomedical/Bio-engineering
○ Business (Including supply chain & logistics)

- Chemical engineering
- Civil engineering
- Electrical engineering
- Electrical and Computer Engineering
- General engineering/Engineering science
- Industrial engineering/Systems Engineering
- Mechanical engineering
- Law
- Medicine
- Other engineering fields
- Other field (not engineering)

Which one of the following best describes your employer's primary business activity? [Categories of the North American Industry Classification Systems]

- Accommodation or food services
- Administrative or support or waste management remediation services
- Agriculture, forestry, fishing or hunting
- Arts, entertainment, or recreation
- Construction
- Educational services
- Finance and insurance
- Health care or social assistance
- Information
- Management of companies or enterprises
- Manufacturing
- Mining (including oil and gas)
- Professional, scientific, or technical services
- Public administration (government, civil service, military)
- Real estate or rental leasing
- Retail trade
- Transportation or warehousing
- Utilities

- Wholesale trade
- Others (Please specify): ______

Which <u>one</u> of the following best describes <u>your current primary job function</u>?

- Business/finance
- Consultant
- Design/process/applications engineer
- Faculty/academic professional
- Human resources
- Information/technology/network support
- Management/administration/excecutive
- Marketing/sales
- Production, installation, delivery of services
- Quality engineer
- Research and development
- Supervisor of professional/technical/research personnel
- Test engineer
- Others (please specify): ______

How close are your current job responsibilities related to your undergraduate engineering degree?

- Directly related
- Somewhat related
- Not related

Overall, where you satisfied with your <u>undergraduate program</u> experience?

- Yes
- No

What aspects of your undergraduate experience or your employer's onboarding program experience, besides those covered in this survey, contributed significantly to your knowledge and skills?

Can we contact you for a short interview to expand on some of your responses?

NOTE: *If selected for the interview, the interview will be approximately 45 minutes long and you will receive a $25 Amazon gift card.*

- Yes
- No

What is your E-mail address?

Would you like to enter for a chance to win a $250 Amazon gift card for your participation?

Note: There will be 3 chances to win a prize. The first drawing will be held and winner notified on December 14th, 2018

- Yes
- No

What is your email address?

APPENDIX G. RESPONDENT SCORES

I assigned an identifier to each survey respondent: RP1 to RP67 for ROP engineers, and DH1 to DH50 for direct-hire engineers. For the learning outcomes (LO), I assigned each outcome as follows:

LO1: Define Problems and Generate Solutions

LO2: Manage a Design Project

LO3: Engineering Contexts

LO4: Communication

LO5: Teamwork

LO6: Leadership

LO7: Interdisciplinary Knowledge and Skills

LO8: Recognizing Perspectives

LO9: Topics in Engineering

LO10: Professional Skills

LO11: Problem Solving

Table G.1 Now Scores – ROP Participants

Now Scores - ROP Participants											
	LO1	**LO2**	**LO3**	**LO4**	**LO5**	**LO6**	**LO7**	**LO8**	**LO9**	**LO10**	**LO11**
RP1	4.10	5.00	4.25	4.83	5.00	5.00	5.00	5.00	5.00	5.00	5.00
RP2	3.90	4.00	3.75	4.00	4.00	4.00	4.13	3.67	4.22	5.00	4.00
RP3	4.50	4.20	4.75	4.33	4.75	5.00	4.88	4.50	5.00	5.00	4.83
RP4	4.20	4.20	3.50	4.17	3.75	4.75	4.38	2.83	3.89	4.50	4.33
RP5	4.50	4.40	4.25	4.50	4.25	4.75	4.50	4.17	5.00	4.50	4.67
RP6	3.90	4.00	4.00	4.67	4.75	3.75	4.75	3.67	2.89	3.83	2.67
RP7	4.70	4.20	3.75	5.00	4.00	4.25	4.13	3.17	3.89	4.17	5.00
RP8	4.20	4.60	3.50	4.33	3.75	4.00	4.63	3.67	4.56	4.83	4.83
RP9	4.20	4.00	3.50	4.83	4.00	4.75	4.13	4.17	4.22	4.50	4.00
RP10	4.10	4.20	4.00	4.33	3.75	4.00	3.75	4.33	3.44	3.83	3.67
RP11	3.70	3.60	2.75	3.83	3.00	4.00	3.75	4.00	2.89	4.67	3.00
RP12	3.40	4.40	4.00	3.83	5.00	5.00	4.13	4.50	5.00	4.83	4.67
RP13	3.60	3.40	3.75	4.00	3.25	3.00	3.63	3.83	3.67	2.50	3.33
RP14	4.60	3.80	4.00	4.50	3.50	4.00	3.88	4.00	4.56	5.00	4.50
RP15	3.80	4.20	4.00	4.00	3.25	4.75	4.00	4.00	4.67	5.00	4.33
RP16	3.60	4.00	2.75	3.83	4.50	4.50	4.50	4.00	3.78	4.50	3.83
RP17	3.50	3.60	3.75	4.17	3.75	4.25	3.38	3.50	2.56	3.83	3.67
RP18	3.70	3.80	3.75	3.83	4.00	4.00	4.00	3.17	4.00	4.00	4.00
RP19	4.70	4.60	4.00	4.67	4.25	4.75	3.88	4.83	5.00	4.33	5.00
RP20	4.70	4.40	4.50	4.50	5.00	4.50	4.25	3.50	4.11	4.33	4.17
RP21	4.00	3.80	3.75	4.00	3.50	4.00	3.63	4.17	3.89	4.00	3.67
RP22	4.70	4.40	4.25	4.83	4.25	5.00	4.75	4.33	4.67	4.67	4.50
RP23	3.50	3.80	3.00	4.17	3.75	4.00	3.75	4.00	3.78	4.50	4.83
RP24	3.40	3.40	2.50	4.17	3.25	3.75	4.38	3.50	3.33	4.17	3.17
RP25	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
RP26	4.50	4.60	4.75	4.83	4.50	5.00	5.00	4.33	4.11	4.83	4.67
RP27	3.80	3.80	3.25	3.83	3.00	4.25	4.50	4.17	4.67	4.50	4.33
RP28	3.80	3.20	3.75	2.83	4.25	4.00	3.50	3.33	3.44	4.33	3.67
RP29	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.33	4.67	5.00	5.00
RP30	3.60	3.60	4.25	3.67	4.00	5.00	4.38	3.83	3.67	4.50	4.33
RP31	3.90	3.20	4.00	4.33	3.75	3.75	3.63	3.00	3.78	4.17	3.50
RP32	4.60	4.00	4.50	4.83	4.00	5.00	4.88	3.83	4.44	4.67	4.67
RP33	4.30	4.20	4.75	3.33	4.25	4.50	4.38	4.67	3.00	4.17	4.33
RP34	3.70	3.40	3.50	3.33	3.50	4.00	4.13	4.33	3.56	3.33	4.50
RP35	4.00	4.80	2.25	4.00	3.00	5.00	3.63	3.33	4.00	5.00	4.17
RP36	4.20	5.00	1.00	5.00	5.00	4.25	3.50	3.50	3.00	4.00	3.50
RP37	3.80	3.40	3.75	2.83	4.00	4.00	4.13	3.17	4.67	4.67	4.33
RP38	3.40	2.80	3.00	3.17	2.50	3.00	4.50	3.67	3.00	3.67	3.50
RP39	3.60	5.00	4.25	4.50	4.50	5.00	4.75	4.00	4.89	5.00	5.00

