All in a Day's Work: Women Engineering Students' Professional Development in a
Living-Learning Community

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ABSTRACT

The engineering profession requires engineers who have not only deep technical knowledge but also broad professional competencies necessary to address complex challenges that impact individuals and communities. While engineering students develop necessary technical competencies during their undergraduate education, professional competencies are often lacking in graduates. This lack of professional development can lead to graduates who are not prepared for the engineering profession and lead to fewer people, particularly individuals from groups historically underrepresented in engineering such as women, entering and continuing in these fields.

Due to the rigidity of the engineering curriculum, out-of-class experiences, such as living-learning communities (LLCs), have become important sites for this professional development and can help women explore engineering and learn professional competencies. However, little is known about *how* these programs support students, particularly in regard to professional development. To further our understanding of these programs, a phenomenographic study was conducted to explore the experiences of 20 students who participated in an LLC for women in engineering. This study examined women's views of professional development in engineering and the experiences within the LLC that could support this development. Following an iterative analysis of interviews, two models were developed: the PD^2 Model captures women's views of the professional competencies relevant in engineering; and the LEEPD Model captures features of beneficial professional development experiences within the LLC.

Combined, these models serve as useful resources for creating beneficial experiences to support women's professional development in engineering education contexts. The PD^2 Model can help educators intentionally identify outcomes of professional experiences, and the LEEPD Model can help in the design of a variety of experiences that are beneficial for students.

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GENERAL AUDIENCE ABSTRACT

In the engineering profession, engineers must develop both technical and professional skills in order to address complex challenges that impact individuals and communities. While undergraduate engineering programs tend to focus on the development of technical skills, engineering graduates often lack necessary professional skills. This lack of professional development can lead to graduates who are not prepared for the engineering profession and can lead to fewer people, particularly individuals from groups underrepresented in engineering such as women, entering and continuing in engineering.

Due to the rigidity of the engineering curriculum, living-learning communities (LLCs), a type of out-of-class experience, have become important sites for this professional development. However, little is known about *how* these experiences support students, particularly in regards to professional development. To further our understanding of these out-of-class experiences, 20 students who participated in an LLC designed for women in engineering were interviewed. During interviews, students described their views of professional development in engineering and the experiences within the LLC that could support professional development. Interviews were analyzed and two models were developed: the PD^2 Model captures women's views of the professional development in engineering and the LEEPD Model captures features of beneficial LLC experiences.

Combined, these models can help educators create beneficial experiences to support women's professional development in engineering education contexts. The PD^2 Model can help educators identify specific outcomes of professional experiences, and the LEEPD Model can help in the design of professional development experiences.

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Chapter 1: Introduction

1.1   Introduction

Engineers are tasked with making the world a better place through technological advancements and new innovations. Engineers play a role in solving many of the world's largest problems in healthcare, sustainable energy, and infrastructure, and these engineered solutions have implications for individuals and communities (National Academy of Engineering, 2008). Meeting these challenges requires not only relevant technical knowledge, but also an awareness and understanding of the context of the problem, the ability to work with a variety of individuals to identify creative solutions, and an understanding of the impact of engineering solutions (National Academy of Engineering, 2004b).

Due to the nature of this work, engineers must develop a range of competencies, from technical expertise to professional skills. While engineering work is often perceived as primarily technical and individual, engineers spend up to two-thirds of their time working with others (Trevelyan, 2007, 2010a) and more than half of their time in social interactions (Trevelyan, 2010b). These proportions are present in positions labeled as both technical and managerial and do not appear to vary with experience level (Trevelyan, 2010b). As described by recent engineering graduates, new engineers are frequently involved in team meetings and planning projects (Howe et al., 2018), and engineering work involves teamwork, communication, data analysis, and problem solving (Passow, 2012). Thus, while engineering work is often perceived as using primarily technical competencies, in practice, engineers need not only discipline-specific knowledge but also broader skills such as leadership, interpersonal skills, and critical thinking (Lowden, Hall, Elliot, & Lewin, 2011).

Despite the importance of these professional competencies in engineering, engineering education focuses primarily on developing students' technical knowledge. As a result, practicing engineers often have to learn necessary professional competencies on the job (Anderson et al., 2011). In particular, new engineers often face a variety of challenges associated with competencies such as communication across ranks, teamwork, and managing their time when working on multiple projects (Gewirtz et al., 2018). Even when necessary professional skills are incorporated into engineering education contexts, students often view school experiences as separate and distinct from engineering practice (Dunsmore, Turns, & Yellin, 2011). Additionally, problems in school

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contexts are often simplified and not accurate representations of the complexity found in the profession (Brunhaver, Korte, Barley, & Sheppard, 2018; Jonassen, 2014). Students, then, may not understand the value and importance of professional competencies learned during school. To better prepare students, practicing engineers have indicated a need for more real-world problems and business acumen in engineering education contexts (Anderson, Courter, McGlamery, Nathans-Kelly, & Nicometo, 2009), and students themselves have articulated the need to balance technical and professional skill development (American Society for Engineering Education, 2017).

The focus on technical aspects of engineering in undergraduate education, with less emphasis on the social and professional aspects, is problematic for multiple reasons. First, while often confident in their technical skills, engineering graduates are often unprepared to perform professional aspects of their engineering work. From the perspective of employers, new engineers often lack crucial skills in communication, flexibility, clarity, creativity, and prioritization (American Society for Engineering Education, 2013). From the perspective of new engineers, they often reported feeling unprepared to take on management roles and to communicate in multidisciplinary teams (R. Martin, Maytham, Case, & Fraser, 2005). These gaps indicate a need to better prepare engineering students for the professional aspects of the engineering work.

Second, a lack of emphasis on the social and professional aspects of engineering portrays a narrow view of the profession which can lead to fewer women pursuing these fields. Students' choice to pursue careers in engineering are impacted by perceptions of whether engineering aligns with their sense of self (Matusovich, Streveler, & Miller, 2010). For longer-term persistence in an engineering career, it is important for individuals to have confidence that a career aligns with personal interests and will be satisfying (Cech, Rubineau, Silbey, & Seron, 2011). However, stereotypes about engineering can make it more difficult for students to see how engineering aligns with diverse interests and skillsets. Engineers and computer scientists are often perceived as masculine and lacking interpersonal skills (Cheryan, Plaut, Handron, & Hudson, 2013; M. Knight & Cunningham, 2004; J. L. Smith, Morgan, & White, 2005), and the work of engineers is perceived as thing-oriented rather than people-oriented (Su & Rounds, 2015) where social aspects of engineering are not considered "real" engineering (Faulkner,

2015). This masculine culture of engineering and the stereotypes about the field may contribute to women's underrepresentation in engineering (Cheryan, Ziegler, Montoya, & Jiang, 2017) because women often choose careers that are more social, artistic, and investigative (Johnson & Muse, 2017) and involve working with and helping others (Diekman, Brown, Johnston, & Clark, 2010; Diekman, Clark, Johnston, & Brown, 2011; Stout, Grunberg, & Ito, 2016). As a result, women often perceive themselves as less similar to the prototypical engineer (Ehrlinger et al., 2018). Therefore, incorporating broader professional competencies necessary in engineering can broaden students' views of the field and potentially help diverse students see how engineering can align with their personal interests.

In an effort to incorporate these professional competencies into engineering education, activities and opportunities for professional development have been incorporated into a variety of contexts, including individual courses and course modules (Humphreys, Lo, Chan, & Duggan, 2001; Mohan, Merle, Jackson, Lannin, & Nair, 2010), entire programs (Cajander, Daniels, McDermott, & Von Konsky, 2011), and out-of-class activities (Dalrymple & Evangelou, 2006). In a comprehensive review of professional skills in engineering, Shuman, Besterfield-Sacre, and McGourty (2005) described a variety of practices for teaching these skills to engineering students, including team-based projects that allow students to gain experience with teamwork firsthand, case studies to teach students about design and the ethics of engineering, and capstone design projects situated in a global context to give students experience in a variety of environments. These activities can be incorporated into individual courses and are often incorporated into the last year of engineering programs. The middle years of engineering programs, on the other hand, typically focus on disciplinary knowledge with relatively few of these design experiences (Lord & Chen, 2014).

Given the heavy focus on the technical content in engineering classrooms, out-of-class experiences are critical opportunities for professional development. Out-of-class activities, including internships and design teams, can supplement students' learning in the classroom and provide opportunities for students to put into practice things that they learn in the classroom (e.g., Burt et al., 2011). And recent work suggests that out-of-class experiences facilitate the development of professional skills such as teamwork, critical thinking, and leadership (Burt et al., 2011; Fisher, 2014; Simmons, Creamer, & Yu, 2017). In addition to benefits for students

broadly, out-of-class activities can support underrepresented students, such as women in engineering (e.g. M. T. Knight & Cunningham, 2004), and prepare them for the engineering profession (e.g. Szelényi, Denson, & Inkelas, 2013). These contexts, then, provide additional opportunities for professional development, particularly for women in engineering.

1.1.1 Living-Learning Communities

One such out-of-class experience that can support students' development as engineers is the living-learning community (LLC). LLCs can supplement curricular learning by connecting students' residential experience with their in-class experiences (Inkelas & Soldner, 2011; Soldner, Rowan-Kenyon, Inkelas, Garvey, & Robbins, 2012). LLCs are often structured around a topic or theme, and many institutions have implemented LLCs designed specifically for engineering students (Inkelas, 2008; Soldner et al., 2012). Engineering LLCs can provide students with a supportive environment (Sriram & Shushok, 2010), help students transition to college (Everett & Zobel, 2012), and increase the interactions that students have with faculty and peers (Everett & Zobel, 2012; Soldner et al., 2012; Sriram & Shushok, 2010). Combined, these factors help support retention in engineering majors.

LLCs often contain activities to prepare students for entry into and success in engineering careers. Engineering LLCs can supplement engineering coursework, help students learn about the engineering profession, and help students develop necessary professional skills such as communication and leadership (Fisher, 2014; Grills, Fingerhut, Thadani, & Machón, 2012; Micomonaco, 2011). For example, Walton and colleagues (2013) described an LLC for engineering students that incorporated interactions with practicing engineers and exposure to various careers. These programmatic elements were designed to help students learn about engineering and develop a variety of professions skills. Additionally, Micomonaco (2011) argued that engineering LLCs could help students develop specific professional skills, such as teamwork and communication, through programming and living arrangements focused on integrating students into engineering programs.

In addition to helping students broadly, LLCs are believed to be particularly beneficial for underrepresented groups, particularly women in engineering. These programs incorporate features specifically designed to support the intended populations and can help students integrate and navigate a variety of experiences (Inkelas, 2008). For women in engineering, LLCs can lead

to a variety of benefits, including an easier transition to college (Grays, 2013; Inkelas, 2011) and increased retention (Everett & Zobel, 2012). LLCs can additionally help women in engineering overcome barriers encountered in an engineering program (Grays, 2013) and can serve as motivation to continue pursuing their degrees despite somewhat isolating environments.

Beyond supporting retention and persistence, several LLCs for women in engineering incorporate career development, professional skill development, and exposure to various aspects of the field in an effort to prepare these students for successful careers (A. Martin, Watford, & Edmister, 2006; Samuelson, Litzler, Staples, Smith, & Amelink, 2014). These programs often incorporate issues specific to women in engineering, such as discussions related to the role of women in a male-dominated field (A. Martin et al., 2006; Samuelson et al., 2014). Such LLCs, therefore, can lead to positive career expectations for women in engineering, help them understand engineering work, and help them anticipate success and work-life balance in an engineering career (Szelényi et al., 2013). This understanding and preparation is an important aspect of students' professional preparation (Andersson & Andersson, 2012; Blau & Snell, 2013; Lopatto, 2004).

1.2   Need for the Study

Given the key role out-of-class experiences can play in complementing curricular experiences and supporting professional development, researchers and practitioners alike need a robust understanding of how such experiences support students. While several studies have examined the benefits and outcomes of LLCs broadly (e.g., Brower & Inkelas, 2010; Inkelas, 2008), few studies have examined students' professional development in these contexts in depth, particularly in regard to women, to understand *how* these programs support professional development. This more nuanced understanding is key because LLCs can differ in focus, mission, and implementation. The structures vary from one implementation to another, not only between different types of LLCs (e.g., focused on a major such as engineering, an interest such as leadership or service, or a demographic such as international students) but also between LLCs of the same type (Wawrzynski & Jessup-Anger, 2010). Additionally, students often can choose what experiences they participate in within an LLC (e.g., A. Martin et al., 2006). Because the experiences in LLCs may vary depending on the implementation of the LLC and the selection of activities by individual students, the current study focuses on the range of experiences within one

implementation of an LLC for women in engineering to identify the core features of experiences that support women's professional development within an LLC. Identifying features, rather than specific activities, supports the transfer of these findings to other LLCs that may use different activities.

To understand how LLCs support women's professional development, this study explored professional development, and the experiences within an LLC that supports such development, from the perspective of women who participated in this program. Existing literature on professional preparation for engineers is often from the perspective of professionals, educators, or recent graduates (e.g., National Academy of Engineering, 2004a). While these perspectives are valuable, it is additionally important to understand students' views because it can be used to identify aspects of professional development that these women identify as important for their own development as well as areas where further development is needed. By understanding the perspectives of women engineering students, the findings from this study can support the design of educational experiences that complement and supplement students' existing views, both preparing women for the engineering profession and broadening their perspectives of who engineers are and what they do.

1.3   Focus and Purpose

The purpose of this study, therefore, was to understand how women engineering students described professional development and how they perceived an LLC for women in engineering as supporting this development. The overarching goal of this study was to understand how LLC experiences support women's professional development. This study addressed the following research questions:

RQ1: How do women engineering students describe professional development after participating in an LLC for women in engineering during their first year in college?

RQ2: What features of experiences within an LLC for women in engineering do these women perceive as contributing to their professional development?

1.4   Methods

To address these questions, my study adopted a phenomenographic approach to examine the qualitatively different ways that the phenomenon, professional development in an LLC, was

experienced. To provide a suitably bounded context, participants were women in their second year of college who participated in an LLC for women in engineering during their first year.

1.4.1 Phenomenography

Phenomenography is a qualitative research method used to examine the different ways that a phenomenon is experienced. This approach assumes that a phenomenon can be described, understood, or comprehended in a limited number of ways (Marton, 1986). Phenomenography was originally developed by educational researchers in Sweden who consistently found that teaching and learning experiences could be grouped into a limited number of categories, which were often hierarchical. In the present study, phenomenography was used to identify the 1) ways that women described professional development and 2) the features of professional development experiences in an engineering LLC that they found beneficial.

Phenomenography was useful for this study due to the varying experiences that students in LLCs have. The structure of LLCs, and students' experiences within LLCs, differ from one implementation to another. Even within one implementation of an LLC, student experiences vary depending on the specific LLC activities in which students participate. Phenomenography allowed for the examination of a variety of professional development experiences within an LLC to provide a more nuanced understanding of beneficial experiences in these contexts. This specificity is particularly useful for practitioners and researchers in the design and examination of experiences that support the development of professional outcomes for women in engineering.

1.4.2 Research Context

This study site was an LLC (referred to as WIE-LLC) designed for women in engineering at a large, land-grant university in the southeastern United States. Each year, WIE-LLC brings together first-year women engineering students and provides support as they pursue engineering degrees. This particular LLC incorporates social, academic, and professional development activities through a variety of optional activities and a required, one-credit seminar. In addition, there is a partner LLC at the same institution for male engineering students (referred to as partner LLC in this study) that has the same required activities as WIE-LLC. The required LLC seminar is separate for WIE-LLC and partner LLC, but many of the optional activities are open to both WIE-LLC and partner LLC. Because participation in WIE-LLC included experiences specific to women as well as experiences for engineering students more broadly, the results from the present

study likely transfer to LLCs for women in engineering and LLCs for engineering students. While this study was situated within one LLC, WIE-LLC incorporated many experiences common to these programs, further facilitating transferability of the results to other LLCs.

1.4.3   Data Collection and Analysis

Twenty second-year students who participated in WIE-LLC during their first year in college were interviewed. To identify participants for phenomenographic interviews, a survey (described in detail in Chapter 3) was sent out to all first-year engineering students in the LLC of interest at the end of the spring semester prior to their second year. Thirty respondents indicated an interest in participating in an interview, and all thirty respondents were invited to participate in an interview to maximize the variation in student experiences and perceptions. Out of the 29 who responded, 19 women and 1 transgender student were able to participant in in-person interviews.

Following data collection, the interviews were analyzed in an iterative process following the practices of phenomenography (Marton, 1981; Marton & Booth, 1997). Categories, and the relationship between categories, were developed to capture 1) the different aspects that participants perceived as related to professional development and 2) features of experiences that students found beneficial for professional development in the context of the LLC.

1.4.4   Researcher Bias

In phenomenographic studies, the focus is on the relation between the subject and the phenomenon. However, in this study, I also have experience with the phenomenon under investigation. While I did not participate in an LLC during my own undergraduate education, I worked for an engineering LLC as a teaching assistant during my graduate studies. Because of this relationship, and because I interviewed participants, it was necessary for me to bracket my own experiences so that I could focus on the relationship that the participant described with the phenomenon. To do so, I asked participants to explain their views of professional development and describe beneficial experiences in detail. The interview protocol was designed to enable the participant to describe aspects of the phenomenon that were most relevant to them rather than asking questions based on my own experiences and understandings. The measures described below to support validity and reliability were also used to help mitigate bias.

1.4.5 Validity and Reliability

Several efforts were made to enhance validity and reliability of the research findings. Pilot interviews were reviewed by the interviewer to ensure that the interview elicited useful information and to check for bias in the questions asked. Feedback was obtained from research advisors, members of my research group, a peer researcher, and members of the LLC community. These checks were conducted to gain additional perspectives on the categories and relationships that emerged from the study and to challenge assumptions that I made during data analysis. Chapter 3 provides more detail on these methods to enhance validity and reliability.

1.5 Contributions of the Study

Most studies that focus on LLCs have examined these programs holistically (e.g., Inkelas, 2008). However, as indicated by the typology of LLCs created by Inkelas (2008) (see Chapter 2 for more detail), different types of LLCs have different missions with different foci and different outcomes. Additionally, while many LLCs incorporate professional development, few studies have focused on professional development outcomes. Therefore, there is a need to better understand the specific experiences within an LLC, and the features of these experiences, that women perceive as helping them develop professionally. To begin addressing this gap, my study examined the qualitatively different ways that students experience professional development in the context of an LLC for women in engineering.

The results of this study, known as the outcome space, include two parts: the PD^2 (Professional Development Domains) Model and the LEEPD (Learning Experiences for Engineering Professional Development) Model. The PD^2 Model is a 2-dimensional outcome space that captures the categories of professional development described by women in engineering. Women's descriptions of professional development were grouped into three domains: 1) Job Acquisition, 2) Job Performance, and 3) Personal Development. Each domain consisted of two or more categories. These domains, and the categories within each, ranged from narrow, specific contexts to broad contexts. Within each category, women's descriptions ranged from externally imposed requirements to internalized skills and competencies that can help them achieve their personal goals.

The LEEPD Model specifies five features of beneficial professional development experiences: 1) exposure, 2) practice, 3) feedback, 4) reflection, and 5) revision. As described by participants,

these features were combined in a variety of configurations to create beneficial experiences within the LLC context. While exposure experiences related to all three domains of professional development in the PD^2 Model, experiences that incorporated practice, feedback, reflection, and revision were related to competencies in the job acquisition domain, which may be a function of the focus of this particular LLC.

The results of this study contribute to the literature on professional competencies from the student perspective. While there is broad agreement on the importance of professional development in engineering, there is variation in the competencies that are emphasized in this development. While many researchers and professionals have articulated the professional competencies necessary for engineering students to develop (e.g., Howe et al., 2018; National Academy of Engineering, 2004a; Trevelyan, 2007), particularly for women (e.g., Dugan, Fath, Howes, Lavelle, & Polanin, 2013), it is crucial to hear the student perspective and understand the professional development that they perceive as relevant in their development. By furthering our understanding of what professional development women engineering students perceive is necessary in engineering, the results of this study can assist LLCs in intentionally designing beneficial learning experiences that can support the development of particular professional competencies. Additionally, the results of this study expand our understanding of how experiences support women's professional development. This contribution is particularly beneficial for those involved in the design and implementation of LLCs for women in engineering. By furthering our understanding of the features of experiences that students find beneficial for professional development, the results of this study provide a more nuanced understanding of the various ways that those benefits can be realized.

Combined, these two models can help educators identify professional development outcomes and intentionally structure activities to support this development. The results of this study, then, have implications for LLC programs as well as other student support programs, advisors, faculty, administrators, and students.

1.6 Transferability

Given the focus on a single site and a single LLC, the findings from this study are most directly applicable within this context. However, as noted, the similarities between this site and similar

institutions, as well as the parallel program for first-year male students, suggest that the results are likely applicable in other contexts.

The results of the PD^2 Model, including the domains, categories, and levels, likely transfer to LLCs designed to support women in engineering and other contexts that support women in engineering, including support programs and student organizations. While the specific categories and levels of the PD^2 Model are more likely limited to contexts that support first-year women in engineering, the domains in the PD^2 Model likely have broader transferability. Because the three domains in the PD^2 Model capture personal development, professional development related to job performance, as well as professional development necessary to be hired for an engineering position, these domains can transfer to curricular and out-of-class contexts that support engineering students' professional development.

The LEEPD Model identifies features of beneficial experiences, rather than experiences themselves, to facilitate the transferability of findings to other contexts. Due to the broad nature of the five primary features of the LEEPD Model, these features likely transfer to professional development experiences in engineering LLCs as well as experiences for engineering students more broadly. Additionally, because participants in the present study described experiences that were specific to WIE-LLC as well as experiences that were joint between WIE-LLC and the partner LLC for men, this model has transferability to LLCs for women in engineering as well as LLCs for engineering students in general. While these features have broader transferability, the specificity in the exposure and practice features have more limited transferability. The specificity in the practice feature, including practice developing and implementing, is likely transferrable to professional development experiences, particularly those related to the Job Acquisition domain of professional development. The specificity within the exposure feature (exposure to processes, strategies, environments, engineering practice, connections, and opportunities) is likely transferrable to professional development experiences for women in engineering.

1.7 Limitations and Future Work

There are several limitations to this study. First, the present study examined the experiences within one type of LLC, and other LLC structures were not included. Therefore, this study may not capture the experiences of women in these other contexts. These other contexts may provide additional understanding, particularly with regards to features of beneficial experiences, that

could benefit LLC practitioners. Future work should examine experiences in these additional contexts. Second, though all participants who agreed to participate in an interview were invited for an in-person interview, participants self-selected to participate in the study. In phenomenographic studies, it is important to try to maximize the variation in participants in order to get a variety of perspectives and experiences. Because the response rate was not sufficient enough to allow purposeful selection, the full range of participant perspectives may not be represented in the current study. Third, this study did not examine the effectiveness of experiences within the LLC via assessment of outcomes, but instead examined only student perceptions of beneficial experiences. Future work should assess these experiences to determine the outcomes that students gain by participating in professional development experiences within LLCs.

1.8   Summary

The purpose of this study was to better understand women engineering students' perceptions of professional development in engineering and the experiences within LLCs that can support that development. To accomplish this, I utilized a phenomenographic approach to capture variation in students' perceptions. The results of this study are twofold: 1) the PD^2 Model captures the variation in students' descriptions of professional development and 2) the LEEPD Model captures the features of experiences within LLCs that students found beneficial for this development. Combined, these models provide useful tools for educators in supporting engineering students' professional development.

This document is divided into seven chapters. Chapter 2 provides an overview of relevant literature. In this chapter, I provide an overview of professional skills relevant in engineering and variations in the professional competencies described as crucial in engineering. Following the discussion of professional development, Chapter 2 describes current efforts, both in and out of the classroom, to help students develop these professional competencies. In particular, living-learning communities provide opportunities to complement students' curricular experiences and support students' professional development. Because this study focused on student experiences in LLCs, relevant literature on living-learning communities, including the history and outcomes of these programs, are described in detail.

Chapter 3 presents the methods used in this study. This study used a phenomenographic approach to examine the qualitatively different ways in which women engineering students described professional development and the features of experiences that students described as beneficial. Chapter 3 describes the research design, including the sample and context, recruitment efforts, data collection, and data analysis. Following a description of the research design, I discuss the validity and reliability of the study as well as the limitations.

The results of the study are described in Chapters 4 and 5. Chapter 4 provides a detailed description of the PD^2 Model. Chapter 5 provides a detailed description of the LEEPD model and example experiences that incorporate features from the model.

In Chapter 6, I revisit the two research questions that guided this study. The PD^2 Model addressed research question 1 and the LEEPD Model addressed research question 2. The results from the study are situated in findings from prior literature and contributions of the present study are described.

Chapter 7 describes implications for educators, practitioners, and researchers as well as limitations. This chapter concludes with recommendations for future work.

Chapter 2: Literature Review

Professional development is an important component of engineering education and continues throughout an engineer's career. During an undergraduate education, engineering students need to gain both the technical and non-technical skills necessary to address complex problems in an increasingly globalized society. Beyond providing essential workplace skills, professional development during an undergraduate education can help broaden students' understanding of what engineering is and what engineers do. Gaining a broader understanding of the engineering profession can help students see how the field aligns with their individual interests and goals, which is particularly beneficial for groups that are historically underrepresented in engineering such as women.

To help students prepare for their future profession, professional development experiences can be incorporated into a variety of curricular and co-curricular, or out-of-class, experiences. Due to the rigidity of the engineering curriculum, out-of-class experiences provide valuable contexts for students to gain additional professional development. In particular, professional development experiences can be, and often are, incorporated into living-learning communities (LLCs) designed to connect students' residential and curricular experiences into a coherent learning experience.

This chapter provides an overview of relevant literature on professional development in engineering contexts, including the importance of professional development in engineering, variation in the professional development described in engineering education contexts, and current efforts to incorporate this development into undergraduate engineering contexts. The second half of the chapter focuses on LLCs in particular, beginning with the history and outcomes of these programs, followed by efforts to support women in engineering and incorporate professional development into these programs.

2.1   The Engineering Profession

The engineering profession requires individuals who can address complex societal issues. To do this, engineers need not only technical expertise but also the ability to collaborate with a wide range of individuals; understand the implications of potential solutions; and continually adapt to changing contexts, changing technologies, and changing problems. In fulfilling their duties, engineers must "hold paramount the safety, health, and welfare of the public," "perform services

only in areas of their competence," and "conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession" (NSPE, 2016). These responsibilities require that engineers acquire a diverse skillset and maintain their skills by continually learning and developing throughout their careers (ASCE, 2006; ASME, 2012; NSPE, 2016).

To ensure that engineers are prepared for this work, several organizations have identified necessary competencies for those entering the field, including both technical and professional skills. ABET, the major accreditation body for engineering programs, specifies outcomes that all engineering students must possess upon graduating from an ABET-accredited institution (Table 1). Several outcomes (shown in bold in Table 1) pertain to the necessary non-technical skills commonly known as professional skills (Shuman et al., 2005). Note that while Shuman and colleagues (2005) identified problem solving (shown in italics) as a technical skill in engineering, Wankat (2017) argued that problem solving should be considered both a technical and a professional skill due to the presence of both technical and professional characteristics in problem solving. To further support the need for engineers to possess professional skills and attributes, the National Academy of Engineering identified attributes that engineers will need to be successful in an increasingly globalized world (National Academy of Engineering, 2004a). These attributes (Table 1) are almost entirely non-technical and include analytical and problem solving skills, creativity, communication, professionalism, and lifelong learning. Combined, the reports from these organizations demonstrated the need for engineers to acquire, and continually develop, professional skills that reach well beyond technical competencies.

Table 1. Necessary outcomes and attributes for engineers

Student Outcomes for Engineering Graduates (ABET, 2016)	Attributes for Engineers (National Academy of Engineering, 2004a)
• Ability to apply math, science, and engineering knowledge • Ability to design/conduct experiments and analyze/interpret data • Ability to design systems to meet needs and constraints • **Ability to function on teams** • *Ability to solve problems* • **Understanding of professional and ethical responsibility** • **Ability to effectively communicate** • **Broad education to understand impact of engineering solutions** • **Life-long learning** • **Knowledge of contemporary issues** • Ability to use skills, techniques, and tools necessary in practice	• Analytical and problem solving skills • Ingenuity • Creativity • Communication • Business and management skills • Leadership skills • Professionalism • Ethics • Resilience and flexibility • Lifelong learning

The importance of professional skills in engineering has also been articulated by employers, practicing engineers, and recent engineering graduates. According to a survey of employers, engineering graduates need to have both discipline-specific knowledge and broader skills such as leadership, communication, teamwork, problem solving, and critical thinking (Lowden et al., 2011). Additional professional competencies required in engineering include clarity in communication, risk-taking, ability to prioritize, and business etiquette (American Society for Engineering Education, 2013). The importance of professional skills is further supported by their prevalence in engineering workplace contexts. Trevelyan (2007, 2010a) interviewed practicing engineers with up to 50 years of experience and found that engineers spend up to two-thirds of their time interacting with others and often have to coordinate the work of others. This trend holds for both experienced and new engineers (Trevelyan, 2010b). In addition, recent engineering graduates indicated that teamwork, communication, data analysis, and problem solving were the most important competencies in their professional work experiences (Passow, 2012), and new engineers frequently spent time in team meetings and in project planning activities (Howe et al., 2018). Professional skills, then, are crucial in engineering work.

Despite the importance of professional skills, new engineers are often unprepared to perform several important aspects of professional engineering work. In surveying employers, engineering graduates were perceived to be lacking in areas such as management, economics, and maintaining global perspectives as well as skills such as leadership, communication, decision-making, and synthesizing priorities (American Society for Engineering Education, 2013). New engineers also report being unprepared for aspects of the engineering profession including interpersonal communication across diverse groups (Gewirtz et al., 2018; R. Martin et al., 2005) and management and leadership roles (R. Martin et al., 2005). Additionally, new engineers faced challenges managing their own time across projects, learning new processes and tools, and communicating with co-workers and supervisors (Gewirtz et al., 2018). These challenges highlight important and often overlooked competencies in professional engineering work.

2.2   Professional Development

As the previous paragraphs demonstrate, the importance of professional development and the development of professional skills has been articulated by organizations, employers, and recent graduates. However, the skills and competencies associated with professional development can vary, leading to variations in how professional development is described in the literature. On the one hand, professional development has been defined broadly as the means of understanding professionalism in a field and maintaining relevant qualities (Andersson & Andersson, 2012; Lopatto, 2004; Wilcox, 2003). Alternatively, it has been defined as the development of specific professional and personal skills (Davis et al., 2010; Lopatto, 2004; Scott, Bates, Campbell, & Wilson, 2010; Walther, Kellam, Sochacka, & Radcliffe, 2011). These views of professional development are discussed in detail below.

2.2.1   Professional Development as a Broad Concept

Some researchers describe professional development as the broad concept of understanding various aspects of a profession. In a study examining undergraduate research in science fields, for example, Lopatto (2004) identified that one benefit of these experiences was professional development, which was defined as "understanding professional behavior in your discipline; understanding personal demands of a career in your discipline; understanding the research process in your field; understanding how professionals work on real problems" (p. 5). Similarly, in a study examining assessment of professional skills in engineering education contexts,

Andersson and Andersson (2012) stated that important aspects of engineering students' professional development included "an understanding among the students of how to act within their specific profession, the culture and the ethical rules as well as understanding the consequences of one's actions" (p. 3). In these descriptions, professional development is the understanding and awareness of a profession such as engineering, including an understanding of the work, accepted behaviors, and the expectations and demands of that profession.

Other researchers extend the definition beyond an understanding of a particular profession and defined it as the continual learning process in which individuals in a given field are engaged. For example, Wilcox (2003) stated that professional development is "the process by which a person maintains the quality and relevance of professional services throughout his/her working life" (p. 6). Professional development, then, is an active learning process where the individual must identify what needs to be learned, seek out ways to learn that material, and be able to determine whether the material was learned. In this process, professional development is a continual learning process for which the learner has the responsibility.

2.2.2 Professional Development as the Attainment of Skills

Other conceptualizations of professional development, particularly within engineering education, focus on the attainment of certain skills, particularly skills identified as professional skills. For example, Davis and colleagues (2010) examined professional skill development in capstone engineering courses and described three categories of abilities and attributes: interpersonal, individual, and technical. Interpersonal skills included communication, collaboration, and leadership, as well as the ability to create and support an inclusive and supportive environment. Individual attributes and abilities included planning, assessing, and achieving goals; producing work that is high quality; adapting to change; and acting with integrity and sensitivity to the needs of individuals and society. In addition to including skills often described as professional skills, Davis and colleagues included technical skills such as the ability to analyze information, solve problems, design products, and research questions, in professional development.

Similar to the study by Davis and colleagues, Walther, Kellam, Sochacka, and Radcliffe (2011) examined the professional formation of engineers and identified that this development consisted of multiple outcomes. In this study, competencies related to engineering students' professional formation included not only personal, interpersonal, and technical skills, but also competencies

related to the work that engineers do. Key outcomes included the following: 1) flexibility and creativity, 2) interaction with others, 3) planning, 4) realities of the engineering practice, such as working under pressure and professional responsibility, 5) competencies related to the self, such as work-life balance and metacognition, 6) understanding the social context of engineering work, and 7) technical competencies such as problem solving. In contrast to the studies providing definitions of professional development from the perspective of educators and researchers discussed thus far, Walther and colleagues examined competencies from the perspective of recent graduates and engineering students in their final year of an undergraduate program.

While Davis et al. (2010) and Walther et al. (2011) focus on professional skills relevant to the workplace, other descriptions of professional development have also included skills necessary for success in an educational context. In a study describing the incorporation of modules designed to help engineering students develop professionally, Scott and colleagues (2010) described professional development modules that were incorporated into a course that covered skills for succeeding in educational contexts, skills related to the engineering profession, and personal skills. Skills and competencies related to success in educational contexts included understanding the history of engineering education, the connection between the engineering curriculum and the mission of the university, the role of ABET, and the philosophy of higher education. Skills and competencies pertaining to the engineering profession included written communication in technical fields and interpersonal skills such as relationship building and networking. Those pertaining to personal preferences included understanding and achieving personal goals and understanding personality and learning styles. These skills were identified to create modules that could be incorporated into engineering education contexts.

As the preceding paragraphs show, researchers and educators have identified a range of knowledge, skills, and abilities necessary for the professional development of engineers. When comparing these studies, there are some noteworthy similarities as well as differences. Table 2 highlights the professional skills that these articles included in their conceptualizations of professional development, as well as the ABET professional skills (Shuman et al., 2005) and the attributes that engineers need as specified by the NAE discussed in the previous section. This table, therefore, allows the comparison of professional skills and attributes identified as

important for engineers with the skills included in the conceptualizations of engineering

professional development described in this section.