RP40	3.00	3.40	2.50	3.67	2.75	3.00	4.00	3.83	4.33	4.67	4.17
RP41	3.40	4.20	4.25	4.83	4.00	4.75	4.88	4.67	4.67	4.83	4.50

Table G.1 continued

RP42	3.30	4.80	3.75	4.33	4.25	5.00	4.63	3.50	3.89	3.67	4.00
RP43	4.90	4.80	4.75	4.00	5.00	4.50	4.00	4.67	4.78	5.00	5.00
RP44	2.70	3.40	3.25	3.00	2.25	3.25	2.88	3.00	3.11	4.33	3.50
RP45	4.40	4.60	3.75	4.33	4.25	4.25	4.50	4.50	4.44	4.50	4.67
RP46	4.60	4.20	5.00	4.50	5.00	4.25	4.25	4.33	4.33	4.33	4.83
RP47	4.80	4.20	4.50	4.00	5.00	5.00	3.38	3.67	4.00	4.17	5.00
RP48	4.50	4.60	4.50	4.33	4.75	4.25	4.50	4.83	4.44	5.00	5.00
RP49	3.30	4.20	3.50	4.17	3.00	3.00	4.38	3.00	2.89	3.67	2.67
RP50	4.30	4.00	3.50	4.83	4.00	4.50	4.38	4.33	4.56	5.00	4.67
RP51	2.80	4.60	2.00	3.50	3.50	4.50	2.75	2.50	2.67	3.17	3.17
RP52	4.30	5.00	3.00	4.67	4.50	5.00	4.50	4.17	4.56	5.00	4.00
RP53	4.30	4.00	4.50	4.33	4.00	4.50	4.63	4.50	4.44	4.67	4.33
RP54	3.60	3.80	2.50	4.83	4.00	4.75	4.75	3.50	4.00	4.17	4.50
RP55	4.10	4.00	4.50	4.33	4.50	4.50	3.38	3.67	3.44	5.00	4.17
RP56	4.10	3.40	3.75	4.00	3.75	3.75	4.00	4.00	4.11	4.67	3.50
RP57	3.90	4.00	3.50	4.83	3.50	4.00	2.63	3.00	3.67	4.83	3.83
RP58	4.70	5.00	5.00	5.00	4.75	4.75	5.00	5.00	5.00	5.00	5.00
RP59	3.70	4.20	3.25	3.33	3.75	4.00	3.25	3.67	3.89	4.50	4.83
RP60	4.70	4.80	4.50	3.67	4.00	4.50	3.38	3.67	3.67	4.00	3.50
RP61	4.90	4.60	4.50	4.67	4.00	5.00	4.75	3.50	4.44	4.50	4.33
RP62	3.80	4.80	4.75	4.50	4.75	5.00	4.00	3.83	3.89	5.00	3.83
RP63	3.70	3.80	3.75	3.83	4.00	4.00	3.75	3.17	3.89	3.83	4.00
RP64	2.90	3.00	4.00	4.00	3.00	3.50	4.38	3.50	4.44	3.00	3.33
RP65	3.80	4.00	3.75	3.83	3.00	3.75	3.38	3.50	3.44	4.17	3.50
RP66	4.50	4.80	4.25	4.67	4.00	5.00	4.13	4.17	4.56	4.83	4.67
RP67	4.00	4.60	3.75	5.00	4.50	4.75	3.88	3.83	3.33	4.50	3.33

Table G.2 Undergraduate Scores - ROP Participants

UNDERGRADUATE Scores - ROP Participants											
	LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8	LO9	LO10	LO11
RP1	3.00	22.00	8.00	4.00	5.00	4.00	2.88	3.83	5.00	3.33	3.33
RP2	3.50	4.00	3.75	4.00	3.75	4.00	4.00	3.67	4.11	5.00	4.00
RP3	3.30	4.20	4.75	4.00	4.00	4.00	4.75	4.17	3.44	3.17	3.83
RP4	2.50	4.20	3.50	2.83	3.00	3.50	2.00	1.83	2.11	3.00	2.17
RP5	2.20	4.40	4.25	2.17	2.50	1.75	3.75	3.00	5.00	3.17	2.83
RP6	3.60	4.00	4.00	3.83	3.25	2.00	4.13	3.67	4.44	4.67	4.00
RP7	2.90	4.20	3.75	2.67	1.75	2.25	2.00	1.33	2.11	2.17	2.00
RP8	3.50	4.60	3.50	3.67	3.50	3.50	4.50	3.67	3.67	3.67	3.67
RP9	3.60	4.00	3.50	4.67	3.75	3.00	3.38	3.67	4.22	4.17	3.50
RP10	2.60	4.20	4.00	3.00	2.75	3.00	1.88	2.67	2.33	3.33	2.17
RP11	2.70	3.60	2.75	3.33	2.50	3.00	3.25	3.67	3.44	2.83	2.17
RP12	3.00	4.40	4.00	4.17	4.75	4.50	3.63	4.00	3.89	4.67	4.00
RP13	2.70	3.40	3.75	3.67	2.25	3.00	3.63	3.67	3.78	3.50	3.83
RP14	3.10	3.80	4.00	4.33	2.00	3.25	3.75	3.50	3.78	4.33	2.83
RP15	2.00	4.20	4.00	3.00	2.25	2.75	3.50	2.67	2.56	1.67	2.67
RP16	3.50	4.00	2.75	3.17	3.50	4.50	4.63	3.50	4.44	4.50	4.67
RP17	2.20	3.60	3.75	2.00	2.75	2.25	2.88	2.67	3.11	2.67	3.17
RP18	2.60	3.80	3.75	2.83	4.00	3.00	3.25	2.33	3.00	3.00	3.00
RP19	3.50	4.60	4.00	3.17	2.75	3.50	3.63	4.33	2.78	3.67	3.33
RP20	3.70	4.40	4.50	3.67	3.25	3.50	3.13	2.83	3.33	3.33	3.33
RP21	3.40	3.80	3.75	3.67	3.00	3.25	2.88	4.00	3.89	4.00	3.50
RP22	3.80	4.40	4.25	4.00	3.75	3.50	3.88	4.00	4.11	4.17	3.50
RP23	2.70	3.80	3.00	3.00	3.00	2.75	2.38	2.67	1.67	2.67	2.50
RP24	3.40	3.40	2.50	3.50	2.50	3.25	4.38	3.83	1.78	3.17	3.33
RP25	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
RP26	4.30	4.60	4.75	2.83	4.75	4.75	4.50	4.33	4.00	3.83	4.50
RP27	2.60	3.80	3.25	3.17	2.75	1.75	4.25	3.50	3.11	3.50	2.50
RP28	2.90	3.20	3.75	2.00	3.25	3.00	2.50	2.17	2.11	2.83	2.50
RP29	4.30	5.00	5.00	4.50	4.50	5.00	4.63	4.17	4.22	4.17	4.50
RP30	2.70	3.60	4.25	3.50	3.00	4.00	3.75	3.50	4.44	3.67	3.67
RP31	3.00	3.20	4.00	2.67	2.75	2.75	2.50	2.00	2.44	3.17	2.50
RP32	3.90	4.00	4.50	4.33	3.50	3.25	4.50	3.50	3.00	4.00	3.83
RP33	3.30	4.20	4.75	3.50	3.25	3.25	3.25	3.17	4.89	4.33	4.17
RP34	3.30	3.40	3.50	3.50	4.00	3.75	4.25	3.83	3.78	4.50	4.00
RP35	3.60	4.80	2.25	3.67	4.00	4.25	2.63	3.17	3.44	4.00	3.67
RP36	3.40	5.00	1.00	3.17	4.25	3.25	3.25	3.50	2.89	2.33	2.17
RP37	3.60	3.40	3.75	2.50	4.00	3.50	3.00	2.83	1.78	2.17	4.33
RP38	2.70	2.80	3.00	2.67	2.25	2.75	3.63	2.67	2.00	3.00	2.33
RP39	3.00	5.00	4.25	3.17	3.00	3.75	2.75	2.83	2.78	4.00	4.00
RP40	2.40	3.40	2.50	3.00	2.00	2.50	2.88	3.33	3.44	4.00	3.50
RP41	3.10	4.20	4.25	4.00	2.50	3.25	4.25	4.00	3.11	3.33	3.33