Table 2. Professional skills and attributes specified as relevant to engineering and professional development

Source / Competency	Engineer of 2020 Attributes (National Academy of Engineering, 2004a)	ABET professional skills (ABET, 2016; Shuman et al., 2005)	Professional Development Ability/ Attribute (Davis et al., 2010)	Professional Development Categories (Scott et al., 2010)	Professional Formation Competencies (Walther, Kellam, et al., 2011)
Networking	○	○	○	●	●
Technical Skills and Analysis	●	○	●	○	●
Problem Solving	●	○	●	○	●
Interpretation	○	○	●	○	○
Awareness of Constraints	●	○	○	○	●
Engineering Judgment	○	○	○	○	●
Importance of Multiple Perspectives	○	○	●	●	●
Engineering Responsibility	●	●	●	○	●
Impact	●	●	○	○	○
Adaptability	●	●	●	○	●
Manage Self	○	○	●	○	●
Work-Life Balance	○	○	○	○	●
Planning	●	○	○	○	●
Manage Others/Projects	●	○	○	○	○
Creativity	●	○	●	○	●
Working with a Team	○	●	●	○	○
Communication	●	●	●	●	●
Empathy	○	○	○	○	●
Leadership	●	○	●	○	○
Understanding the Organization	○	○	○	○	●
Understanding of Professional Role	○	○	○	●	●
Accept Feedback	○	○	○	○	●
Continued Growth & Development	●	●	●	●	●
Understanding of Self	○	○	○	●	●
Understanding the Educational Context/Process	○	○	○	●	○

Note: Circles indicate whether a particular competency was present in a study (● = present, ○ = not present).

Two skills were common across the conceptualizations: 1) communication and 2) continued growth and development. In conceptualizations of professional development, communication included general statements of the ability to communicate and share information in an effective and convincing way (ABET, 2016; Davis et al., 2010; National Academy of Engineering, 2004a) and the ability to create written communication in technical fields (Scott et al., 2010). Communication was also described in more nuanced terms that included the ability to tailor communication to meet the needs of others and the ability to maintain documentation for engineering projects (Walther, Kellam, et al., 2011).

The other common skill was the ability to continually grow, develop, and learn, although the focus of this learning and development varied between articles and included both personal and professional growth. In the article by Davis and colleagues, this development and learning, termed self-growth, was described as "planning, self-assessing, and achieving goals for *personal* [emphasis added] development (Davis et al., 2010, p. 2). Similarly, Scott and colleagues described the need to help students "define their *personal* [emphasis added] purpose and goals to achieve maximum satisfaction" (Scott et al., 2010, p. 2). In contrast, the continued learning in the article by Walther and colleagues focused on that which "contributes to the development of *professional* [emphasis added] competence" (Walther, Kellam, et al., 2011, p. 740). While these articles highlight similarities and common competencies, they also highlight the complexity of these common competencies.

In addition to the skills that were common across all studies, several skills were present in multiple studies included in the table. For example, adaptability was a professional skill included in most of the studies, but the focus differed. As described by NAE (2004a) and ABET (2016), adaptability included an awareness of issues in a world that is continuously changing. Engineers, then, need to be able to adapt and learn new things. Davis and colleagues similarly described the ability to adapt and be aware of "social, global, and technological change" (p. 2). In contrast to these perspectives where engineers adapt to changes in society, Walther and colleagues described adaptability in regards to the "preparedness to cope with practical influences in the workplace (external factors, changes etc.) that necessitate a flexible way of working" (p. 739). Adaptability, while described as an important competency in engineering, can relate to both the work that engineers do as well as the context in which engineers work.

It is also worth noting that one skill common to three of the research studies (Davis et al., 2010; Scott et al., 2010; Walther, Kellam, et al., 2011) was not explicitly stated in the attributes and outcomes specified as necessary for engineers by other entities (ABET, 2016; National Academy of Engineering, 2004a). This skill was the ability to understand the importance of multiple perspectives. In the studies describing professional development in engineering education, Davis and colleagues (2010) included the ability to create a supportive environment for all perspectives, Walther and colleagues (2011) included the ability to work across different cultural and personal perspectives, and Scott and colleagues (2010) included the ability to understand the strengths and weakness that different personalities bring to an engineering environment in professional development. While the Engineer of 2020 (National Academy of Engineering, 2004a) described the need to work with interdisciplinary and diverse teams, the value of multiple perspectives was not explicitly described. In these reports, the attributes for individual engineers was described and therefore considerations in engineering designs may not have been explicitly included in these descriptions of necessary attributes. However, incorporating diverse perspectives as well as balancing a variety of considerations is a necessary competency in the field of engineering. In adequately preparing engineers, it is important that these necessary competencies are made explicit. If necessary competencies are not made explicit and instead remain implicit, we cannot be certain that engineering students are developing those skills.

There were also several notable differences across the conceptualizations of professional development. Two articles included the ability to understand specific educational and work contexts: Scott and colleagues (2010) included an ability to understand the educational context in engineering students' professional development, and Walther and colleagues (2011) included an ability to understand an organizational context. Walther and colleagues also included skills that were not included in any other studies, such as work-life balance and the ability to understand organizational structures (i.e., hierarchies) in a workplace.

In addition, several studies contained skills that are typically considered technical, not professional, skills. For example, analytical skills, which are necessary for engineers (ABET, 2016; National Academy of Engineering, 2004a), are generally considered technical skills, not professional (Shuman et al., 2005). However, these attributes were often included with professional development and professional formation (Davis et al., 2010; Walther, Kellam, et al.,

2011). While technical and professional competencies are often considered as separate, these studies emphasize the complexity of professional development and the interconnectedness between professional and technical competencies.

As evident in Table 2, many other differences existed between the various conceptualizations of professional development, even when professional development was considered to be the attainment of professional skills. For a more detailed comparison of the similarities and differences from these studies, refer to Appendix A.

2.2.3 Summary

As highlighted in this section, professional development has been defined in a variety of ways and can vary in meaning from a broad understanding of the engineering profession to the development of a specific set of skills. Commonalities between these descriptions highlight the importance of professional skills in engineering and provide a foundation that allows for further investigation of professional development. But while there is broad agreement on the need for professional development, differences in the professional development identified for engineers can make it challenging for educators to help students develop these competencies and for students to understand the competencies that they need to develop.

While many agencies, researchers, and educators have described professional development in engineering, the student perspective is often lacking. The student perspective can help educators understand the needs of students and determine if they are achieving the necessary professional development. The present study begins to address this gap by exploring the student perspective and their descriptions of professional development in engineering. By understanding both students' views and the views of educators and professionals, learning experiences can be designed to further students' development and provide students with a better understanding of the competencies needed in their future careers.

2.3 Professional Development for Women in Engineering

While professional development is important for all engineering students, it is particularly important for supporting underrepresented students, such as women, in these male-dominated fields. Professional development focused on helping students understand the engineering profession and develop relevant skills (Andersson & Andersson, 2012; Blau & Snell, 2013; Lopatto, 2004) can help students understand the breadth of engineering and identify alignments

between their interests and goals and engineer professions. The perception that engineering aligns with who they are can impact a student's choice to pursue a career in engineering (Matusovich et al., 2010). However, strong stereotypes about engineers and the work that they do can lead to misalignments between an individual's career interests and perceptions of engineering, particularly for women. Engineers and computer scientists are often perceived as masculine and lacking interpersonal skills (Cheryan et al., 2013; M. Knight & Cunningham, 2004; J. L. Smith et al., 2005), and the work that engineers do is often perceived as thing-oriented rather than people-oriented (Su & Rounds, 2015). Because of this orientation towards things as opposed to people, social aspects of engineering are often not considered "real" engineering work (Faulkner, 2015). In contrast, women often choose careers that are more social, artistic, and investigative (Johnson & Muse, 2017) and involve working with and helping others (Diekman et al., 2010, 2011; Stout et al., 2016). As a result, women often perceive themselves as differing from the prototypical engineer (Ehrlinger et al., 2018). Because engineering is stereotypically masculine, more isolated, and less relevant in social contexts, Cheryan and colleagues (2017) argued that these stereotypes can contribute to women's underrepresentation in engineering. By providing professional development that helps women understand the engineering profession and move beyond stereotypes, more women might choose to enter and remain in these fields.

2.4 Professional Development in Engineering Education Programs

Given the strong consensus on the need to prepare engineering students for the professional aspects of work, professional skill development has been incorporated into a variety of educational contexts, including individual course modules, individual courses, entire programs, and out-of-class activities. Individual courses that incorporate professional skills do so through standalone course modules or projects incorporated into existing courses with numerous examples across the literature. For example, Humphreys and colleagues (2001) described the incorporation of professional skills such as communication, problem solving, leadership, and teamwork into an existing engineering group project, and concluded that students viewed the group work as beneficial for learning professional skills. At the course level, Mohan and colleagues (2010) described a seminar course designed to cover a variety of topics relating to engineering professional skills, including interpersonal communication, globalization, and the importance of these skills, through readings, discussions, and lectures by guest speakers. At the

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program level, Cajander and colleagues (2011) described an engineering curriculum that incorporated opportunities for the development of professional skills into various aspects of the curriculum, such as design projects and courses.

While professional development experiences have been incorporated into a variety of curricular contexts, the engineering curriculum is tightly packed with courses in mathematics, science, and discipline-specific content with little room for elective courses. To help students synthesize and apply their technical knowledge, design courses are often integrated in the final year of engineering programs (Atman, Eris, McDonnell, Cardella, & Borgford-Parnell, 2014; Lord & Chen, 2014). These design-based courses help prepare students for the transition to the engineering profession (Atman et al., 2014; Lord & Chen, 2014) and typically incorporate the development of professional skills such as communication and teamwork (Atman et al., 2014). During the middle years of the curriculum, on the other hand, courses focus on delivering technical content and providing a foundation of knowledge necessary in engineering contexts (Brunhaver et al., 2018; Lord & Chen, 2014). In these middle years, there is less emphasis on the development of professional competencies. As a result, students often gain much of their experience with professional skills during the final year of their programs.

Out-of-class experiences, then, become increasingly important as complementing the engineering coursework and allowing students to develop professional competencies throughout their undergraduate education. Broadly defined, out-of-class experiences, including curricular, co-curricular, and extracurricular activities, are activities that occur outside of the required coursework (Simmons, Tendhar, Yu, Vance, & Amelink, 2015). In a review of studies on the outcomes of out-of-class activities for undergraduate students, and engineering students in particular, Simmons, Creamer, and Yu (2017) identified career and professional development, which included the attainment of professional skills, as an outcome of these activities. In a similar vein, Dalrymple and Evangelou (2006) examined the role of out-of-class activities on engineering students' professional preparation and found that students perceived involvement in activities outside of the classroom as leading to professional skills such as interpersonal communication and confidence to lead. While out-of-class experiences broadly can support the development of professional skills, studies have described specific types of out-of-class activities and programs, such as design teams, community service, and professional experiences, that help

engineering students develop professionally. For example, to provide engineering students with opportunities to develop professional skills, Colorado State University (CSU) developed the Professional Learning Institute (PLI) where students participated in required out-of-class activities such as presentations, workshops, and other experiences that focused on cross-cultural communication, cross-cultural teamwork, leadership, innovation, ethics, and public services (Siller, Rosales, Haines, & Benally, 2009).

2.5   Living-Learning Communities

One out-of-class experience in particular, living-learning communities (LLCs), provide a valuable context to incorporate professional development experiences for students who participate. Living-learning communities, designed to connect students' residential and curricular experiences to increase student learning (Inkelas & Soldner, 2011; Soldner et al., 2012), have become increasingly popular since the 1980s (Inkelas & Soldner, 2011), particularly for first-year students. According to a national study of 527 four-year institutions, a third of first-year students participate in a learning community, 60% of which contained a residential component (Barefoot, Griffin, & Koch, 2012). LLCs, then, reach large numbers of students during their first year of college. These programs create smaller communities for students within larger institutions (Pace, Witucki, & Blumreich, 2008) and, accordingly, are often aimed at helping to retain students. As such, LLCs are often designed to support particular populations of students, such as women in engineering (Pace et al., 2008), and studies have found that women in engineering were more likely to participate in LLCs than their male peers (Raelin et al., 2014; Simmons, Yi, Ohland, & Garahan, 2018). While the focus of engineering LLCs has historically been on retaining students, these programs additionally include elements to help students academically and professionally, making them ideal sites to explore out-of-class professional development.

2.5.1   History of LLCs

Originally, higher education learning communities in the United States were residential and were modeled after English universities (Fink & Inkelas, 2015). But the rise of the Germanic model of education, which focused on creating original scholarship and providing students with specialized knowledge as opposed to a liberal education, prevented the residential model from remaining prominent (Fink & Inkelas, 2015). Resources that had previously been dedicated to

student housing were allocated to laboratories and classrooms (Blimling, 2015; Brubacher & Rudy, 1968). Therefore, while learning communities were created throughout the 20th century, several early learning communities closed after a few years due to conflicting priorities between a focus on student experience and a focus on original scholarship and specialized knowledge (Fink & Inkelas, 2015). Then in the 1980s and 1990s, several policy agencies criticized public research universities for being disengaging and disconnected for students and recommended recreating learning communities to address this critique (Fink & Inkelas, 2015). As a result, living-learning communities, a type of learning community where undergraduate students live together on campus and participate in curricular and/or out-of-class activities together (Inkelas, 2008), were incorporated into higher education to help address these concerns, ease students' transition to college, and make the undergraduate experience more coherent and less fragmented (Inkelas, 2011).

Because LLCs are believed to lead to several critical benefits, these communities have gained in popularity since the 1980s (Inkelas & Soldner, 2011). In a 2002 survey, The Policy Center on the First Year of College found that approximately 80 percent of universities surveyed had learning communities (O'Connor et al., 2003). In the National Study of Living-Learning Programs (NSLLP), which examined living-learning programs ("living-learning programs" is another term for a living-learning community) at 49 colleges and universities in the United States, more than 600 different LLCs were identified.

Despite the common label, LLCs in higher education institutions across the country differ in their focus and structure as well as the programming included. Therefore, in a seminal study of LLCs in the United States, Inkelas and colleagues grouped LLCs according to program theme or topic and created a typology that included 17 categories (Brower & Inkelas, 2010; Inkelas, 2008): civic/social leadership, cultural, disciplinary, fine and creative arts, general academic, honors, leisure, political interest, research, ROTC, residential college, sophomore, transition, umbrella, upper division, wellness, and women's programs. Each broad category has a different focus and mission. For example, honors programs focus on providing the most academically talented students with an enriched academic environment; general academic programs focus on providing academic support that is not tailored to a specific major or discipline; and discipline-specific LLCs group students according to major or disciplinary interest. Particularly relevant to

this study, a number of universities have incorporated LLCs designed to support engineering students as they pursue rigorous engineering programs. These include LLCs for engineering students (a type of disciplinary program) and LLCs for women in engineering (a type of women's program).

2.5.2 Outcomes of LLCs

Existing research has indicated that participation in LLCs leads to several benefits for participants. For example, studies have indicated that students who lived in LLCs experienced an easier social and academic transition to college (Brower & Inkelas, 2010) and were more satisfied with the college experience (Inkelas, 2008; Inkelas & Weisman, 2003; Pike, 1999). In addition, because LLCs combine students' residential and curricular experiences, studies have also examined the level of interactions that students have with faculty and peers. Students in LLCs were found to have more interactions with faculty about course-related topics, receive more faculty mentorship, and have more conversations with peers about academic, career, and sociocultural issues than students who did not participate (Inkelas, 2008).

However, studies have also led to mixed results for a number of outcomes, including academic achievement and persistence. When examining the GPAs of LLC participants, some studies found that LLC participation was related to higher GPA for students (e.g. Pasque & Murphy, 2005), while other studies did not find significant differences in GPAs when comparing LLC participants with non-participants (e.g. Chafin, 2006). Additionally, Edwards and McKelfresh (2002) concluded that LLC participation was associated with increased GPAs for men but not for women. Studies on persistence and retention have similarly led to mixed results. Some studies indicate that participation in LLCs is related to increased persistence (e.g. Light, 2005), while other studies yielded mixed results (e.g. Stassen, 2003). In their meta-review of these retention studies, Taylor and colleagues (2003) concluded that the mixed results across the LLC literature could be due to the various structures of learning communities and the different experiences that students have within those communities.

2.5.3 Outcomes of LLCs for Engineering Students

To take into account the different types of LLCs, researchers have begun to examine the outcomes of specific types of LLCs, such as engineering LLCs. Because retaining students in engineering programs is an important issue (Lichtenstein, Chen, Smith, & Maldonado, 2014),

several studies examined the role of LLCs in helping engineering students transition to college and remain in engineering programs. For example, Everett and Zobel (2012) found that involvement in an engineering LLC helped engineering students transition from high school to college. And while Light (2005) found that participation in an engineering LLC could have direct as well as indirect effects on students' persistence in engineering, other studies have found that participation in an engineering LLC has only an indirect effect on persistence (Micomonaco, 2011; Soldner et al., 2012). Additionally, aligning with the idea that living in an LLC can lead to increased interaction with others on campus, several studies found that participants in engineering LLCs were more engaged with faculty and peers than those who did not participate (Everett & Zobel, 2012; Sriram & Shushok, 2010) and had more conversations with peers who held different opinions and beliefs (Soldner et al., 2012). While limited in number, these studies indicate the potential benefits for engineering students who participate in an engineering-specific LLC.