Table G.2 continued

RP42	2.50	4.80	3.75	2.50	2.75	5.00	1.38	1.83	2.00	2.67	1.83
RP43	1.90	4.80	4.75	1.83	3.00	1.75	1.38	1.67	1.89	2.50	1.67
RP44	3.00	3.40	3.25	3.00	3.00	3.00	3.25	3.17	3.00	3.83	3.00
RP45	2.80	4.60	3.75	2.83	2.25	2.00	3.75	3.83	3.56	3.50	3.33
RP46	2.50	4.20	5.00	2.67	3.50	2.50	3.38	2.83	2.56	2.83	3.17
RP47	3.20	4.20	4.50	3.83	5.00	4.75	2.38	3.67	3.56	2.17	4.50
RP48	3.50	4.60	4.50	3.83	4.25	3.25	4.38	4.00	4.00	4.33	4.50
RP49	1.80	4.20	3.50	3.67	2.00	1.75	3.13	2.67	3.00	3.17	2.00
RP50	3.70	4.00	3.50	3.50	2.50	3.25	3.38	3.17	3.44	4.00	3.00
RP51	2.70	4.60	2.00	3.50	3.25	4.50	2.88	2.50	2.44	3.50	2.83
RP52	3.70	5.00	3.00	4.83	4.00	4.00	4.00	3.33	2.56	3.50	2.33
RP53	2.90	4.00	4.50	3.83	3.25	3.25	3.88	3.17	3.78	4.33	2.67
RP54	1.40	3.80	2.50	4.50	3.75	3.50	2.88	1.67	2.00	2.67	2.00
RP55	3.10	4.00	4.50	4.00	3.25	3.50	2.50	2.83	3.00	3.83	3.50
RP56	3.30	3.40	3.75	3.67	3.50	3.50	3.50	3.33	3.00	3.83	3.00
RP57	2.40	4.00	3.50	3.67	3.00	4.00	2.13	2.33	2.11	2.67	2.33
RP58	3.00	5.00	5.00	3.17	3.00	3.00	2.88	3.00	3.00	3.17	3.00
RP59	3.00	4.20	3.25	3.17	3.25	4.00	3.00	3.00	3.33	4.50	2.50
RP60	4.50	4.80	4.50	3.67	4.25	4.50	3.00	3.67	2.33	3.00	3.00
RP61	3.90	4.60	4.50	3.83	3.25	3.50	4.00	3.33	3.00	2.67	3.50
RP62	3.70	4.80	4.75	3.83	3.75	3.25	3.63	3.00	2.44	2.83	2.50
RP63	3.20	3.80	3.75	3.83	4.00	3.75	3.50	3.50	3.78	3.67	3.50
RP64	2.10	3.00	4.00	3.67	2.00	2.50	3.38	3.33	2.33	3.67	2.50
RP65	3.50	4.00	3.75	3.50	3.00	3.00	3.13	3.50	3.33	2.50	2.67
RP66	4.30	4.80	4.25	4.33	3.25	4.75	3.63	3.50	3.00	4.67	3.00
RP67	3.40	4.60	3.75	4.50	4.00	4.00	3.50	3.83	3.00	3.17	3.33

Table G.3 Now Scores - Direct-hire Participants

Now Scores - Direct-hire Participants											
	LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8	LO9	LO10	LO11
DH1	3.10	3.00	3.00	3.17	3.00	3.75	3.50	3.17	2.89	3.33	2.83
DH2	3.40	3.00	2.75	3.83	2.75	2.50	3.63	2.67	4.22	3.67	3.50
DH3	4.50	4.60	4.00	4.33	4.50	3.75	4.13	3.83	4.22	4.83	4.50
DH4	3.80	3.20	3.50	3.17	3.00	4.00	4.38	3.67	3.22	2.83	4.00
DH5	3.00	3.00	3.00	3.00	3.00	4.00	3.00	3.00	3.00	3.00	3.00
DH6	3.20	3.20	3.50	3.50	2.75	4.00	3.25	3.33	3.56	3.33	3.67
DH7	4.40	3.80	4.00	4.50	5.00	4.75	4.13	4.33	4.22	4.50	4.50
DH8	4.30	4.20	4.00	4.00	4.00	4.50	4.13	3.83	4.11	4.33	4.17
DH9	4.40	4.60	4.50	4.67	4.75	5.00	4.88	4.00	4.67	4.83	3.50
DH10	4.40	4.60	5.00	4.50	4.75	4.50	4.75	4.33	3.78	2.83	4.17
DH11	5.00	4.60	4.50	4.33	5.00	4.75	4.00	4.00	4.67	4.83	4.67
DH12	4.50	4.40	4.00	4.50	4.25	4.50	4.50	3.50	2.67	3.33	3.50
DH13	3.30	3.20	2.25	3.50	2.00	3.50	4.13	3.33	3.00	3.00	3.33
DH14	3.80	4.20	3.50	4.50	2.75	4.00	4.50	3.50	4.56	4.50	4.50
DH15	3.90	4.60	4.25	4.33	4.00	4.75	4.63	3.83	4.22	4.33	4.50
DH16	4.90	4.40	5.00	5.00	4.25	5.00	4.50	4.00	5.00	4.83	5.00
DH17	4.30	4.80	3.75	5.00	4.25	4.75	4.50	4.67	4.44	4.50	4.00
DH18	4.00	4.60	4.00	5.00	5.00	5.00	4.13	3.83	3.78	4.83	4.33
DH19	4.20	4.60	3.25	3.83	3.50	3.50	2.75	3.83	3.33	3.67	3.17
DH20	3.10	3.80	3.00	4.00	3.50	3.50	3.63	3.33	2.44	3.17	2.50
DH21	4.00	3.80	2.75	4.33	4.00	4.50	3.63	3.17	3.89	4.50	3.50
DH22	4.50	4.20	2.25	4.83	4.50	4.25	4.50	4.83	4.67	4.50	5.00
DH23	5.00	5.00	5.00	5.00	5.00	5.00	4.00	5.00	4.56	5.00	5.00
DH24	4.10	4.20	4.00	4.33	4.75	5.00	4.25	3.50	4.11	4.67	4.17
DH25	4.20	4.00	3.00	4.67	5.00	5.00	0.00	0.00	0.00	0.00	0.00
DH26	3.80	4.80	3.25	4.50	4.00	4.00	4.38	3.33	4.33	4.50	3.83
DH27	4.90	4.00	4.00	4.83	3.25	4.00	3.50	3.17	3.89	4.00	3.83
DH28	3.10	4.00	3.00	3.50	3.00	4.00	4.13	4.33	3.11	3.83	2.67
DH29	2.20	3.20	2.75	4.00	3.50	4.75	4.00	2.83	3.11	4.17	3.50
DH30	4.80	5.00	4.75	5.00	4.50	5.00	4.63	4.33	4.67	5.00	4.67
DH31	4.20	4.00	3.75	4.50	4.00	4.25	4.63	4.67	4.22	4.50	4.00
DH32	4.40	4.00	4.50	3.50	3.75	4.25	4.38	4.00	3.78	4.50	4.67
DH33	3.20	4.20	3.50	5.00	3.75	5.00	4.38	4.17	3.56	4.17	4.83
DH34	3.30	4.00	3.75	3.83	3.25	4.75	4.00	3.33	3.78	4.00	3.83
DH35	4.40	4.40	3.75	4.83	4.00	4.75	3.88	3.83	4.33	5.00	4.50
DH36	3.40	3.80	2.50	4.33	3.25	5.00	3.88	3.83	3.67	4.83	3.00
DH37	3.90	4.40	3.75	4.67	3.75	4.75	4.38	4.17	4.44	4.00	3.67
DH38	4.20	3.80	3.75	4.83	3.50	3.75	2.50	3.83	3.89	4.50	4.00
DH39	4.50	3.60	4.50	4.83	4.75	5.00	4.38	4.00	4.78	4.00	4.67

Table G.3 continued

DH40	3.90	4.00	3.50	3.50	3.25	3.75	3.63	3.83	3.44	3.67	3.83
DH41	4.60	4.00	4.50	4.50	4.00	4.00	4.75	4.50	4.78	4.83	4.33
DH42	4.40	4.80	4.75	4.33	4.25	4.50	4.75	4.17	4.56	4.83	4.83
DH43	4.30	4.20	4.00	3.50	4.00	4.00	4.75	4.00	4.00	4.17	4.33
DH44	3.00	3.40	3.75	3.17	3.50	4.00	4.00	2.83	1.89	3.50	3.50
DH45	2.70	3.00	2.50	3.17	2.75	3.25	3.63	3.33	3.78	4.00	4.00
DH46	4.40	4.60	3.25	5.00	5.00	5.00	4.25	4.00	5.00	4.33	3.50
DH47	4.70	4.60	4.25	4.33	4.75	4.25	3.88	3.67	5.00	4.83	4.50
DH48	3.90	4.00	4.00	4.17	4.00	4.25	4.50	3.67	5.00	5.00	5.00
DH49	4.40	4.20	4.50	4.50	4.75	5.00	5.00	3.67	5.00	5.00	5.00
DH50	4.30	4.80	4.25	5.00	4.50	5.00	5.00	4.67	5.00	5.00	5.00

Table G.4 Undergraduate Scores – Direct-hire Participants

UNDGERGRADUATE Scores - Direct-hire Participants											
	LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8	LO9	LO10	LO11
DH1	2.20	3.00	3.00	2.67	2.75	3.50	3.38	3.17	3.33	3.00	2.50
DH2	3.00	2.20	2.00	3.83	2.50	2.00	3.25	1.67	3.89	2.67	2.17
DH3	3.10	4.00	2.75	3.33	3.75	3.00	3.63	3.50	2.22	3.67	3.83
DH4	3.30	3.00	3.25	3.00	2.75	3.50	4.25	3.67	1.44	2.50	1.83
DH5	4.00	4.00	4.00	3.83	4.00	4.00	4.00	4.00	4.00	4.00	4.00
DH6	2.60	3.00	3.25	2.50	2.50	4.00	3.00	2.83	3.00	3.33	3.33
DH7	3.60	2.00	2.00	3.67	2.00	3.00	2.88	2.50	3.56	2.00	2.17
DH8	3.70	4.00	4.00	3.50	3.50	4.50	3.63	3.33	4.33	4.00	4.00
DH9	3.80	4.00	4.00	4.00	4.25	3.50	4.25	3.17	3.56	4.33	4.00
DH10	4.10	4.40	4.50	4.17	4.25	4.50	4.13	3.50	3.67	3.50	3.33
DH11	2.40	3.60	1.50	3.33	3.75	3.00	3.13	2.17	2.22	3.50	2.17
DH12	4.20	3.60	3.75	3.83	4.00	3.25	4.13	3.00	3.78	4.33	4.50
DH13	2.60	3.20	1.75	2.33	2.25	4.00	4.13	3.33	3.44	4.33	4.83
DH14	3.70	3.60	3.25	4.33	2.75	3.75	4.38	3.50	4.56	4.00	4.50
DH15	2.90	3.20	2.25	3.33	3.75	4.00	3.38	2.50	2.89	3.17	3.00
DH16	3.60	3.40	2.00	3.83	2.50	4.50	3.00	2.00	3.33	4.00	3.33
DH17	2.60	2.80	2.50	4.33	2.25	2.50	2.63	2.67	3.56	2.00	2.67
DH18	3.50	4.20	3.25	4.67	4.50	4.00	3.63	3.83	3.78	4.33	3.83
DH19	3.40	3.00	2.00	2.83	2.25	3.25	2.25	2.67	2.44	3.17	2.83
DH20	3.20	3.40	3.50	3.67	3.25	3.00	3.38	3.17	3.22	3.67	3.50
DH21	2.80	2.20	1.75	3.67	3.00	3.00	2.63	2.33	3.56	3.50	3.50
DH22	2.90	3.40	2.25	3.00	3.00	3.00	4.50	4.50	4.33	3.67	4.83
DH23	4.00	4.60	4.25	5.00	5.00	5.00	4.00	5.00	3.67	5.00	3.50
DH24	3.90	4.00	3.50	4.50	4.00	5.00	4.25	3.50	4.00	4.00	3.67
DH25	3.90	2.80	3.00	3.67	5.00	5.00	0.00	0.00	0.00	0.00	0.00
DH26	3.30	3.40	3.00	3.83	3.75	3.50	3.88	3.17	3.56	3.50	2.83
DH27	3.10	2.80	3.00	3.67	3.00	3.00	2.88	3.00	3.89	3.00	3.00
DH28	3.00	2.80	2.25	2.67	3.00	2.25	2.75	3.33	2.22	4.17	3.67
DH29	1.50	2.40	2.00	3.33	3.00	3.00	3.63	2.50	2.44	3.33	2.67
DH30	3.90	5.00	3.75	4.67	3.75	4.50	3.75	3.33	4.22	4.33	4.17
DH31	3.50	3.60	3.75	4.50	3.25	3.75	4.75	4.33	4.11	4.33	3.67
DH32	3.30	3.40	3.25	3.33	3.25	3.00	3.50	3.17	3.56	3.83	3.83
DH33	2.70	4.00	2.00	4.83	4.25	4.75	3.63	3.50	4.22	4.17	3.33
DH34	2.80	3.60	2.75	3.50	3.00	3.25	3.00	2.83	3.33	3.17	3.00
DH35	3.60	3.80	3.25	3.67	3.75	3.75	3.38	3.50	4.33	5.00	4.50
DH36	4.10	3.80	3.75	3.67	2.50	5.00	3.50	3.17	3.22	2.67	3.00
DH37	3.50	4.00	3.50	4.00	3.50	4.25	4.13	4.17	3.67	3.67	2.67
DH38	3.10	3.20	3.25	3.83	3.00	3.00	2.50	3.00	3.56	3.33	2.83
DH39	4.20	3.00	2.75	4.50	4.25	4.75	3.63	3.50	4.56	4.67	4.00

Table G.4 continued

DH40	3.20	3.20	3.00	3.33	2.50	2.75	3.25	3.00	3.22	3.50	3.17
DH41	3.60	3.80	4.00	3.83	3.75	3.75	4.25	4.17	4.00	3.00	3.83
DH42	4.40	4.40	4.75	3.83	4.00	4.50	4.50	3.50	4.44	4.17	4.50
DH43	2.90	3.20	2.25	2.83	3.00	2.50	3.25	2.50	2.67	2.83	2.83
DH44	3.60	3.20	3.25	3.17	3.75	4.50	4.13	3.33	3.89	3.83	4.17
DH45	1.30	1.80	1.50	1.83	2.00	2.25	3.38	3.00	3.44	2.83	3.83
DH46	4.00	4.40	3.00	4.67	5.00	5.00	3.25	2.50	3.78	3.67	2.83
DH47	3.30	3.60	2.25	3.17	4.00	2.75	2.75	2.67	3.67	3.83	3.33
DH48	2.80	2.60	2.25	2.83	3.00	3.25	3.88	3.00	3.11	1.83	2.83
DH49	2.80	3.00	3.50	3.67	4.00	5.00	4.25	2.67	3.44	2.50	4.50
DH50	3.30	3.80	3.75	3.00	3.25	4.75	5.00	4.67	5.00	5.00	4.83