2.5.4   Outcomes of LLCs for Underrepresented Groups

In general, as the previous section suggests, LLCs are believed to help students 1) integrate into the university community, 2) create bonds with faculty and peers, and 3) navigate a variety of experiences in the university setting (Inkelas & Soldner, 2011). Participation in LLCs, then, is believed to be particularly beneficial for underrepresented groups, such as women in engineering. These programs can serve as a means to recruit and retain underrepresented groups (Banks, 2012), and studies have found that women were more likely to participate in LLCs than men (Raelin et al., 2014; Simmons, Van Mullekom, & Ohland, in press). Because LLCs have been implemented to support underrepresented groups, several studies have focused on the impact of LLCs on these populations and found that they can support women academically and socially and help them persist through difficult situations. For example, LLCs were found to create an environment that helped women in engineering overcome barriers in engineering programs and stay motivated despite a sometimes isolated engineering environment (Grays, 2013). In another study, Belichesky (2013) examined LLCs from the perspective of women who participated in a co-educational STEM (science, technology, engineering, and math) LLC and found that aspects of the LLC, including linked courses and the residential aspect of the program, facilitated female students working together alongside their male peers which allowed the

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women to see the struggles of their male peers and share in similar academic struggles which resulted in more confidence in women's academic abilities.

In addition to examining persistence within the major immediately following LLC participation, researchers have examined the career expectations of women who participated in a STEM LLC years after participation concluded. For example, Szelényi et al. (2013) examined women's career expectations three years after participating and found that participation in a co-educational STEM LLC was positively associated with expectations for getting a good job, achieving success in their career, and achieving a balanced personal and professional life. The authors hypothesized that participation in a co-educational LLC was beneficial for women's professional outcome for several reasons: it provided women with a supportive environment where they gained an understanding of the climate of engineering in the field; it allowed women to see their potential for success in engineering in the company of men; and it enabled women to learn about these factors in an environment that had lower consequences.

These studies indicate that LLCs can provide valuable support for students, and women engineering students in particular, during their educational careers. Benefits include an easier transition to college, increased retention in an engineering major, academic and social support, and resilience that can help students overcome challenges. And these benefits can extend years beyond students' engagement in the community.

2.5.5   Professional Development in LLCs

As the previous sections demonstrate, participation in LLCs can lead to benefits for engineering students broadly and can be particularly beneficial for women in engineering. However, these studies have focused primarily on students' transition to college and retention and persistence in college. Because LLCs are intended to connect students' out-of-class experiences with their curricular learning, there is a need to expand research to focus on additional learning outcomes that are emphasized in these programs. These programs can and do provide prime opportunities to incorporate professional development experiences for engineering students that can supplement other curricular learning experiences.

Such an expansion is warranted in large part because LLCs, particularly those designed to support specific populations such as women in engineering, often incorporate programmatic experiences tailored to the needs of the intended population (Inkelas, 2008). Several LLCs for

women in engineering, for example, incorporate career and professional development and provide exposure to various aspects of engineering that help prepare these young women for successful careers in engineering (A. Martin et al., 2006; Samuelson et al., 2014). These programs can incorporate professional development specific to women in engineering, such as discussions related to the role of women in a male-dominated field (A. Martin et al., 2006; Samuelson et al., 2014).

Because aspects of professional preparation are often incorporated into these programs, it is important to examine students' professional development in these contexts. However, few studies have examined outcomes of LLCs related to professional development for participants. There are two notable exceptions. Micomonaco (2011) found that LLC participants experienced greater gains in leadership than non-participants; however, participants did not differ on other learning outcomes such as communication, teamwork, and understanding engineering contexts. Additionally, as discussed previously, Szelényi and colleagues (2013) found that women engineering students reported that participation in LLCs helped them understand the professional work of engineers and helped them anticipate both success and work-life balance in an engineering career which led to positive career expectations for the young women. Such studies point to the potential of LLCs to supplement professional development learning, but also highlight the need for more work in this area.

Because of the role that LLCs can play in supporting women's professional development and the importance of this development for the retention and persistence of women in engineering fields, it is important to understand the aspects of these programs that students find beneficial. As mentioned previously, different programs incorporate different experiences and activities. Due to this variation, it is helpful to gain the perspective of women who participate in a particular LLC environment in order to identify specific activities that students find beneficial. By gaining the perspective of these women, a more detailed understanding of beneficial professional development experiences can be gained. This detail can have implications for other LLCs that support women in engineering and provide necessary professional development.

2.6   Study Overview

To address this need, the goal of this study is to understand how experiences within LLCs can support women's professional development. As discussed previously, the work of engineers

continually evolves and requires individuals who can adapt to these new contexts and solve complex problems while working with a variety of individuals and stakeholders. Such work requires a variety of professional competencies. However, engineering programs typically focus on technical aspects of engineering, with less focus on the social, and engineering is stereotypically masculine and thing-oriented. These elements of engineering as a field can make it more challenging for women to see the alignment between engineering and their own interests and goals. To help not only prepare students for the engineering profession but to broaden perceptions of engineering, broader professional competencies should be included in engineering education contexts. Engineering programs have incorporated professional skills into a variety of contexts including full programs, individual courses, and out-of-class opportunities to support this development. However, the engineering curriculum is rigid, making it difficult to incorporate professional development opportunities for students.

Because of the rigid engineering curriculum, out-of-class experiences have grown in popularity as environments that can provide additional support and complement what students learn in the classroom, particularly in terms of professional development. One such experience is the living-learning community, which connects students residential and curricular experiences. These programs are often designed to support women in engineering and are a valuable context to incorporate professional development. This professional development can provide not only necessary skill development but can help women understand how engineering could align with their future career aspirations. For women in particular, this development is important not only for retention in an engineering major but also longer-term retention in an engineering career.

Due to the importance of helping women develop professionally and learn about the engineering profession, it is necessary to not only identify that programs such as LLCs *can* support this development but to examine *how* they do so. To gain this insight, it is important to hear from the women themselves to gain their perspective on experiences that are beneficial. Researchers and educators can create learning experiences intended to support students, but the perspective of women engineering students can provide valuable insight into the aspects of experiences that students find helpful. This perspective is an important step in creating meaningful learning experiences that provide necessary professional development and can support students in areas that they articulate as important for their own development.

To begin to fill this gap, the present study examined the experiences that women found beneficial for professional development in an LLC designed to support women in engineering. The purpose of this study was to identify features of beneficial professional development experiences in the context of LLCs. To identify beneficial experiences, this study explored how women described professional development in engineering and the experiences that can support different aspects of this development.

Understanding women's conceptions of professional development and the experiences that can support that development has important implications, particularly for educators. First, the results of this study help educators design learning experiences that incorporate these features of beneficial experiences. Second, by understanding women's views of professional development, educators can identify gaps in their understanding of professional development and help broaden students' views of professional competencies in engineering. Finally, these results better enable educators to design experiences that help students develop particular professional competencies, for example by designing experiences that incorporate features of beneficial experiences to help address a gap in students' development.

Chapter 3: Methods

The purpose of this study was to examine the ways in which women engineering students experience and describe professional development in a living-learning community (LLC) for women in engineering. The overarching goal of this study was to understand how such experiences can support women's professional development. To address this overarching goal, the study addressed the following research questions:

RQ1: How do women engineering students describe professional development after participating in an LLC for women in engineering during their first year in college?

RQ2: What features of experiences within an LLC for women in engineering do these women perceive as contributing to their professional development?

To address these questions, I conducted a phenomenographic study in which I interviewed second-year students who participated in an LLC for women in engineering, hereafter referred to as WIE-LLC, during their first year in college. Each participant was interviewed to elicit her description of professional development and salient professional development experiences within the LLC. Following data collection, the interviews were analyzed to develop two distinct outcome spaces–one that captures participants' descriptions of professional development and one that captures features of LLC experiences that they found beneficial for professional development. These results include distinct, descriptive categories that capture the various ways that the phenomenon, professional development, was experienced or understood.

In this chapter, I describe the methods used in this qualitative study, including the selection of a phenomenographic approach, the data collection and analysis, and the limitations of the study.

3.1 Phenomenography

Phenomenography is a qualitative research method that can be used to examine the different ways in which individuals experience a phenomenon. Qualitative research methods in general attempt to answer questions about how or why a phenomenon occurs (Creswell, 2009). Similar to other qualitative methods, phenomenographic studies attempt to understand phenomena by "describing people's experience of various aspects of the world" (Marton, 1981, p. 177), with a focus on the range of ways that a phenomenon is experienced (Åkerlind, 2005c; Marton, 1981; Marton & Booth, 1997). Phenomenography originated as a research approach after observations

that the ways in which individuals experience a phenomenon, such as reading or learning, could be described in a limited number of qualitatively different ways (Marton & Booth, 1997). As such, phenomenography assumes that a phenomenon can be described, understood, or comprehended in a limited number of ways (Marton, 1986). In a phenomenographic view, the way a phenomenon is experienced depends on an individual's awareness of different dimensions, or aspects, of the phenomenon (Marton & Booth, 1997). Differences in how the phenomenon is experienced are due to an awareness of different combinations of dimensions as well as different meanings that an individual attributes to those dimensions in context (Marton & Booth, 1997). In phenomenography, the orientation towards the range of understandings and perceptions of a particular phenomenon is considered the second-order perspective because it focuses on individuals' *perceptions* of an experience (Marton, 1981). In contrast, in a first-order perspective, the focus is on describing the particular aspect of the world itself. Phenomenography, therefore, attempts to identify and describe the range of qualitatively distinct ways that a phenomenon is experienced by a particular group.

3.1.1   History of Phenomenography

Phenomenography was developed by educational researchers in Sweden, and the term was first introduced by Marton (1981). Early studies associated with a phenomenographic approach have examined the learning and understanding of individuals and have examined phenomena such as the different outcomes of learning (Marton, 1975), different processes of learning (Marton & Säljö, 1976), and different approaches to learning (Säljö, 1979). The earliest recognized phenomenographic study is Marton's 1975 work (Richardson, 1999). Marton (1975) examined the qualitative differences in students' comprehension of a newspaper article and found that their comprehension could be grouped into four distinct categories that formed a hierarchy of depth of learning. These categories captured the qualitatively different outcomes of student learning and constituted the outcome space. Additional studies, several of which are described by Marton and Booth (1997), have similarly found that experiences of phenomena being studied can be grouped into a finite number of qualitatively distinct categories. In phenomenographic studies, not only are categories of experiences described, but the relationships between categories are also identified; these relationships are typically hierarchical. The hierarchical relationship is not a judgment of the value of the categories; instead, it typically indicates that certain categories include other categories (Åkerlind, Bowden, & Green, 2005).

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3.1.2   Phenomenography vs. Phenomenology

Phenomenography is similar to other qualitative research methods in that it aims to describe and to understand experiences and phenomena (Marton, 1981). However, phenomenography differs from other research approaches in several important ways. In this section, I will briefly contrast aspects of phenomenography with aspects of phenomenology, which is a distinct methodology. First, phenomenography aims at understanding differences in experiences based on the notion that experiences of phenomena can be described in a limited number of qualitatively distinct ways (Marton, 1981). In a review of studies conducted by Marton and the Goteborg research group, Gibbs, Morgan, and Taylor (1982) described the results of studies examining how students experience and conceptualize learning, and these experiences and conceptualizations were consistently able to be described in a limited number of categories. Marton concluded that "there seems, thus, to exist a level; a level of modes of experience, forms of thought, worthy of studying" (Marton, 1981, p. 181). Therefore, phenomenography categorizes the finite variety of ways that a phenomenon is experienced or conceptualized.

This categorization of experiences differs from phenomenology, which aims at understanding the common *essence* of an experience (Husserl, 2001). According to Husserl, who is considered the founder of phenomenology, phenomenology provides a way to identify and describe the essential structures of experiences (Cerbone, 2006; Gallagher, 2012). Phenomenology is concerned with "experiences intuitively seizable and analysable in the pure generality of their essence" (Husserl, 2001, p. 86). In phenomenological studies, researchers begin with a phenomenon, or experience, and collect data from multiple individuals who have experienced that phenomenon in order to describe its essence (Creswell, 2007). Therefore, while phenomenology and phenomenography both aim to describe, analyze, and understand experiences, phenomenology aims to understand the *essence* of an experience while phenomenography, the approach used in the current study, aims to describe the variety of ways that the phenomenon is experienced.

Phenomenology and phenomenography also differ in the aspects of the phenomenon that are examined. From a phenomenographic point of view, the world can only be accessed through experiences, and when understanding experiences, we cannot separate perceptions of the experience from the experience itself (Marton, 1981). Therefore, "there is just one thing, the phenomenon-as-understood, and this is exactly what we should describe" (Marton, 1992, p. 260).

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To do so, phenomenographic studies focus on the second-order perspective in order to understand the subject's perceptions of a particular phenomenon. Phenomenology, in contrast, focuses on the first-order perspective where the phenomenon is described by participants to determine the essence of the phenomenon itself (Barnard, McCosker, & Gerber, 1999). Therefore, while phenomenology focuses on describing the phenomenon – its structure and meaning – as it is, phenomenography focuses on describing the phenomenon as it is perceived. Thus the two approaches differ in both their ontology and their epistemology.

3.1.3   Selection of Phenomenography

A phenomenographic method was selected for the current study for a variety of reasons. First, previous studies examining outcomes of LLCs have focused on these programs holistically; however, as discussed in Chapter 2, the experiences that students have in LLCs can differ for a variety of reasons. Both the structure and the form of LLCs can differ from one campus to another and from one type of LLC to another, leading to different experiences for the students who participate. Second, students who participate in LLCs often can choose which specific activities to participate in, leading to different experiences even for students who participate in the same LLC environment. Finally, specific to this study, students who participate in engineering LLCs, while all initially enrolled in an engineering major, are enrolled in (or interested in) different engineering disciplines and these disciplines can often differ significantly from one another. Because different majors may emphasize different aspects of professional development, students may likely have different goals and expectations for the LLC program, particularly in this area. Given these variations, it is reasonable to hypothesize that students who participate in these programs will have different experiences not only across but within LLCs. Phenomenography, with its explicit focus on variation, allowed me to gain insight into students' descriptions of professional development and allowed me to identify and describe different features students found beneficial in professional development experiences.

3.1.4   Phenomenographic Approach: Overview

In phenomenography, the focus of the study is on the relationship between the participants and the phenomenon under investigation (Bowden, 2005); it is therefore important that participants experience the same phenomenon (Collier-Reed & Ingerman, 2013). In this study, the phenomenon under investigation is students' professional development in one implementation of

an LLC for women in engineering. As described in Section 3.2.1, by selecting participants from the same LLC, I was able to ensure that participants shared the same set of opportunities for professional development and experience a common overarching living-learning environment.

This relationship between participants and the phenomenon is typically explored through semi-structured phenomenographic interviews, detailed in Section 3.2.3. These interviews are guided by several questions established by the researcher; however, follow-up questions depend on participants' responses and are used to gain clarification, to encourage the participant to elaborate, and to explore contradictions (Åkerlind et al., 2005; Green, 2005). Pilot studies are often conducted to allow the researcher to refine their interviewing skills and to ensure that the interview questions allow the researcher to gain information related to the phenomenon of interest (Åkerlind et al., 2005). Following the interview, the interviews are transcribed verbatim.

Once transcribed, interviews are analyzed in an iterative process focusing on both whole transcripts and parts of transcripts to identify similarities and differences (Åkerlind, 2005b). This iterative process, described in detail in Section 3.2.5, results in categories of experiences and relationships between those categories. Because phenomenographic studies focus on the relationship between participants and the phenomenon (shown in Figure 1 enclosed by the dotted line), only evidence from the transcripts can be used to create categories and relationships, and all outcomes from the study should be justified by segments of the transcripts. This approach requires that the interviewer acknowledge and bracket any relationships that they have with either the participant or the phenomenon (gray arrows in Figure 1) and check that the interpretations align with the words and descriptions that the participants used to describe the phenomenon (Åkerlind et al., 2005; Ashworth & Lucas, 2000). Efforts to bracket my own experiences with the phenomenon are described in Section 3.3.3.
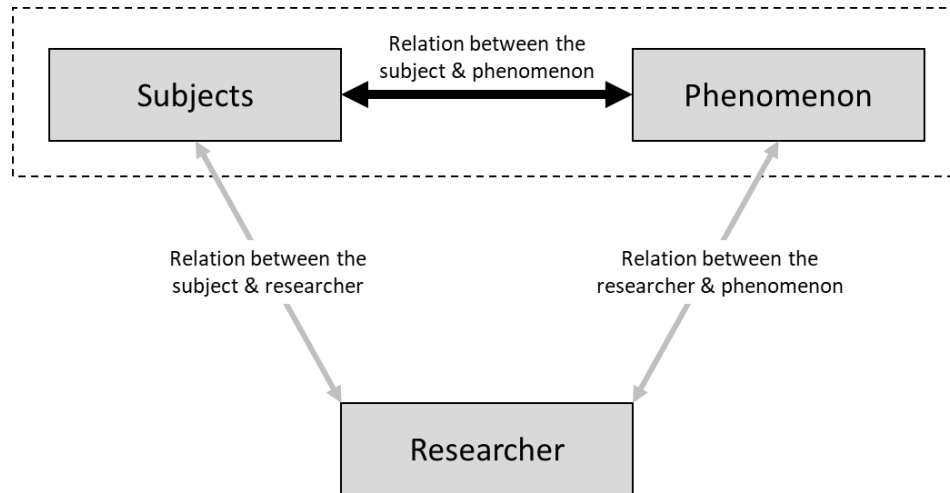
Figure 1. Relations in phenomenographic research (adapted from Bowden (2005))

Given the two guiding research questions, the results of this study are two models – one describing women's perspectives of the categories included in professional development and another describing the features of beneficial professional development experiences in an LLC for women in engineering. The results of this study help educators and administrators, such as faculty and LLC directors, understand the different ways that students experience and think about professional development.