Table G.5 ROP Gains

ROP Participants	ROP Gain (Now-Undergraduate scores)										
	LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8	LO9	LO10	LO11
RP1	1.10	0.60	1.80	0.83	0.00	1.00	2.13	1.17	0.00	1.67	1.67
RP2	0.40	0.20	0.20	0.00	0.25	0.00	0.13	0.00	0.11	0.00	0.00
RP3	1.20	1.20	0.80	0.33	0.75	1.00	0.13	0.33	1.56	1.83	1.00
RP4	1.70	1.60	1.40	1.33	0.75	1.25	2.38	1.00	1.78	1.50	2.17
RP5	2.30	2.00	1.80	2.33	1.75	3.00	0.75	1.17	0.00	1.33	1.83
RP6	0.30	1.20	1.40	0.83	1.50	1.75	0.63	0.00	-1.56	-0.83	-1.33
RP7	1.80	1.60	1.40	2.33	2.25	2.00	2.13	1.83	1.78	2.00	3.00
RP8	0.70	1.00	0.20	0.67	0.25	0.50	0.13	0.00	0.89	1.17	1.17
RP9	0.60	0.20	0.80	0.17	0.25	1.75	0.75	0.50	0.00	0.33	0.50
RP10	1.50	1.80	2.00	1.33	1.00	1.00	1.88	1.67	1.11	0.50	1.50
RP11	1.00	0.40	0.20	0.50	0.50	1.00	0.50	0.33	-0.56	1.83	0.83
RP12	0.40	0.20	0.60	-0.33	0.25	0.50	0.50	0.50	1.11	0.17	0.67
RP13	0.90	0.20	0.60	0.33	1.00	0.00	0.00	0.17	-0.11	-1.00	-0.50
RP14	1.50	0.80	1.20	0.17	1.50	0.75	0.13	0.50	0.78	0.67	1.67
RP15	1.80	1.80	1.60	1.00	1.00	2.00	0.50	1.33	2.11	3.33	1.67
RP16	0.10	0.20	0.20	0.67	1.00	0.00	-0.13	0.50	-0.67	0.00	-0.83
RP17	1.30	1.40	1.60	2.17	1.00	2.00	0.50	0.83	-0.56	1.17	0.50
RP18	1.10	1.00	1.20	1.00	0.00	1.00	0.75	0.83	1.00	1.00	1.00
RP19	1.20	1.00	1.20	1.50	1.50	1.25	0.25	0.50	2.22	0.67	1.67
RP20	1.00	0.80	0.80	0.83	1.75	1.00	1.13	0.67	0.78	1.00	0.83
RP21	0.60	0.80	0.60	0.33	0.50	0.75	0.75	0.17	0.00	0.00	0.17
RP22	0.90	0.40	0.40	0.83	0.50	1.50	0.88	0.33	0.56	0.50	1.00
RP23	0.80	1.80	1.40	1.17	0.75	1.25	1.38	1.33	2.11	1.83	2.33
RP24	0.00	1.00	0.40	0.67	0.75	0.50	0.00	-0.33	1.56	1.00	-0.17
RP25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RP26	0.20	1.20	1.60	2.00	-0.25	0.25	0.50	0.00	0.11	1.00	0.17
RP27	1.20	1.80	1.00	0.67	0.25	2.50	0.25	0.67	1.56	1.00	1.83
RP28	0.90	1.00	1.20	0.83	1.00	1.00	1.00	1.17	1.33	1.50	1.17
RP29	0.70	0.80	0.40	0.50	0.50	0.00	0.38	0.17	0.44	0.83	0.50

Table G.5 continued

RP30	0.90	1.00	1.20	0.17	1.00	1.00	0.63	0.33	-0.78	0.83	0.67
RP31	0.90	0.60	0.80	1.67	1.00	1.00	1.13	1.00	1.33	1.00	1.00
RP32	0.70	-0.20	0.20	0.50	0.50	1.75	0.38	0.33	1.44	0.67	0.83
RP33	1.00	1.20	1.60	-0.17	1.00	1.25	1.13	1.50	-1.89	-0.17	0.17
RP34	0.40	0.20	0.00	-0.17	-0.50	0.25	-0.13	0.50	-0.22	-1.17	0.50
RP35	0.40	1.20	0.20	0.33	-1.00	0.75	1.00	0.17	0.56	1.00	0.50
RP36	0.80	1.00	0.00	1.83	0.75	1.00	0.25	0.00	0.11	1.67	1.33
RP37	0.20	0.00	0.00	0.33	0.00	0.50	1.13	0.33	2.89	2.50	0.00
RP38	0.70	0.60	0.60	0.50	0.25	0.25	0.88	1.00	1.00	0.67	1.17
RP39	0.60	2.80	1.80	1.33	1.50	1.25	2.00	1.17	2.11	1.00	1.00
RP40	0.60	0.80	0.20	0.67	0.75	0.50	1.13	0.50	0.89	0.67	0.67
RP41	0.30	1.00	1.00	0.83	1.50	1.50	0.63	0.67	1.56	1.50	1.17
RP42	0.80	0.40	1.20	1.83	1.50	0.00	3.25	1.67	1.89	1.00	2.17
RP43	3.00	3.20	3.00	2.17	2.00	2.75	2.63	3.00	2.89	2.50	3.33
RP44	-0.30	0.80	0.20	0.00	-0.75	0.25	-0.38	-0.17	0.11	0.50	0.50
RP45	1.60	2.20	0.60	1.50	2.00	2.25	0.75	0.67	0.89	1.00	1.33
RP46	2.10	2.40	1.80	1.83	1.50	1.75	0.88	1.50	1.78	1.50	1.67
RP47	1.60	1.60	1.80	0.17	0.00	0.25	1.00	0.00	0.44	2.00	0.50
RP48	1.00	0.80	0.40	0.50	0.50	1.00	0.13	0.83	0.44	0.67	0.50
RP49	1.50	1.00	1.80	0.50	1.00	1.25	1.25	0.33	-0.11	0.50	0.67
RP50	0.60	0.60	0.80	1.33	1.50	1.25	1.00	1.17	1.11	1.00	1.67
RP51	0.10	0.20	0.00	0.00	0.25	0.00	-0.13	0.00	0.22	-0.33	0.33
RP52	0.60	0.80	0.40	-0.17	0.50	1.00	0.50	0.83	2.00	1.50	1.67
RP53	1.40	1.20	1.20	0.50	0.75	1.25	0.75	1.33	0.67	0.33	1.67
RP54	2.20	0.80	1.00	0.33	0.25	1.25	1.88	1.83	2.00	1.50	2.50
RP55	1.00	1.20	1.20	0.33	1.25	1.00	0.88	0.83	0.44	1.17	0.67
RP56	0.80	0.00	0.20	0.33	0.25	0.25	0.50	0.67	1.11	0.83	0.50
RP57	1.50	1.00	1.20	1.17	0.50	0.00	0.50	0.67	1.56	2.17	1.50
RP58	1.70	2.00	2.20	1.83	1.75	1.75	2.13	2.00	2.00	1.83	2.00
RP59	0.70	0.60	0.60	0.17	0.50	0.00	0.25	0.67	0.56	0.00	2.33
RP60	0.20	0.40	0.00	0.00	-0.25	0.00	0.38	0.00	1.33	1.00	0.50
RP61	1.00	1.60	1.20	0.83	0.75	1.50	0.75	0.17	1.44	1.83	0.83

Table G.5 continued

RP62	0.10	0.40	1.20	0.67	1.00	1.75	0.38	0.83	1.44	2.17	1.33
RP63	0.50	0.60	0.60	0.00	0.00	0.25	0.25	-0.33	0.11	0.17	0.50
RP64	0.80	0.20	0.00	0.33	1.00	1.00	1.00	0.17	2.11	-0.67	0.83
RP65	0.30	0.60	0.60	0.33	0.00	0.75	0.25	0.00	0.11	1.67	0.83
RP66	0.20	0.80	0.60	0.33	0.75	0.25	0.50	0.67	1.56	0.17	1.67
RP67	0.60	0.20	0.40	0.50	0.50	0.75	0.38	0.00	0.33	1.33	0.00

Table G.6 Direct-hire Gains

Direct-hire Participants	Direct-hire Gain (Now - Undergraduate scores)										
	LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8	LO9	LO10	LO11
DH1	0.90	0.00	0.00	0.50	0.25	0.25	0.13	0.00	-0.44	0.33	0.33
DH2	0.40	0.80	0.60	0.00	0.25	0.50	0.38	1.00	0.33	1.00	1.33
DH3	1.40	0.60	1.00	1.00	0.75	0.75	0.50	0.33	2.00	1.17	0.67
DH4	0.50	0.20	0.20	0.17	0.25	0.50	0.13	0.00	1.78	0.33	2.17
DH5	-1.00	-1.00	-0.80	-0.83	-1.00	0.00	-1.00	-1.00	-1.00	-1.00	-1.00
DH6	0.60	0.20	0.20	1.00	0.25	0.00	0.25	0.50	0.56	0.00	0.33
DH7	0.80	1.80	1.60	0.83	3.00	1.75	1.25	1.83	0.67	2.50	2.33
DH8	0.60	0.20	0.00	0.50	0.50	0.00	0.50	0.50	-0.22	0.33	0.17
DH9	0.60	0.60	0.40	0.67	0.50	1.50	0.63	0.83	1.11	0.50	-0.50
DH10	0.30	0.20	0.40	0.33	0.50	0.00	0.63	0.83	0.11	-0.67	0.83
DH11	2.60	1.00	2.40	1.00	1.25	1.75	0.88	1.83	2.44	1.33	2.50
DH12	0.30	0.80	0.20	0.67	0.25	1.25	0.38	0.50	-1.11	-1.00	-1.00
DH13	0.70	0.00	0.40	1.17	-0.25	-0.50	0.00	0.00	-0.44	-1.33	-1.50
DH14	0.10	0.60	0.20	0.17	0.00	0.25	0.13	0.00	0.00	0.50	0.00
DH15	1.00	1.40	1.60	1.00	0.25	0.75	1.25	1.33	1.33	1.17	1.50
DH16	1.30	1.00	2.40	1.17	1.75	0.50	1.50	2.00	1.67	0.83	1.67
DH17	1.70	2.00	1.00	0.67	2.00	2.25	1.88	2.00	0.89	2.50	1.33
DH18	0.50	0.40	0.60	0.33	0.50	1.00	0.50	0.00	0.00	0.50	0.50
DH19	0.80	1.60	1.00	1.00	1.25	0.25	0.50	1.17	0.89	0.50	0.33
DH20	-0.10	0.40	-0.40	0.33	0.25	0.50	0.25	0.17	-0.78	-0.50	-1.00
DH21	1.20	1.60	0.80	0.67	1.00	1.50	1.00	0.83	0.33	1.00	0.00
DH22	1.60	0.80	0.00	1.83	1.50	1.25	0.00	0.33	0.33	0.83	0.17
DH23	1.00	0.40	0.60	0.00	0.00	0.00	0.00	0.00	0.89	0.00	1.50
DH24	0.20	0.20	0.40	-0.17	0.75	0.00	0.00	0.00	0.11	0.67	0.50
DH25	0.30	1.20	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DH26	0.50	1.40	0.20	0.67	0.25	0.50	0.50	0.17	0.78	1.00	1.00
DH27	1.80	1.20	0.80	1.17	0.25	1.00	0.63	0.17	0.00	1.00	0.83
DH28	0.10	1.20	0.60	0.83	0.00	1.75	1.38	1.00	0.89	-0.33	-1.00
DH29	0.70	0.80	0.60	0.67	0.50	1.75	0.38	0.33	0.67	0.83	0.83
DH30	0.90	0.00	0.80	0.33	0.75	0.50	0.88	1.00	0.44	0.67	0.50
DH31	0.70	0.40	0.00	0.00	0.75	0.50	-0.13	0.33	0.11	0.17	0.33
DH32	1.10	0.60	1.00	0.17	0.50	1.25	0.88	0.83	0.22	0.67	0.83
DH33	0.50	0.20	1.20	0.17	-0.50	0.25	0.75	0.67	-0.67	0.00	1.50
DH34	0.50	0.40	0.80	0.33	0.25	1.50	1.00	0.50	0.44	0.83	0.83
DH35	0.80	0.60	0.40	1.17	0.25	1.00	0.50	0.33	0.00	0.00	0.00
DH36	-0.70	0.00	-1.00	0.67	0.75	0.00	0.38	0.67	0.44	2.17	0.00
DH37	0.40	0.40	0.20	0.67	0.25	0.50	0.25	0.00	0.78	0.33	1.00
DH38	1.10	0.60	0.40	1.00	0.50	0.75	0.00	0.83	0.33	1.17	1.17

Table G.6 continued

DH39	0.30	0.60	1.40	0.33	0.50	0.25	0.75	0.50	0.22	-0.67	0.67
DH40	0.70	0.80	0.40	0.17	0.75	1.00	0.38	0.83	0.22	0.17	0.67
DH41	1.00	0.20	0.40	0.67	0.25	0.25	0.50	0.33	0.78	1.83	0.50
DH42	0.00	0.40	0.00	0.50	0.25	0.00	0.25	0.67	0.11	0.67	0.33
DH43	1.40	1.00	1.40	0.67	1.00	1.50	1.50	1.50	1.33	1.33	1.50
DH44	-0.60	0.20	0.40	0.00	-0.25	-0.50	-0.13	-0.50	-2.00	-0.33	-0.67
DH45	1.40	1.20	0.80	1.33	0.75	1.00	0.25	0.33	0.33	1.17	0.17
DH46	0.40	0.20	0.20	0.33	0.00	0.00	1.00	1.50	1.22	0.67	0.67
DH47	1.40	1.00	1.60	1.17	0.75	1.50	1.13	1.00	1.33	1.00	1.17
DH48	1.10	1.40	1.40	1.33	1.00	1.00	0.63	0.67	1.89	3.17	2.17
DH49	1.60	1.20	0.80	0.83	0.75	0.00	0.75	1.00	1.56	2.50	0.50
DH50	1.00	1.00	0.40	2.00	1.25	0.25	0.00	0.00	0.00	0.00	0.17