3.1.5 Use of Phenomenography

Phenomenography has been used to study qualitative differences in learning outcomes, learning approaches, and preconceptions of learning (Marton, 1986). From this early work, studies adopting a phenomenographic approach have expanded to examine a variety of topics, such as experiences teaching large classes (Woollacott, Booth, & Cameron, 2014), perceptions of teaching and learning (Tigchelaar, Vermunt, & Brouwer, 2014; Walter, 2016), perceptions of a field such as STEM (Bell, 2016), experiences with information literacy (Johnston, Partridge, & Hughes, 2014), and concepts such as computing (Bucks & Oakes, 2011).

While phenomenography has been used in a number of different disciplines, it has only recently emerged in engineering education, with limited use to date. When present in the engineering education literature, phenomenography has been used to study specific learning experiences as well as experiences in discipline-specific contexts. For example, in a study examining the qualitatively different ways that engineering students experience entrepreneurship, researchers identified four categories of student experiences in entrepreneurship education (Täks, Tynjälä,

Toding, Kukemelk, & Venesaar, 2014). These categories were organized in a nested and inclusive structure where higher categories included aspects of the lower categories. Similarly, in a study examining engineering students' experiences of human-centered design, Zoltowski, Oakes, and Cardella (2012) identified seven different ways that students understood and experienced human-centered design.

In addition to studies on learning experiences more broadly, phenomenography has also been used to examine student experiences in a particular discipline. In a study focusing on experiences in a civil engineering discipline, Franz, Ferreira, and Thambiratam (1997) examined students' experiences in civil engineering specific courses as well as conceptions of learning from the perspective of the instructor. From the student perspective, learning was viewed as either memorization or understanding content in the course unit, and instructors viewed learning as either understanding material specific to the discipline or preparation for professional practice. Perhaps most relevant to this study, phenomenography can also be used to study experiences outside of a classroom environment. For example, Smith (2015) used phenomenography to study the mentoring experiences of female African American students in engineering to identify salient aspects of mentoring relationships. These studies highlight various ways that phenomenography has been used in engineering education to examine learning experiences both in and out of the classroom.

While not widely used in engineering education research currently, the studies noted above demonstrate several opportunities for using phenomenography to study engineering education contexts. In particular, exploring variation in engineering students' experiences could help ensure that experiences of all students, not just those in the majority, are captured, which is particularly beneficial for underrepresented students whose experiences and approaches may differ from students in the majority population (Ro & Knight, 2016). Using phenomenography to examine and describe the variety of experiences of engineering students allows researchers to further examine differences in the ways in which engineering students experience engineering contexts and help educators better support diverse students.

3.2   Research Design

In the current study, phenomenography was used to examine students' descriptions of professional development and their understanding of beneficial professional development

experiences in an LLC designed for women in engineering. I obtained Human Subjects Research Approval through the Virginia Tech Institutional Review Board prior to commencing research procedures. The following sections describe the context, participants, data collection, and data analysis procedures used in this study.

3.2.1   Research Context

This study examined the experiences of engineering students who participated in an LLC, referred to as WIE-LLC, designed for women in engineering. Participants were second-year engineering students who participated in WIE-LLC during their first year at a large, land-grant institution in the southeastern United States. As noted earlier, bounding the study to a single institution and a single LLC helps ensure that study participants experienced a common phenomenon. While situated within one LLC, WIE-LLC is a large program that provides many options for students and incorporates experiences that are common to these programs nationally, including an associated course, community service, study groups, social events, mentoring, and housing students together in a residence hall (Brower & Inkelas, 2010). In addition, the university itself is representative of high research land-grant institutions broadly; it has a large engineering program, approximately 20% female engineering enrollment, and a general first-year engineering program. Therefore, while this study is situated in one LLC, the results of this study are transferable to other LLC contexts due to the common features of the LLC and the breadth of options available to students who participate.

At the institution where WIE-LLC is incorporated, engineering students are initially enrolled in a general engineering (GE) program and can select a specific engineering major at the conclusion of their first year provided they have completed the required first-year courses and meet certain requirements. Women who are accepted into general engineering can apply to participate in an engineering-specific LLC when applying for on-campus housing, and WIE-LLC is designed to bring together first-year women engineering students and support them as they pursue degrees in engineering. Students who participate in WIE-LLC must enroll in a one credit-hour seminar course that meets once a week during the fall semester and must participate in a certain number of professional development, social, and academic activities throughout the academic year. Additionally, students in WIE-LLC must complete a certain number of community service hours. These activities are organized by upper-class leaders in the learning community, and students can

select which activities to participate in within the three categories of activities. In addition, participants are assigned student mentors, typically sophomores, who meet with the first-year students regularly during the first half of the fall semester. Participation is only required for one academic year for those accepted into the community, but students who participate in WIE-LLC can choose to remain in the community by applying to be an upper-class leader during subsequent years.

While WIE-LLC is designed to support women enrolled in engineering degrees, there is a partner LLC at the same institution for male engineering students (referred to as partner LLC in this study). The partner LLC has the same required activities as WIE-LLC, including a seminar, a requirement to participate in a certain number of social, professional development, and academic activities, peer mentoring, and community service. The required seminar is separate for WIE-LLC and partner LLC, but many of the activities organized by student leaders are open to both WIE-LLC and partner LLC. Because WIE-LLC shared many experiences with the partner LLC, the results from the present study likely transfer to LLCs for women in engineering and LLCs for engineering students more broadly.

3.2.2   Sample

According to Bowden (2005), a sample size of 20-30 participants is desired for phenomenographic studies in order to identify the range of variation in the sample. To capture a variety of perspectives on the phenomenon of interest, it is desirable to recruit a sample that increases the likelihood of variation (Åkerlind, 2005b).

To achieve this variation, I used a survey to identify participants for in-person interviews. At the conclusion of the spring semester, first-year women engineering students who participated in LLCs were invited to participate in an online survey about their experiences. Working with the university campus housing unit, I identified the three living-learning communities with the highest numbers of women engineering students. These LLCs included an engineering LLC, an LLC for honors students (Honors LLC), and an LLC focused on leadership (Leadership LLC). The survey was emailed by a member of housing and residence life to all first-year women engineering students enrolled in these three LLCs, and two follow-up emails were sent reminding students of the opportunity to participate in the survey. The survey, summarized in Table 3, contained questions regarding students' major, the LLC in which they were enrolled,

outcomes they believed they achieved through their LLC participation, professional skills gained through their LLC, and demographics. At the conclusion of the survey, students indicated whether they wanted to be entered to win one of three $10 Amazon gift cards for filling out the survey. In addition, students indicated their willingness to participate in an in-person interview during the following fall semester.

Table 3. Survey administered to first-year women in engineering who participated in WIE-LLC

Background Questions	Possible Responses
What is your current academic level?	First-year, sophomore, junior, etc.
What is your current major? - Selected Choice	[list of potential engineering majors], Other
What is your intended major? - Selected Choice	[list of potential engineering majors], Other
Living-Learning Community Participation	
What living-learning community (LLC) did you participate in during the 2016-2017 academic year?	[List of LLCs at university]
To what extent do you agree that you gained the following outcomes from your involvement in the LLC?	
• Intellectual development	Likert scale: SD, D, A, SA
• Personal development	Likert scale: SD, D, A, SA
• Social development	Likert scale: SD, D, A, SA
• Academic engagement	Likert scale: SD, D, A, SA
• Professional development	Likert scale: SD, D, A, SA
• Sense of belonging	Likert scale: SD, D, A, SA
• Satisfaction with the college experience	Likert scale: SD, D, A, SA
To what extent do you agree that you gained the following professional skills from your involvement in the LLC?	
• Communication skills	Likert scale: SD, D, A, SA
• Leadership skills	Likert scale: SD, D, A, SA
• Teamwork skills	Likert scale: SD, D, A, SA
• Problem Solving skills	Likert scale: SD, D, A, SA
• Critical Thinking skills	Likert scale: SD, D, A, SA
• Creativity	Likert scale: SD, D, A, SA
• Management skills	Likert scale: SD, D, A, SA
• Other skills	Likert scale: SD, D, A, SA
Demographic Questions	
What gender do you most identify with? - Selected Choice	
Which of these racial/ethnic groups do you most identify with (check all that apply)? - Selected Choice	

Note: SD=Strongly Disagree, D=Disagree, A=Agree, and SA=Strongly Agree.

The survey was sent to approximately 200 first-year women engineering students across the three LLCs: approximately 90% of these students participated in WIE-LLC. Sixty-four students responded to the survey, and approximately 85% of the survey respondents had participated in WIE-LLC. The number of students from each LLC who completed the survey, were willing to participate in an interview, and completed an interview is shown in Table 4.

Table 4. Number of survey respondents and interview participants

LLC	Completed Survey	Willing to Participate in Interview	Participated in Pilot Interview	Participated in Interview
WIE-LLC	58	29	0	21
Honors LLC	4	3	2	0
Leadership LLC	3	2	2	0

Given the number of respondents from each LLC, only WIE-LLC had enough potential interview subjects to provide a sufficiently large sample pool while maintaining a common phenomenon. Participants from the Honors and Leadership LLCs who were willing to participate in an interview were contacted to participate in pilot interviews. As discussed below, pilot interviews were conducted to ensure that the interview protocol elicited responses related to the phenomenon of interest.

In the survey results for WIE-LLC participants, all survey respondents either agreed or strongly agreed that WIE-LLC helped them develop professionally (Figure 2a). However, in response to the question regarding the extent to which WIE-LLC supported specific professional skills, students varied in both the skills they perceived to have gained and the extent to which they agreed WIE-LLC helped them develop those skills (Figure 2c). Importantly, the survey responses for interview participants were similar to the survey responses for all WIE-LLC students who filled out the survey (Figure 2b and 2d), indicating that the interview participants were a representative sample of those who filled out the survey. However, one notable exception was identified. One WIE-LLC participant who filled out the survey strongly disagreed that LLC participation helped her develop any of the professional skills included in the survey. This participant did not indicate a willingness to participate in an interview and therefore was not contacted. This participant's perspective, therefore, is not included in the results of this study.
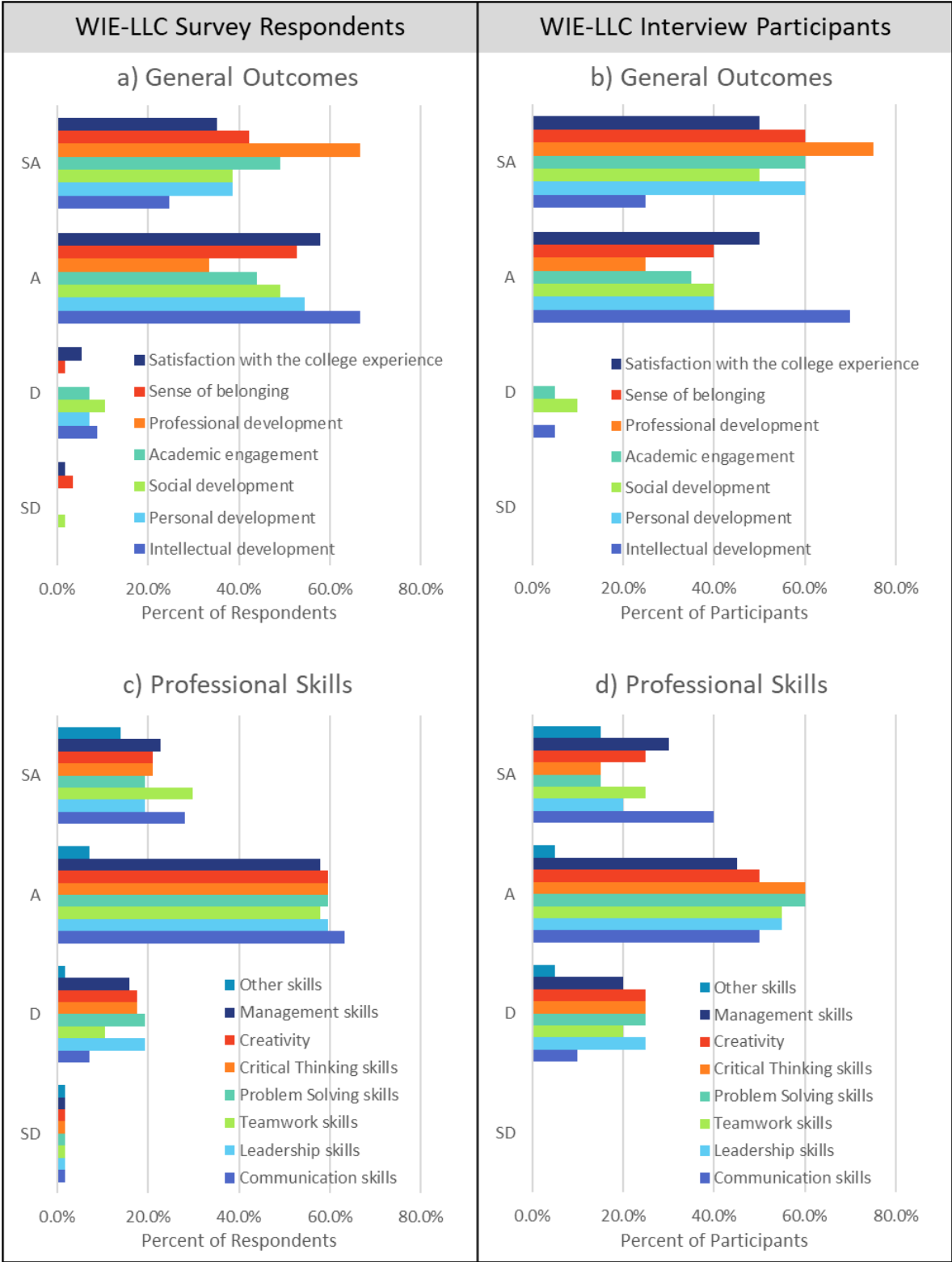
Figure 2. Survey responses for all WIE-LLC survey respondents (a, c) and for interview participants (b, d)

To maximize the variation in the sample, all participants who indicated willingness were invited to participate in a semi-structured interview. Participants were interviewed during their second year in college after participating in the LLC for women in engineering during their first-year. This timing ensured that women had the complete LLC experience prior to the interview. In addition, by interviewing second-year students, participants were able to reflect on their participation in the LLC as they started their in-major courses while still being able to describe specific LLC experiences that were beneficial. Interview participants received a $10 Amazon gift card for participating. Of the 29 students who were contacted, 21 participated in interviews. The survey responses for the professional skill outcomes for WIE-LLC interview participants are included in Table 5. The table is sorted according to participants' level of agreement for each question, with participants who indicated a stronger agreement at the top of the table. Similar to the survey responses for all WIE-LLC survey respondents, interview participants all agreed or strongly agreed that an outcome of participating in the WIE-LLC was professional development. At the same time, as with the full survey response set, the professional skills that participants indicated that they gained through the LLC varied (Table 5). For example, Participant 6 and Participant 7 strongly agreed that WIE-LLC helped them develop all of the professional skills included in the survey, while Participant 13 agreed that WIE-LLC helped her develop communication and other "professional development skills" but disagreed that it helped her develop the remaining skills listed.

Table 5. Survey responses to professional skill outcomes for WIE-LLC students who participated in interviews

Participant ID	Professional development	Communication skills	Leadership skills	Teamwork skills	Problem Solving skills	Critical Thinking skills	Creativity	Management skills	Other skills	Other professional skills
P7	SA	SA	SA	SA	SA	SA	SA	SA	SA	
P6	SA	SA	SA	SA	SA	SA	SA	SA		
P21	SA	SA	SA	SA	SA	SA	SA	SA		
P16	SA	SA	A	SA	A	A	A	SA	SA	Time Management
P5	SA	SA	A	SA	A	A	SA			
P19	SA	SA	D	A	A	A	A	A	SA	Organization
P17	SA	SA	A	A	A	A	D	D		
P8	SA	SA	A	A	A	A	A	SA		
P22	SA	A	SA	A	A	A	SA	A		
P18	SA	A	A	A	A	A	A	A		
P14	SA	A	A	A	A	A	A	A		
P9	SA	A	D	A	A	A	A	A		
P15	SA	A	A	A	A	A	A	D		
P25	SA	A	A	D	D	D	D	A		
P13	SA	A	D	D	D	D	D	D	A	professional development skills
P12	A	A	A	A	A	A	A	SA		
P10	A	A	A	A	A	A	A	D	D	
P24	A	D	A	D	D	D	A	A		
P23	A	A	D	A	D	D	D	A		
P20	A	D	D	D	D	D	D	A		

Note: SA=Strongly Agree, A=Agree, D=Disagree, SD=Strongly Disagree.

While all interview participants were in the general engineering program during their participation in WIE-LLC, they were in a variety of engineering majors at the time of the interview (Table 6).

Table 6. Majors for interview participants

Major	Number of Participants
Mechanical Engineering	5
Industrial and Systems Engineering	4
Aerospace Engineering	2
Civil Engineering	2
Computer Science	2
Electrical Engineering	2
Chemical	1
Material Science Engineering	1
General Engineering	1
Non-Engineering	1
Total	**21**
Total in Engineering Majors	**20**

One interview participant had switched out of engineering at the time of the interview. While this participant was interviewed, this interview was excluded from the data analysis for this study. The current study focused on the perceptions of professional development in engineering and the experiences that are beneficial for professional development in engineering; therefore, only those students who remained in an engineering major at the time of the interview were included in the analysis. The demographics of participants interviewed and included in the analysis, as self-reported in the screening survey, are shown in Table 7.