APPENDIX H. TESTS OF NORMALITY

Table H.1 Tests of Normality for ROP Engineers

	Shapiro-Wilk					
	Undergraduate			Now		
Learning Outcomes	Statistic	df	Sig.	Statistic	df	Sig.
Define Problems and Generate Design Solutions	0.99	66	0.83	0.97	66	0.19
Manage a Design Project	0.98	66	0.28	0.96	66	0.03
Engineering Contexts	0.98	66	0.27	0.93	66	0.00
Communication	0.98	66	0.35	0.95	66	0.01
Teamwork	0.97	66	0.15	0.95	66	0.01
Leadership	0.97	66	0.09	0.90	66	0.00
Interdisciplinary Knowledge and Skills	0.98	66	0.52	0.96	66	0.03
Recognizing Perspectives	0.97	66	0.10	0.98	66	0.45
Topics in Engineering	0.97	66	0.17	0.95	66	0.02
Professional Skills	0.98	66	0.54	0.89	66	0.00
Problem Solving	0.98	66	0.49	0.94	66	0.00

Table H.2 Tests of Normality for Direct-hire Engineers

	Shapiro-Wilk					
	Undergraduate			Now		
Learning Outcomes	Statistic	df	Sig.	Statistic	df	Sig.
Define Problems and Generate Design Solutions	0.95	49	0.06	0.94	49	0.01
Manage a Design Project	0.98	49	0.72	0.93	49	0.01
Engineering Contexts	0.96	49	0.13	0.97	49	0.18
Communication	0.98	49	0.64	0.91	49	0.00
Teamwork	0.97	49	0.17	0.95	49	0.05
Leadership	0.95	49	0.03	0.90	49	0.00
Interdisciplinary Knowledge and Skills	0.98	49	0.73	0.94	49	0.02
Recognizing Perspectives	0.97	49	0.36	0.98	49	0.67
Topics in Engineering	0.96	49	0.08	0.95	49	0.03
Professional Skills	0.97	49	0.33	0.91	49	0.00
Problem Solving	0.98	49	0.39	0.96	49	0.06

APPENDIX I. CORRELATION COEFFICIENT ANALYSIS FOR NOW SCORES

The researcher checked whether the engineers' ratings of their current knowledge and skills varied with their graduation year: did older graduates rate their current skills higher than recent graduates? The researcher considered dichotomizing the engineers into two groups, with graduation years 2012–15 and 2016–18, but for greater statistical power, the researcher decided instead to calculate the correlations between graduation year and Now scores. Since most of the data failed the normality test, the researcher chose Spearman's rho instead of the Pearson correlation coefficient, which assumes normality.

Table I.1: Correlation Coefficient Between Graduation Year and Now Scores for ROP Engineers (*n* = 67) and Direct-hire Engineers (*n* = 50)

	ROP Engineers		Direct-hire Engineers	
Learning Outcome	**rho**	***p***	**rho**	***p***
Define Problems and Generate Design Solutions	-0.17	0.18	0.04	0.76
Manage a Design Project	-0.14	0.27	0.17	0.24
Engineering Contexts	-0.16	0.20	0.05	0.75
Communication	-0.17	0.16	0.11	0.46
Teamwork	-0.14	0.28	-0.09	0.54
Leadership	-0.18	0.16	-0.09	0.52
Interdisciplinary Knowledge and Skills	0.07	0.57	0.22	0.13
Recognizing Perspectives	-0.08	0.54	0.20	0.18
Topics in Engineering	0.03	0.83	0.19	0.19
Professional Skills	-0.13	0.29	0.07	0.62
Problem Solving	-0.01	0.95	0.05	0.73

Rho – correlation coefficient, p- level of significance

The results in Table I.1 indicate that the correlations between graduation year and Now scores are not significantly different from zero ($p > 0.05$) for all 11 learning outcomes and both groups of engineers. These results suggest that older engineers did not rate their current skills significantly higher than younger engineers, a potential response bias. These results provide further evidence for the validity of the survey measures.

APPENDIX J. COMPARISON OF ROP AND DIRECT-HIRE SCORES

Table J.1: Mann-Whitney *U* Comparison test for ROP and Direct-hire engineers Undergraduate scores

	Median					
Learning Outcomes	**ROP**	**Direct-hire**	**U**	**Z**	***p***	***r***
Problems Generation & Design Solutions	3.10	3.30	1388.00	1.58	0.11	0.15
Manage Design Project	3.20	3.40	678.50	5.51	<0.01	0.51
Engineering Context	2.63	3.00	778.00	4.96	<0.01	0.46
Communication	3.67	3.67	1484.50	1.05	0.29	0.10
Teamwork	3.25	3.25	1564.50	0.61	0.54	0.06
Leadership	3.25	3.63	1376.00	1.66	0.10	0.15
Interdisciplinary Knowledge & Skills	3.38	3.63	1438.50	1.31	0.19	0.12
Recognizing Perspectives	3.33	3.17	1491.50	1.02	0.31	0.09
Topics in Engineering	3.11	3.56	1254.50	2.32	0.02	0.21
Professional Skills	3.50	3.67	1553.50	0.67	0.50	0.06
Problem Solving	3.33	3.50	1372.50	1.67	0.10	0.15

The result of the analysis suggests that there is no statistically significant difference between the ROP and direct-hire engineers for eight of the 11 learning outcomes ($p \geq 0.05$). There was a statistically significant difference between the ROP and direct-hire engineers for three learning outcomes and medium to large effect size: Manage Design Project ($p < 0.01$), with a large effect size ($r > 0.5$), Engineering Context ($p < 0.01$) with a medium effect size $r = 0.46$, and Topics in Engineering ($p < 0.02$) with a medium effect size $r = 0.21$. This implies that for these three learning outcomes, ROP engineers had a higher median scores than the direct-hire engineers

Table J.2: Mann-Whitney *U* Comparison test for ROP and Direct-hire engineers Now scores

	Median					
Learning Outcome	**ROP**	**Direct-hire**	**U**	**Z**	***p***	***r***
Problems Generation & Design Solutions	4.00	4.20	1635.50	0.22	0.83	0.02
Manage Design Project	4.20	4.20	1596.00	0.44	0.66	0.04
Engineering Context	3.75	3.75	1534.00	0.78	0.43	0.07
Communication	4.33	4.33	1561.00	0.63	0.53	0.06
Teamwork	4.00	4.00	1586.00	0.49	0.62	0.05
Leadership	4.50	4.50	1665.50	0.05	0.96	0.00
Interdisciplinary Knowledge & Skills	4.13	4.13	1641.50	0.19	0.85	0.02
Recognizing Perspectives	3.83	3.83	1513.00	0.90	0.37	0.08
Topics in Engineering	4.00	4.11	1630.50	0.25	0.81	0.02
Professional Skills	4.50	4.50	1361.50	1.74	0.08	0.16
Problem Solving	4.33	4.00	1468.00	1.15	0.25	0.11

For the Now scores, the results of the Mann-Whitney U Comparison test show that the Now scores are not significantly different from zero ($p > 0.05$) for all 11 learning outcomes.

The researcher believes that the Now scores represent the engineers' current levels skills more accurately than do the Undergraduate scores represent the engineers' former levels of skills because the latter required the engineers to recall their experiences. The lack of significant differences in the Now scores between the ROP and the direct-hire engineers is evidence of the reliability of the survey instrument. Since the ROP engineers had lower Undergraduate scores on three learning outcomes, the researcher believe they realized that they significantly improved their skills in these three outcomes through their ROP experiences.

APPENDIX K. INTERVIEW CONSENT FORM

RESEARCH PARTICIPANT CONSENT FORM
P*rotocol #1809021095*

Onboarding Early-Career Engineers: Knowledge & Skill Acquisition in Rotational Programs
School of Engineering Education
Purdue University

What is the purpose of this study? The purpose of this study is to explore the impact of the professional development experiences on early career engineers. Specifically, the interview will investigate the relationship between undergraduate experiences and onboarding programs in the development of the skills and knowledge of early-career engineers in engineering and manufacturing industries in the United States.