Table 7. Demographic information for interview participants

Demographic	Number of Participants	Percentage (Interview Participants)	Percentage (College of Engineering Entering Class)
Race/Ethnicity			
White	13	65%	64.1%
Asian	3	15%	12.3%
Black or African American	3	15%	3.1%
Two or more	1	5%	3.8%
Gender			
Woman	19		25.9%
Trans	1		Not listed
Total	**20**		

The percentages of interview participants as well as students in the college of engineering entering class who identify with a particular race/ethnicity are also shown in Table 7. The

demographics of participants in the study are similar to the demographics of entering engineering students with one notable exception: more students who identified as Black or African American participated in the study. WIE-LLC is run by an engineering student support center at the university focused on supporting underrepresented groups in engineering which may contribute to more students from these groups participating. While 19 out of 20 interview participants indicated that the gender that they most identify with is woman, one participant indicated that they most identify as trans. Therefore, it is important to note that while WIE-LLC was designed to support women in engineering, individual gender identity is more complex. In this study, because all students interviewed participated in an LLC designed to support women in engineering, I will refer to these students collectively as women throughout this dissertation. But it is important to acknowledge the complexity of gender identity for individual participants.

3.2.3 Data Collection

As is typical in phenomenographic studies, (Marton, 1986), semi-structured interviews were used in this study. The phenomenographic interview is similar to semi-structured interviews used in other qualitative methodologies. However, the aim of phenomenographic research is to allow the participants to describe their experiences and to focus on aspects of the phenomenon that are most relevant to them through concrete examples (Åkerlind, 2005a; Marton, 1986; Marton & Booth, 1997). To allow the participants the opportunity to define the phenomenon in their own words and reflect on their experiences, interview questions were broad and supplemented by several types of follow-up questions. The full interview protocol is shown in Table 8. This protocol allowed the interviewer to follow the interests of the interviewee, which aligns with the structure of phenomenographic interviews (Ashworth & Lucas, 2000). Participants were asked open-ended questions about experiences within LLCs that they perceived were beneficial for their professional development and were asked to describe professional development. These broad questions allowed participants to describe aspects of the phenomenon most relevant to them personally. Follow-up questions were used to encourage students to elaborate, clarify, and provide specific examples.

Table 8. Interview protocol

Interview Question	RQ
Background Questions	
To start the interview, I want to get to know a little bit more about you. Could you tell me a little about your experiences at [**institution**] so far? • What year are you in school? • What is your major/intended major? • *If no longer in engineering:* Why did you switch from engineering to [**major**]? • What activities were you involved in prior to coming to [**institution**]? • What activities are you involved in at [**institution**]? • Why did you join [**LLC**]?	n/a
Descriptions of Professional Development Experiences	
In addition to knowing your definition of professional development, I am also interested in your experiences within [**LLC**] that helped you develop professionally. What was one experience in [**LLC**] that helped you develop professionally? • How did this experience help? • Why did this experience help? • Can you give me examples?	
What other experiences in [**LLC**] helped you develop professionally? • How did this experience help? • Why did this experience help? • Can you give me examples?	
Were there experiences in [**LLC**] related to professional development that weren't helpful? • Why were these experiences not helpful? • Can you tell me more about that?	RQ1
Are there any experiences related to professional development that you wish you had in [**LLC**] but didn't? • Can you tell me more about that?	
Are there experiences or parts of [**LLC**], other than what we have already talked about, that helped you develop professionally? • Can you tell me more about that? • Are there any that hindered your professional development? Can you tell me more about that?	
Are there any experiences outside of [**LLC**] that helped you develop professionally? • How did these experiences help? • Can you give me some examples?	
Definitions of Professional Development and Relevant Skills	
In this study, I am interested in your views of professional development. For you, how would you define professional development? • How do you think you developed this definition of professional development? • Can you give some examples of professional development? • Who have you talked to about professional development? • How important is professional development? Why do you say that? • What are some ways that your idea of professional development has changed?	RQ2

Interview Question	RQ
If specific skills are mentioned: You mentioned that [**skill**] was related to professional development, could you tell me more about that? • Why are these skills important? • Are there any other skills that are related to professional development? What are they? Why are they important?	
If specific skills were not mentioned: So we have talked a bit about professional development. What skills, if any, do you think are related to professional development? • Why are these skills important?	
Descriptions of Future Professional Development	
I am interested in how this professional development relates to your future plans. How does professional development relate to what you want to do after you graduate? • What do you want to do after you graduate? • What kind of professional development is needed in [**intended field**]? • What skills are relevant to professional development in [**intended field**]? • Why are these skills important? • How do you think [**skills**] will be useful for you in your [**intended field**]? • What professional development are you hoping to gain while at [**university**] to prepare you for [**intended field**]? Where do you think you will get this professional development?	
Conclusion Questions	RQ1 & RQ2
As a reminder, I am interested in professional development and experiences that help you develop professionally in [**LLC**]. Is there anything else that you thought of or wanted to say related to that?	
Potential Follow-Up Questions	n/a
• Can you tell me more about that? • Can you give concrete examples? • Can you explain that to me?	

3.2.4   Pilot Study

To test the interview protocol and methods, I conducted a pilot study. In phenomenographic studies, pilot interviews are used to refine interview questions and ensure that the questions in the interview elicit responses related to the phenomenon of interest without leading the participant (Åkerlind et al., 2005; Bowden, 2005). I conducted pilot interviews with students who responded to the screening survey yet participated in an LLC other than WIE-LLC. Pilot interview participants received a $10 Amazon gift card after the interview. By interviewing participants who shared characteristics with the participants in the study (first-year women engineering student who participated in an LLC), I was able to gain an understanding of the ability of my interview protocol to elicit information related to the phenomenon being studied.

Following the pilot interviews, I reviewed the interview questions and participant responses and modified the order of interview questions. In the pilot study, I first asked participants to define professional development and then asked about their experiences in the LLC that helped support their professional development. Participants in the pilot study had a difficult time describing professional development without having some context in which to think about the concept. Therefore, the order of questions was rearranged to first ask students to describe experiences that were helpful for professional development and then ask students to define professional development. This order allowed students to reflect on their experiences that they found helpful and then further reflect on their views of professional development.

3.2.5   Data Analysis

Consistent with a phenomenographic approach, analysis began after all of the interviews were conducted (Bowden, 2005) and transcribed verbatim. Within phenomenography, there are two general approaches for conducting analysis. In the first approach, transcripts are read to identify all excerpts relevant to the phenomenon under investigation. The excerpts from all transcripts are then collected in a single 'pool of meanings' (Marton, 1986; Marton & Booth, 1997), and the excerpts are sorted into categories. In this approach, each excerpt is considered in the context of the interview from which it came as well as the context of the pool of meanings with which it is grouped. In the second approach, each transcript in its entirety, or large sections of the transcript related to a particular topic, is considered as a whole in the sorting process (Åkerlind, 2005c).

This study utilized the first approach and transcript excerpts were collected into pools of meanings. This approach was used to ensure that the focus of data analysis remained on the collective group as opposed to individuals. Additionally, this approach allowed for the identification of multiple meanings from each interview and for the selection of excerpts that most directly demonstrated the meaning (Åkerlind, 2005c). Using segments was particularly beneficial in examining participants' descriptions of professional development and their experiences with professional development because students described many aspects of professional development and participated in a variety of experiences in WIE-LLC. Focusing on the segment, rather than on each participant, allowed me to examine these nuances in both participants' descriptions of professional development and their experiences.

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The outcome space of phenomenographic studies include the categories and the logical relationships between them. There are several criteria used to evaluate the outcome spaces in phenomenographic studies including the following (Marton & Booth, 1997):

1. Each category should reveal something distinct about the experience of the phenomenon under investigation.
2. The categories should be related to one another, and this relationship often comes in the form of a hierarchical relationship.
3. The phenomenon should be captured by the fewest categories possible while still capturing the variation in experiences.

These criteria were used during iterations of analysis to evaluate the outcome space.

The process of analysis involved several steps (Marton, 1986). During initial iterations of coding, relevant segments were identified. To answer the first research question, relevant quotes were those related to descriptions and aspects that participants described as related to professional development. To answer the second research question, relevant quotes were those related to aspects of experiences within the LLC that participants described as beneficial for professional development. Once segments were identified, a preliminary descriptor was attached to each segment. As more interviews were analyzed, additional descriptors were identified. After the initial analysis of all interviews, interviews were reexamined using the full set of descriptors. Interview segments were then collected and grouped according to descriptor to create categories. Relationships between categories were also examined throughout the analysis phase due to the connected nature of categories and relationships. These groups of segments and their relationships were compared in an iterative process to identify similarities and differences within and between groups. Segments on the border between two groupings were examined to further refine categories. This process was used to identify categories and the relationships between categories. During analysis of initial interviews, I maintained an open mind to the students' experiences and descriptions of professional development. As categories and their relationships were refined, interview transcripts were reexamined to ensure that the context of each segment was not lost. An overview of this process is shown in Figure 3.
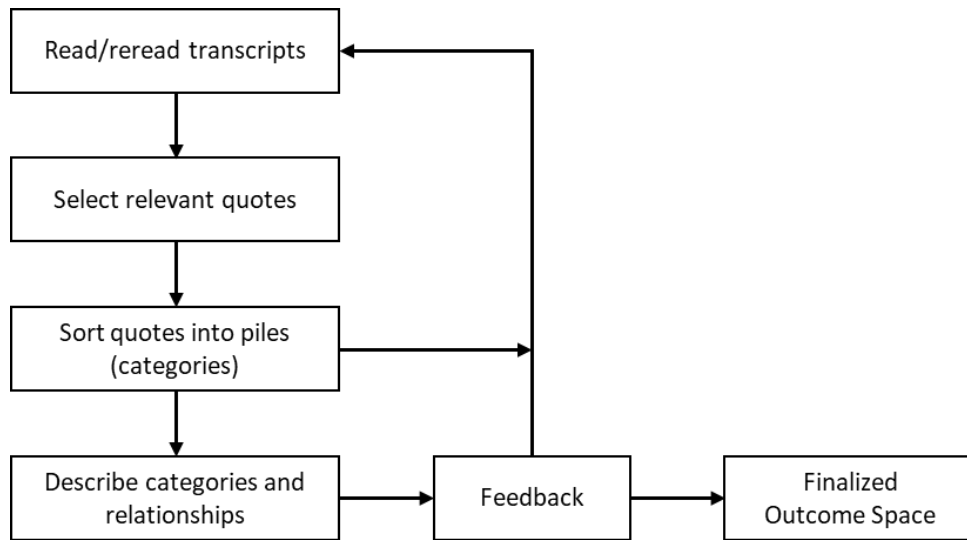
Figure 3. Overview of each iteration of data analysis

3.3 Validity and Reliability

Several steps were taken to ensure that the findings and interpretations of data were consistent and of high quality (reliability) and that the findings from the study reflect the phenomenon in the study (validity) (Åkerlind, 2005c). The methods described below were used in the current study to enhance the validity and reliability[1] of the outcome space.

3.3.1 Reliability

To enhance reliability in phenomenographic approaches, reliability checks are often conducted to obtain multiple perspectives that helps ensure that a more complete outcome space is captured (Åkerlind, 2005c). Two types of reliability checks are often conducted in phenomenographic studies: coder reliability checks and dialogic reliability checks (Åkerlind, 2005c). For coder reliability checks, two researchers code the same segment of data and compare coded segments. For dialogic reliability checks, multiple researchers come to consensus on the interpretation of the data through discussion and critique. While coder reliability checks have been used, some argue that these checks are not appropriate in phenomenographic studies because category development is based on segments from interview transcripts as a collective and not on

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[1] While terms such as validity and reliability are not typically used in qualitative research (Leydens, Moskal, & Pavelich, 2004), references describing these concepts in phenomenographic literature used these terms (Åkerlind, 2005c). Therefore, I use the terms validity and reliability in this dissertation.

individual transcripts. This approach makes consensus in coder reliability checks difficult to obtain.

As a result, Bowden and others have advocated for the use of dialogic reliability checks in phenomenographic studies instead to incorporate multiple perspectives during data analysis while helping to ensure that the categories emerge from the data (Åkerlind, 2005c; Collier-Reed, Ingerman, & Berglund, 2009). For example, Bowden (2005) described using a team of researchers to play devil's advocate and question the creation of categories. This study utilized dialogic reliability checks with a research group, a second researcher, faculty advisors, and individuals involved with LLC communities (Figure 4). The research group consisted of Ph.D. students studying engineering education, and the peer researcher was a postdoctoral researcher well versed in qualitative methods. The advisors included two faculty members whose specializations are in qualitative research methods and out-of-class experiences. Individuals involved with LLCs included an administrator in Student Affairs with experience overseeing and researching these communities as well as a faculty member who has been involved with WIE-LLC, and the student support center that runs the LLC, for more than 5 years. These individuals who were familiar with LLC communities were consulted to question the creation of categories and provide input on the appropriateness of findings, as discussed in the validity section below.

To obtain feedback, the categories and relationships for each iteration were presented to the individual or group who was providing feedback, and the categories and relationships were subsequently questioned and challenged. This process brought to light new perspectives and ideas, which were further examined in the next iteration. After each reliability check, categories and relationships were modified based on the feedback received. These reliability checks were used to ensure that the results capture the experiences of participants and are supported by evidence in the transcripts. Following these iterations, the outcome space was finalized.

Iteration 1 → Iteration 2 → Iteration 3 → Iteration 4 → Iteration 5 → Iteration 6 → Finalized Outcome Space

Feedback: ● | Feedback: ◇ ● | Feedback: ◆ ● | Feedback: □ ● | Feedback: ◇ ■ | Feedback: ●

Feedback from:
● = Advisors
◇ = Research Group
◆ = Peer Researcher
□ = LLC Community
■ = Committee
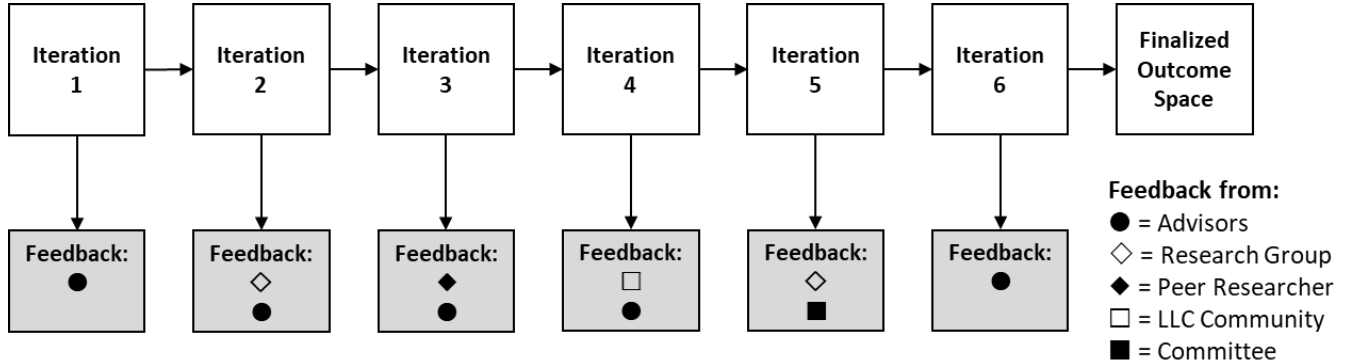
Figure 4. Overview of iterations included in the study

3.3.2 Validity

Throughout the iterations, members of the LLC communities were contacted for feedback to ensure that the findings were appropriate. Phenomenographic research identifies and categorizes the ways in which participants experience a phenomenon from the perspective of the researcher (Marton & Booth, 1997). Therefore, the aim of phenomenographic research is to find an interpretation that can be defended and is useful as opposed to one that is "correct" (Åkerlind, 2005c). The validity of this interpretation can be accomplished in multiple ways (Åkerlind, 2005c), including 1) obtaining feedback from the individuals who were interviewed, 2) obtaining feedback from other individuals in the population being studied, and 3) obtaining feedback from individuals in the intended audience. While these methods are common in qualitative studies broadly, the first is not typically used or seen as appropriate in phenomenographic studies because categories are identified based on the collection of participants and do not represent one individual's understanding of the phenomenon. In this study, I discussed the outcome space and obtained feedback from an administrator in Student Affairs as well as from a faculty member who has been involved with various aspects of WIE-LLC. This feedback was used to ensure that the interpretation and findings were viewed as appropriate by members of the LLC community. While not included in this dissertation, future validity checks will involve obtaining feedback from the director of the WIE-LLC to discuss the alignment of the outcome space with the director's perspective of professional development experiences based on their experiences working with students.

3.3.3   Researcher Bias

An important aspect of phenomenographic studies is the focus on the relation between the subject and the phenomenon, even though the researcher may also have a relation to the phenomenon. Therefore, it was important for me to bracket my own perspectives and maintain a focus on the descriptions and experiences of the participants (Ashworth & Lucas, 2000). In an effort to be transparent, this section outlines my own experiences with LLCs.

I received my Bachelor's degree in mechanical engineering from a land-grant institution, and did not participate in a living-learning community during my undergraduate career. My first experience with an LLC was as a graduate student. For one year, I was a graduate assistant working for an LLC designed to support women in engineering. I taught a seminar class for the LLC and met with students individually. Through this experience, I talked with the director of the LLC, students who participated in the LLC, and other graduate students who worked for the LLC, and I heard a range of perspectives on the program as a whole as well as various experiences within the LLC. I heard students describe aspects of the LLC that they enjoyed as well as aspects of the LLC that they did not.

Given the need to focus on the experiences of the participants who were interviewed, I had to bracket these experiences related to LLCs. This involved letting the participants define the phenomenon and the experiences related to the phenomenon without assuming that my understanding was the same as theirs. To understand the perspectives of the participants, the interview protocol was structured in a way that encouraged participants to explain and elaborate on aspects of the phenomenon that were most relevant to them. Follow-up questions were designed to probe and gather more information related to the topics described by the participant. These questions allowed for a more detailed description of the phenomenon. To reduce the influence of bias during data analysis, I used participants' terminology and ensured that categories identified were supported by interview segments.

In addition to bracketing my personal experiences, it was crucial to bracket other conceptions, such as existing literature and theories. Therefore, throughout the study, I ensured that the following conceptions did not influence the direction of data collection nor analysis (Ashworth & Lucas, 2000, p. 298):

- Earlier research findings;

- A priori theoretical structures or particular interpretations;
- My personal knowledge and belief;
- My concern to uncover the `cause' of certain forms of the student experience.

These conceptions, as well as my own experiences with LLCs, were continually examined and challenged through reliability checks to ensure that they did not influence the analysis of participant interviews.

3.4 Limitations

There are several limitations of this study. First, in phenomenographic studies, the aim is to maximize the variation in perspectives and experiences represented in the sample. In this study, interview participants were selected from respondents to a survey on LLC experiences, and I reached out to all participants from WIE-LLC who were willing to participate in interviews. Because participants self-selected to participate in the study, I was not able to purposefully select participants who indicated a full range of perspectives. Therefore, I may not have interviewed participants who participated in the full range of LLC experiences, who disagreed that the LLC helped them develop professionally, or who did not enjoy their LLC experience as a whole.

Second, the participants were from a single LLC at one institution. Therefore, this study may not capture the experiences of students in these other contexts. Additionally, because the study focused on one LLC, the results may not transfer to other LLCs that have a different mission or focus. To help mitigate this, I have provided rich descriptions of the context and outcome space to allow the readers to identify relevance. Additionally, the LLC selected for this study was incorporated in a university representative of high research land-grant institutions broadly and included many experiences common to LLCs nationally, including a seminar course, interactions with faculty and peers, service learning, study groups, and mentoring, and students were housed in the same portion of a residence hall. This breadth of experiences common to LLCs helps promote transferability to other contexts that incorporate similar experiences.

3.5 Implications

In phenomenographic studies, it is worth noting that the aim is not to generalize the findings. The aim is to examine the various ways a phenomenon is experienced. These studies focus on one group of participants who are experiencing the same phenomenon in order to illuminate salient

features that may prove useful in other related settings. In this study, the focus was on the perceptions of women engineering students who participated in an LLC for women in engineering and the experiences within this program that women perceived as helping them develop professionally. The results, which include descriptions of professional development and features of experiences that women found beneficial for this development, can help guide the creation of out-of-class experiences that support women engineering students' professional development. These results can help individuals who are involved in running and designing programs for engineering students that incorporate elements of professional development, as discussed in detail in Chapter 6.

3.6   Summary

This study adopted a phenomenographic approach as a means to understand women engineering students' descriptions of professional development, and the experiences that help with that development, after participating in an engineering LLC. Prior literature on LLCs has focused on general outcomes of these programs, and there was a need to examine the specific experiences within these programs that support intended outcomes. In particular, while professional development is often incorporated into these programs, few studies have focused on professional development outcomes, particularly for underrepresented groups. This study begins to fill this gap. This study used a phenomenographic approach which allowed me to examine the qualitatively different ways that women engineering students described and experienced professional development in a living-learning community. In addition to identifying these categories, I identified the relationships between categories of professional development.

Chapter 4: Descriptions of Professional Development

4.1   Introduction

The purpose of this study was to examine the ways in which women engineering students experienced and described professional development after participating in a living-learning community (LLC) for women in engineering. The overarching goal of this study was to understand how experiences within LLCs can support women's professional development. To address this purpose, I examined the following research questions:

RQ1: How do women engineering students describe professional development after participating in an LLC for women in engineering during their first year in college?

RQ2: What features of experiences within an LLC for women in engineering do these women perceive as contributing to their professional development?

To address these questions, students who participated in an LLC for women in engineering were interviewed, as described in Chapter 3. During interviews, participants described their understanding of professional development and the experiences that they found helpful for professional development. Interviews were transcribed and analyzed to identify variations in participants' views. The results of this analysis are twofold: the PD^2 (Professional Development Domains) Model and the LEEPD (Learning Experiences for Engineering Professional Development) Model. These two models are described in Chapter 4 and Chapter 5, respectively. The PD^2 Model captures the various ways that women described professional development and the various categories that made up students' descriptions (RQ1). The LEEPD Model captures features of experiences that women found beneficial for professional development (RQ2).

4.2 PD^2 Model

The PD^2 (Professional Development Domains) Model (RQ1) depicts women's descriptions of professional development and consists of domains, categories, and levels. These results form a 2-dimensional outcome space that provides an overview of participants' descriptions of professional development. This outcome space represents composite descriptions of professional development based on interview segments, not entire participant interviews.

Participants' descriptions of professional development were grouped into three domains: Job Acquisition, Job Performance, and Personal Development. Each domain consists of multiple

categories of skills and competencies. These domains and categories capture the content of students' descriptions of professional development. Categories within Job Acquisition include 1) Application Components and 2) Interactions. Categories within Job Performance include 1) Technical Knowledge, 2) Engineering Judgment, 3) Time and Task Management, 4) Working with Others, 5) Communication, and 6) Self-Presentation. Finally, categories within Personal Development include 1) Career Choice and 2) Lifelong Learning. Each of these categories consists of multiple levels that indicate the depth to which they were discussed by participants. Combined, these domains, categories, and levels form the PD^2 Model (Figure 5).
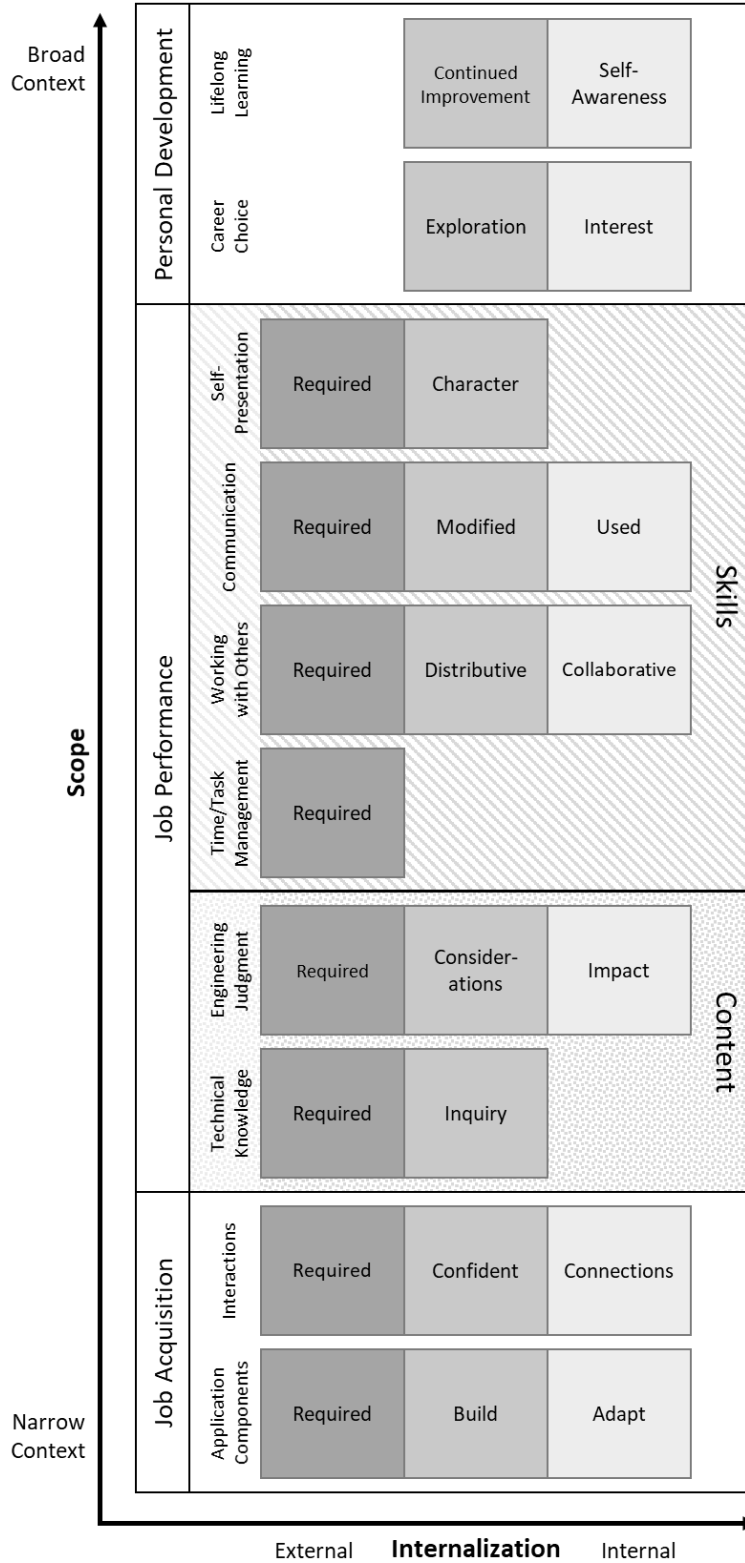
Figure 5. PD^2 Model depicting participants' descriptions of professional development

One dimension of the outcome space (represented by the y-axis in Figure 5) indicates the scope of the domains and categories. Narrow contexts are specific to a particular situation or activity; broader contexts extend beyond specific situations or include multiple contexts. The three domains, and the categories within each, increase in scope from the narrow context of acquiring a job to the broader context of performing a job to the most encompassing context of personal development. Job Acquisition includes skills and experiences necessary to acquire an engineering position and were described as relevant in environments and situations where participants were attempting to acquire a job, such as when applying for internships, co-ops, or entry-level positions. The Job Performance domain extends beyond the immediate application process and includes aspects necessary to work in an engineering position. The Job Performance domain, then, is broader in scope in that the categories pertain to a variety of contexts experienced in engineering workplace environments broadly. Finally, while the Job Acquisition and Job Performance domains pertain to workplace contexts, the Personal Development domain pertains to skills, experiences, and qualities that, while relevant in workplace contexts, are applicable in broader contexts within participants' lives and are not limited to workplace settings. In addition, categories within each domain increase in scope from narrow to broad contexts and will be discussed in detail in the sections below.

The second dimension (represented by the x-axis in Figure 5) indicates the level of internalization for a particular category. Within each category, participants' descriptions differed in the level of ownership discussed for each category or skill. In general, moving from left to right in Figure 5, categories consist of three levels of internalization: an external level, an intermediate level, and an internalized level. Descriptions in the external level (level 1) include skills and content areas that are externally imposed by others, such as instructors and recruiters. For most categories, the external level describes required skills that participants were told were necessary in the engineering profession. In this external level, participants described little to no ownership of the skill or competency. Participants' descriptions in the internalized level (level 3), in contrast, demonstrated ownership of the competency through descriptions of how the skills and content areas relate to a participant's own goals and interests. Descriptions in the intermediate level (level 2) include modifying and adapting the skills and content areas to meet the goals of others. In this level, participants described some ownership of competency but the aim was typically to meet the needs of others. While levels within each category typically follow

this pattern, variations are present, particularly in level 2. And in some instances, fewer than 3 levels were identified and are left blank in the model.

The following sections provide detailed descriptions of each domain, category, and level.

4.2.1 Job Acquisition Domain

The first domain of participants' descriptions of professional development is Job Acquisition (Figure 6). Categories within Job Acquisition relate to specific contexts (e.g., career fairs) in which students are applying for positions (e.g., internship, co-op, or entry-level position) or progressing from one position to the next. This domain, then, is narrowest in scope of the three domains. Categories in the Job Acquisition domain include 1) Application Components and 2) Interactions. Application Components, comprising the narrowest category, were described as specific to contexts in which participants were seeking to be hired for a position. The Interactions category, while still primarily described as relevant in contexts where participants were applying for positions and opportunities, extends to other contexts such as interviews and networking opportunities. These interactions were described as relevant in structured job acquisition settings (e.g., career fairs) but also academic, personal, and professional settings that could lead to a job.
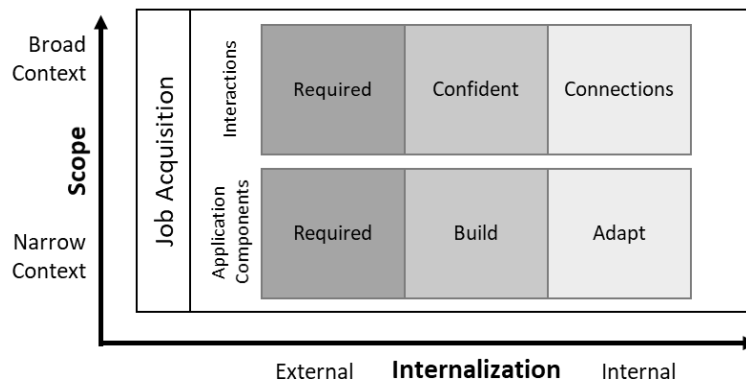
Figure 6. Job Acquisition domain

4.2.1.1 Category: Application Components

Application Components included the elements necessary during the process of acquiring a job, including résumés, elevator pitches, cover letters, and interviews. These components were described as most applicable in structured settings where the primary purpose was seeking and applying for job opportunities.

At an external level (Required), participants described the externally imposed requirement to create these components. The Build and Adapt levels moved these components beyond an external requirement to an element that was modified to incorporate experiences specific to the participant. At the intermediate level (Build), participants described further building these components by gaining experiences that were relevant to a position or field. At the internalized level (Adapt), participants described adapting job application components to highlight their individualized strengths and experiences to better promote themselves in the job acquisition process.

4.2.1.1.1 Level 1: Required

At the Required level, participants described the need to understand the steps and artifacts involved in the process of applying for a job that were externally imposed by recruiters and employers. The job acquisition process involved the creation of artifacts such as résumés and cover letters and involved processes such as attending career fairs and interviewing for positions. In participants' descriptions, professional development included learning about the expectations of what components were required and what should be included. As one segment illustrates:

> Yeah, so the initial part [of professional development] is more just everything that [LLC] has been doing so far. So just like the résumé, the cover letter, professional emails, what to wear to different events, professional development events. And like just preparing yourself for all that. And then also interviews and just like what to do after an interview. Basically everything leading up to before you get the job, I feel like is more the initial stage of professional development. *Participant 19*

This excerpt highlights the need to understand the required artifacts, including the résumé, cover letter, and emails, as well as the required process involved when acquiring a job, including preparation to talk with companies, interviewing, and follow-up conversations with companies. In this level, participants described the required components involved in the process of applying for jobs, and these components were described as required by external entities such as recruiters and companies.

4.2.1.1.2 Level 2: Build

In the Build level, participants described the need to not only create required artifacts but also gain experiences and skills relevant to engineering work that could be incorporated into the

required artifacts. Participants stated that such experiences could be incorporated into artifacts such as résumés, elevator speeches, and interviews. These experiences provided tangible experiences that could be discussed during the job application process to highlight skills that potential employers were interested in, as explained in the following segment:

> So I definitely feel like getting those experiences [design teams and internships] is also a really important thing to developing as a professional. Because, especially if you, if you're trying to find a full-time job upon graduation, like if you don't have that experience, a lot of times companies are going to look at you and say "what have you been doing? Why haven't you been on design teams?" Or "why haven't you had internships?" Or things like that. "Yeah, you had this great GPA, but we don't know that you can actually do it." So I feel like it's important too. *Participant 16*

This excerpt illustrates the perception that employers want candidates to gain certain experiences during their undergraduate education and to demonstrate relevant skills. As a result, participants stated that they needed to gain those skills and experiences and include them in the various job application components. Similar to the Required level, this need to further build their job application components by incorporating experiences and skills was imposed externally. In this level, participants described the need to build these components based on the needs and wants of external recruiters and employers. But in contrast to the Required level, the Build level was more internalized because participants began to personalize and modify the required components through their own choices and actions.

4.2.1.1.3 Level 3: Adapt

In the Required and Build levels, participants described the need to create and build job application components based on requirements imposed by external sources. In the Adapt level, participants discussed adapting both artifacts and processes to highlight certain skills and experiences that were specific and important to the student (i.e., not just "what the employers want"). In these adaptations, participants identified experiences, or parts of experiences, that they perceived were important to highlight and emphasize when applying for a position. Similar to the Build level, participants described gaining experiences to incorporate into job application components. However, in contrast to more externalized levels, when participants adapted components, they described gaining experiences that aligned with their own interests as opposed

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to only those that aligned with the interests of potential employers. Experiences, then, could be adapted to highlight skills that the women saw as personal strengths. As one excerpt highlights:

> [A part of professional development is] learning how to take the experiences you have from different organizations and make it into, like, make it into how you can describe yourself differently. You can kind of seize upon different opportunities other people might not have had and talk about those. So um, like I'm a part of Engineers Without Borders. So like talking about that, because not as many people are in that. […] So like taking like organizations that aren't necessarily the standard organizations and then like talking about your impact with that and how you like showed leadership. So just learning how you can differentiate, differentiate yourself. *Participant 20*

In this excerpt, the participant described using experiences that were interesting and important to her to "differentiate herself," as opposed to gaining experiences for the purpose of meeting the requirements of others, as was present in the Build level. In the Adapt level, participants engaged in experiences that were of interest to them and emphasized skills and competencies from those experiences when applying for an engineering position. This adaptation of job application components was the most internalized level of the Application Components category.

4.2.1.2   Category: Interactions

The second category within the job acquisition domain was Interactions. Interactions included those involved during the process of applying for a job as well as interactions that could lead to job opportunities. While job application components were described as required in the job search process and relevant in more structured job acquisition contexts, interactions were not limited to these contexts. Beyond the narrow confines of career fairs and interviews, participants described the importance of interactions that had the potential to lead to job opportunities in broader professional, personal, or academic contexts.