What will I do if I choose to be in this study? You will be asked to answer a series of questions about your experiences as an undergraduate student and about your experiences during your early-career with your employer.

How long will I be in the study? The interview will take approximately 45 minutes.

What are the possible risks or discomforts? The risks are minimal, no greater than everyday life. There is a risk of breach of confidentiality, but measures to minimize this risk can be found in the confidentiality section.

Are there any potential benefits? There are no direct benefits. However, the potential benefit is for the engineering community at large--both academics and practitioners--to understand the knowledge and skills that early career engineers gain from university experiences and from onboarding programs.

Will I receive payment or other incentive? There is a $25 Amazon gift card for the interview.

Will information about me and my participation be kept confidential? You will not be asked for your name, and we will not collect any identifiable information. The data will be stored in a password protected computer. The project's research records may be reviewed by the College of Engineering at Purdue University, and by departments at Purdue responsible for regulatory and research oversight. This data may be used for future research purposes.

What are my rights if I take part in this study? Your participation in this study is voluntary. You may choose not to participate or, if you agree to participate, you can withdraw your participation at any time without penalty or loss of benefits to which you are otherwise entitled.

Whom can I contact if I have questions about the study? If you have questions, comments or concerns about this research project, you can talk to one of the researchers, Bunmi Babajide, Bunmi@purdue.edu

Please contact:

Dr. William Oakes
701 West Stadium Avenue
West Lafayette, IN 47907

If you have questions about your rights while taking part in the study or have concerns about the treatment of research participants, please call the Human Research Protection Program at (765) 494-5942, email (irb@purdue.edu)or write to:

Human Research Protection Program - Purdue University
Ernest C. Young Hall, Room 1032
155 S. Grant St.,
West Lafayette, IN 47907-2114

Documentation of Informed Consent

I have had the opportunity to read this consent form and have the research study explained. I have had the opportunity to ask questions about the research study, and my questions have been answered. I am prepared to participate in the research study described above. I will be offered a copy of this consent form after I sign it.

____ _________________________
Participant's Signature Date

____
Participant's Name

____ _________________________
Researcher's Signature Date

APPENDIX L. SURVEY RECRUITMENT LETTER

Dear [User],

My name is Bunmi Babajide and I am a PhD candidate in the School of Engineering Education at Purdue University. I am writing to invite you to participate in my dissertation research study: ***Onboarding Early-Career Engineers: Knowledge & Skill Acquisition in Rotational Programs***

This study is designed to better understand the alignment between academia and industry on skills and knowledge acquisition of new engineers, and to determine how academia can better prepare students for professional practice.

To gather data for my study, I am surveying engineers who have completed rotational onboarding programs or engineering leadership development programs in engineering practice. The survey will be open from now until February 22nd, 2019. You must be 18 years or older to participate in this survey. The risks are minimal. No greater than everyday life. There is a risk of breach of confidentiality, but measures to minimize this risk can be found in the confidentiality statement in the survey link.

Kindly take the survey and share link with your network. Each person taking the survey has a chance to win two $250 Amazon gift cards. Each person who refers a person who takes the survey will receive an additional chance to win for each person referred. There will be 2 raffle drawings for this study. The first raffle drawing will be on **January 31st, 2019.** As an incentive to forward the survey invitation to your friends who fit the criteria for the study, you will receive extra chances to win the $250 Amazon gift card. One additional chance for each participant. Simply have your friends input your email address at the end of the survey under *Enter your referrer's email address*.

If you decide to participate in this anonymous survey, it will take approximately 15 minutes to complete using the link attached. https://goo.gl/8S3ZVv

Remember, this is completely voluntary. You can choose to be in the study or not. If you have any questions about the study, please email or contact me Bunmi Babajide (Bunmi@purdue.edu). For more information about the study please visit www.onboardingprograms.com.

Please note: the principal investigator for this research is:

Professor William Oakes
Purdue University
701 West Stadium Avenue
West Lafayette, IN 47907
oakes@purdue.edu
(765) 494 3892

Thank you very much.

Sincerely,

Bunmi Babajide

Oakes [Protocol #1809021095 recruitment letter group 1 10/26/2018]

APPENDIX M. IRB APPROVAL

PURDUE
UNIVERSITY

HUMAN RESEARCH PROTECTION PROGRAM
INSTITUTIONAL REVIEW BOARDS

To:	WILLIAM OAKES ARMS
From:	JEANNIE DICLEMENTI, Chair Social Science IRB
Date:	11/16/2018
Committee Action:	Amended Exemption Granted
Action Date:	11/16/2018
Protocol Number:	1809021095
Study Title:	Onboarding Early-Career Engineers: Knowledge & Skill Acquisition in Rotational Programs

The Institutional Review Board (IRB) has reviewed the above-referenced amended project and has determined that it remains exempt. Before making changes to the study procedures, please submit an Amendment to ensure that the regulatory status of the study has not changed. Changes in key research personnel should also be submitted to the IRB through an amendment.

Please retain a copy of this letter for your regulatory records. We appreciate your commitment towards ensuring the ethical conduct of human subject research and wish you well with this study.

Ernest C. Young Hall, 10th Floor - 155 S. Grant St. - West Lafayette, IN 47907-2114 - (765) 494-5942 - Fax: (765) 494-9911

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HUMAN RESEARCH PROTECTION PROGRAM
INSTITUTIONAL REVIEW BOARDS

To:	WILLIAM OAKES ARMS
From:	JEANNIE DICLEMENTI, Chair Social Science IRB
Date:	05/21/2019
Committee Action:	Amended Exemption Granted
Action Date:	05/21/2019
Protocol Number:	1809021095
Study Title:	Onboarding Early-Career Engineers: Knowledge & Skill Acquisition in Rotational Programs

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APPENDIX N. QUALITATIVE ANALYSIS CODEBOOK

Academic Experiences	Definition	University Experiences	Influence Statement
Classroom Experiences	Classroom experiences are characterized by formal and informal learning. It consists of the type of educational activities students encounter, the type and frequency of feedback they receive from their instructor, and the strength of their teacher's instructional abilities.	• Service-Learning Project • Project Based-Learning projects • Senior Capstone • Laboratory Experiments • Lectures	Kelly: "The JDQ program had a lot of like group work and report writing and learning, learning about a subject and then applying that knowledge very quickly to solve an extensive problem. So definitely group and lab work in school prepared me for that you know."
Curricular Experiences	Curriculum experiences are described by the student's overall educational coursework, the selection of academic majors, the characteristics and type of socialization students engage in the field, and the degree of exposure to other academic experiences related to the general or major field curriculum	• Internships • Co-op Experience • Study Abroad • Learning community • Undergraduate Research	Von: "Yes, I interned for two summers at [Deleted]. I would say R&D in [Deleted] and, I guess in the nonwovens department. So, we weigh all of the material that goes into making diapers for them, and I did a lot of, yeah, it was like, it was a lot of tensile testing."
Out-of-class Experiences	Out-of-class experiences are experiences that include factors that have the ability to shape student's success from a social, attitude, and behavioral perspective. These factors include on/off campus living arrangements, student work on/off campus, and co-curricular activities hours worked on or off-campus, involvement co-curricular activities, and time spent supporting their family.	• Engineering clubs • Social clubs • Work on/off campus • Community service • Living/Learning Communities	Hanna: "I was part of the [Deleted] orientation program So, I was a part of that program and I was the team leader and the following year I was a supervisor for the program and then that really helps me with, um, if not be afraid of talking to people who don't know and because people are looking up to you in that leadership role."

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