At an external level (Required), participants described presenting themselves and interacting appropriately in professional settings broadly and emphasized appropriate appearance and behaviors. At an intermediate level (Confident), participants described presenting themselves and interacting *confidently* in professional settings. This level, then, moved from adopting appropriate appearance and behavior to being able to better promote themselves through confident interactions. At an internalized level (Connections), participants described interacting

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with others to make connections that could be beneficial in finding and pursuing job possibilities. In contrast to the Required and Confident levels, the Connections level moved beyond presenting oneself in job acquisition interactions to developing longer-lasting relationships and connections that could be beneficial for the participant in the near and/or distant future.

4.2.1.2.1 Level 1: Required

At the Required level, participants described professional development as learning about the interactions required in job acquisition settings. These interactions included required appearance and behavior when applying for a job such as appropriate dress and specific etiquettes (e.g., when to ask questions). As one participant described, professional development involves "[understanding] you are supposed to dress a certain way or like you need to talk in a certain way" (Participant 7). The required appearance and behavior was based on the expectations of external recruiters and potential employers. When describing appropriate behavior, participants stated that it was important to "have a firm handshake" (Participant 5), and "[keep] eye contact, [keep] good communication skills, [make] sure that they hear you" (Participant 19).

Appropriate behavior in this context also included knowing how to act professionally and knowing appropriate etiquette in these environments. As illustrated in the following segment, knowing both appropriate and inappropriate behavior in these settings was important:

> I think [professional development is] just like making sure when you're coming into a workplace environment, that you're confident in your skills and abilities as well as being able to be professional. […] Cuz a lot of people coming in like would just say things that weren't the best things to say to a company. And my roommate actually said this one kid came up and was talking to a recruiter and he goes "oh I have no questions for you, I know everything about the company." And that's not something you want to ask after talking to a recruiter. You want to be like "oh like this is what your favorite thing [is]," like you-- […] you got to keep talking. Like and [LLC] taught me like this is something you don't want to say to somebody, this is something that you should say. And like knowing that like, I was like, I'm going to shy away from certain topics. And they're like, never ask like what you're getting paid, never ask certain things. And I was like, and like I thought that was common knowledge. But I guess it wasn't. So it's just kind of teaching you like certain etiquettes that you wouldn't have all the time. *Participant 8*

This excerpt illustrates the importance of understanding the behaviors and etiquettes required by recruiters and employers in job acquisition environments, which differ from other environments.

4.2.1.2.2 Level 2: Confident

At the Confident level, participants described moving beyond an understanding of required interactions to being able to better present themselves through *confident* interactions. Participants stated that it was important to appear confident when interacting with potential employers in order to promote and differentiate themselves from other candidates, as illustrated in the following excerpt:

> I feel like a lot of [the things that you can do to sell yourself and further your career] is just becoming more comfortable with yourself and then becoming more confident and comfortable talking about yourself. *Participant 22*

This excerpt demonstrates the importance that participants placed on being confident when interacting in job acquisition settings and trying to differentiate themselves from other candidates. This confidence is further elaborated in the following excerpt:

> When I came into the spring career fair, I felt a lot more confident in my ability. […] And so I just kind of went up to one of the companies I was going to talk to. And I just, I just kind of threw myself at them and I was like "hey, I'm [participant], I'm, I'm amazing, like let's do this." I just had so much confidence when I went up. […] I like made this analogy of you have to pretend that you are Beyoncé when you go up to these career recruiters. The career recruiters don't want to tell Beyoncé about themselves, they want to hear about Beyoncé. And so you got to pretend like you're Beyoncé, like you're the shit. You just have to go up there and be like "yeah, I'm just going to tell you about myself, I'm amazing, I'm like a goddess." So just like definitely that confidence when you walk up to a recruiter. And the confidence also I feel like transforms into excitement about what you do. So it's not just like monotone like "oh I'm a part of [design team]." Like no. It's like "I'm a part of [design team]. I'm a part of the research and development team." Just like that overall excitement shows that like, hey she's really excited about what she does. *Participant 19*

In this excerpt, the participant described differentiating herself through confident interactions and behavior which could also demonstrate an excitement towards a company or a particular type of work. This confidence was described as relevant in general interactions in job acquisition settings as well as when describing specific experiences in these contexts.

4.2.1.2.3   Level 3: Connections

At the Connections level, participants described moving beyond presenting themselves to others in a single encounter and described using interactions to build relationships and connections. Participants described these connections as beneficial for both acquiring a job and advancing in a career. As illustrated in one segment:

> The main thing about professional development is just the connections that you make, whether that be your peers if you're at school, your teachers or just whoever you, even like Ph.D. students. It's the people or the connections that you make now that can make a difference later. So you're building that network and like that's part of the whole professional development, is having that social ability to build that network to further along your professional career in the future. *Participant 10*

In this excerpt, the participant described the value of building relationships and making connections for progressing in a career. Connections had the potential to lead to new opportunities in either the short term or the long term. As a result, they were an important and continual component in professional development. To make and maintain these beneficial connections, participants described the need to continue to talk to others, search for opportunities, be open to new connections, and keep in touch with people, as described in the following excerpt:

> I think networking is important because you have to under--, like you have to be able to make a connection. […] But like it's so important to like make those little connections, so you can be like, oh I'm connected to this, I'm connected to this. And eventually, like there's people who I know, my um team member, he was at a gas station, working at a gas station with cars, and his next boss like drove up. And they were just talking about the cars. And then it just spurred into, um, what jobs he's had, you know. And that was his boss. Like he was like "alright, do you want to come work for me?" […] But it's just that short period of time where he was able to make a connection with someone, um give

them, have a good impression on them, and then talk to them in a way that was able, like

in a way that advanced the conversation, you know. So I've learned that that's super

important as well. Um, not just like being able to talk to someone, but making the

conversations meaningful. And being able to make those connections. *Participant 17*

This excerpt highlights the importance of continuously making connections in a variety of contexts. Several participants described situations where they, or friends of theirs, acquired a job through a connection. Because of the potential opportunities available through connections, participants described the need to not only present themselves in structured job acquisition settings such as career fairs, but to work to develop meaningful connections and relationships. Because participants had to move beyond presenting themselves and seek out opportunities to build and maintain relationships, these connections were more internalized.

4.2.2   Job Performance Domain

The second domain of participants' descriptions of professional development was Job Performance (Figure 7). This domain included skills and content necessary in the engineering workplace, and the categories were grouped into two subdomains: 1) the content of engineering work and 2) the skills involved in engineering work. The content subdomain related to the specific subject matter and expertise that participants perceived as relevant in their future jobs, while the skills subdomain included skills necessary not only to complete the technical work, but also to interact in a workplace environment more broadly.
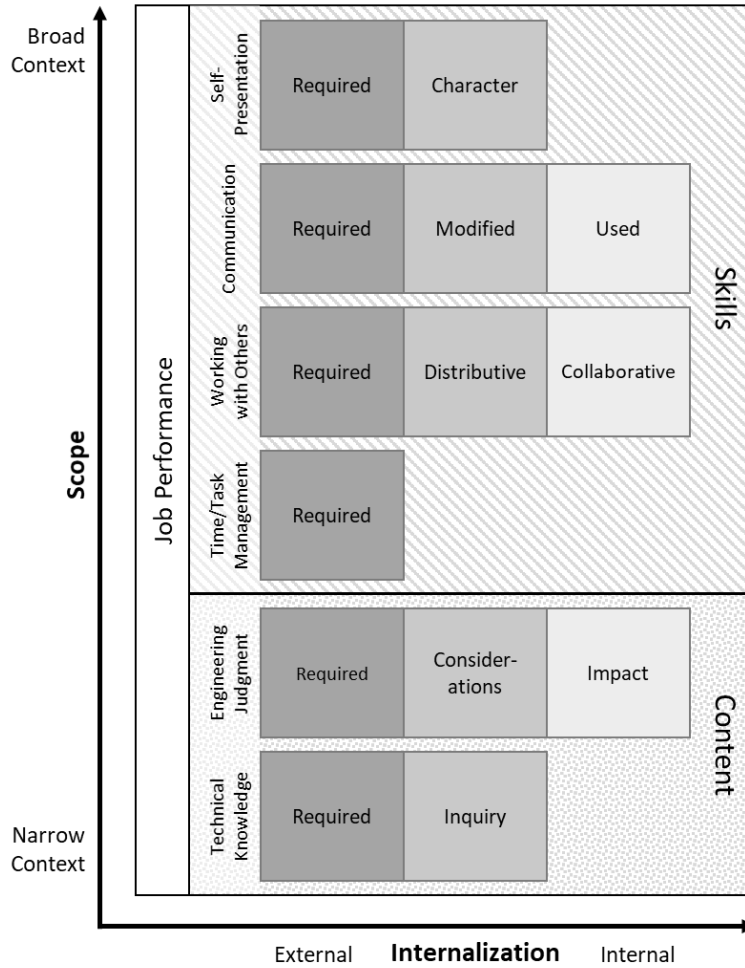
Figure 7. Job Performance domain

4.2.2.1   Content related to Job Performance

The first subdomain within Job Performance included categories corresponding to the content necessary in technical engineering work. The content described by participants included both the technical knowledge necessary and the engineering judgment involved in technical solutions (Figure 8).
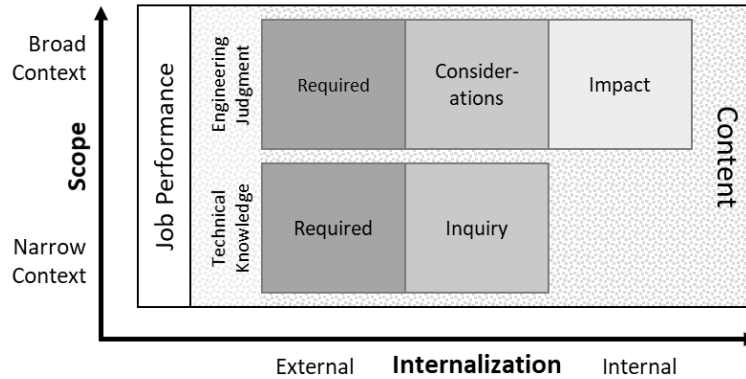
Figure 8. Content subdomain in Job Performance domain

The Technical Knowledge category related to specific content and subject areas that participants described as necessary or beneficial in engineering work. The Engineering Judgment category related to aspects and considerations that influenced and affected the technical work as well as the impact of engineering work and solutions. Engineering Judgment was described as moving beyond technical calculations and included consideration of elements that influence technical work as well as consideration of the impact of technical solutions.

4.2.2.1.1 Technical Knowledge

The category with the narrowest scope in the Content subdomain was Technical Knowledge. Participants described particular content areas as being necessary in engineering workplace contexts. Technical knowledge included content and expertise directly related to a specific area in engineering.

At an external level (Required), participants described the requirement to possess certain technical knowledge in workplace settings. This requirement was described as externally imposed and necessary to effectively perform engineering work. At an intermediate level (Inquiry), participants described an awareness of the limits of their own knowledge and a need for knowledge inquiry. Participants acknowledged that they would not always have the appropriate technical knowledge or know the appropriate steps to take. In these instances, participants described the need to ask for information and seek help from others. This category consisted of only two levels and an internalized level was not identified in women's descriptions of professional development.

4.2.2.1.1.1 Level 1: Required

At the Required level, participants described the importance of having a base of technical knowledge in an engineering profession. This knowledge was described as a requirement for engineers and therefore was externally imposed. As described in one segment, companies want engineers to enter positions with a certain amount of base knowledge:

Participant 22:	[Companies] don't want to have to teach you everything. And it's always a learning experience and you're always going to learn something new in a new job. But they don't want to teach you everything. Which is why you go to school to get an education.
Interviewer:	Are there any kind of things in particular that you think is, like companies are wanting you to go in with those aspects?
Participant 22:	[…] I think some of the important things are just like basic coding skills. Um because I think most, most engineering majors have to take a coding class at some point. […] Uh you're--, most engineers are going to need to know how to use a circuit board, how to make a circuit, and the foundations of circuits. Um basic, how basic electronics work. Um cuz I guess engineering in itself is just making things, so you're going to need to know how things work. If that makes any sense. Um a manufacturing job might need, you might need experience working on machines. Um different kind of cutting machines or like conveyor belt machines, yeah. It's so broad. I don't know how to list everything. The design process, knowing how the design process works. That's definitely an important one.

This excerpt illustrates participants' perceptions of the external expectations that engineers develop a foundation of technical content knowledge in engineering workplace environments. Different positions and fields may require specific expertise and knowledge, but engineers were described as being required to have a technical foundation including competencies such as coding, design, and electronics.

4.2.2.1.1.2 Level 2: Inquiry

At the Inquiry level, participants described understanding the limits of their technical knowledge and the need to ask for help. In these instances, participants described the need for knowledge inquiry. This awareness of the need to seek help and the willingness to inquire in those situations demonstrated a deeper and more internalized understanding of the technical knowledge in engineering workplace settings.

As one segment illustrated, part of being professional was being "willing to ask for any help that would be necessary to get the job done" (Participant 5). This participant elaborated on the ability to ask for help when reflecting on an internship experience:

> I had to be able to get up and go to another cubicle and talk with somebody, know what I wanted to say, and articulate it well. I couldn't kind of just skirt around the question. If I said "I need to know how to organize these ships on this excel sheet, how do I do that?" And they could come around and do that with me. That I had to be sure to ask things in a way that I knew what I was doing but I was also not afraid to ask for help." *Participant 5*

This quote highlights the importance of being able to inquire about necessary technical knowledge when the particular expertise was lacking.

An additional component of this inquiry was an awareness of who to go to for help. Participants stated that it was important and helpful to know who would be able to assist in different situations and who was an appropriate person to ask for help, as illustrated in the following segment:

> [Professional development involves being able to] understand […] how like mutual things can build like a professional relationship. Cuz like when you get older, you're kind of like, "oh, like who can I go to?" And like knowing that this person would help me, this person won't help me, is really helpful. […] Like when you enter a professional environment, like I can talk to--, can I talk to my boss about this or should I go to a different person who's higher up and talk about this cuz it's, cuz like is it under his range? Or is it someone else's range? I think that's like important. *Participant 8*

This excerpt illustrates the importance of knowing who can both help when assistance is needed and who is appropriate to go to for help, whether that is a boss, co-worker, or another person in

the company. In the instances where participants described inquiry, the women demonstrated an increased awareness that their technical expertise in future workplace settings would have limits and would continue to expand beyond school.

4.2.2.1.2 Engineering Judgment

The category with broader scope in the Content subdomain was Engineering Judgment. In contrast to Technical Knowledge, which pertained to specific subject matter, Engineering Judgment included broader aspects of engineering problems beyond the technical content, such as initial considerations affecting the direction of the technical design as well as impacts resulting from a technical solution.

At an external level (Required), participants described imposed requirements affecting technical engineering work, including the goals and interests of clients. At an intermediate level (Considerations), participants described a variety of considerations that impact engineering work, including diverse perspectives, diverse needs, and ethics. These considerations were broader than requirements imposed by external entities and included considerations internal to the participant, such as their own ethics and morals, as well as considerations of the needs and perspectives of others. At an internalized level (Impact), participants described an awareness of the impact that engineering solutions have on others, highlighting a deeper understanding of the role of engineering solutions in larger communities.

4.2.2.1.2.1 Level 1: Required

At the Required level, participants described the role of requirements and judgment imposed by external sources, such as clients. When discussing imposed requirements, participants viewed engineers as being required to meet the needs of those for whom they are working. These requirements were described as absolute and originating from an external source. As an example, one excerpt demonstrates the need to meet the client's specifications when solving engineering problems:

> Maybe the reason like professional development is such a big deal to engineers is like, I know a lot of us, at least me personally, we're introverted. And so like we've always been good at doing something. And so we do our thing and like solve a problem, that's done. Except it's not just for us anymore. It's for the client. And so we have to communicate that to the client. We have to do it for the client. We have to do it to the client's

specifications. And so it's like, professional development also reminds you that you're not alone in the problem solving world anymore. *Participant 15*

This excerpt demonstrates the perception that engineers design solutions that must meet the requirements imposed by others, and the client – not the engineer – determines the specifications. As with other level 1 categories, this required judgment was imposed by others.

4.2.2.1.2.2 Level 2: Considerations

In the Considerations level, participants described additional considerations involved in engineering solutions beyond those imposed by an external entity (as in the Required level) that must be acknowledged and accounted for in engineering designs and solutions.

Examples of considerations that participants discussed included economic considerations, considerations of diverse perspectives, and ethical considerations. Examples of these considerations are included in Table 9.

Table 9. Considerations of engineering problems described by participants

Consideration	Example Quote
Economic	You also have to understand the financial side of things so that you can understand when you're losing money and what to do to stop that. And that's very important because I know as engineers, a lot of times people don't think about like how much money they need to save. And like they don't care, they just want to build things. And that can't happen because otherwise you're just going to run out of, run out of money and the company is going to go bankrupt. *Participant 21*
Diverse Perspectives	You're just like you're trying to develop yourself more. […] Cuz like having a diverse perspective is good. And like not, like being able to think about more than one factor … from your experiences. Um like I definitely think about stuff more globally now with [study abroad program]. *Participant 9*
	That's one thing that they keep harping on in a lot of our, your intro to your major courses, or just intro to engineering courses, is that a big part of the work world is not just "okay, here's a bunch of problems, do the math to it, build a bridge." It's, you have to think about not just that, but also […] all the people's different, uh different perspectives, and take them all into consideration when working. *Participant 14*
Ethical	Ethics. I guess that would fall under professional development. Um we talked a lot about that in all of our intro to engineering, like the intro to general engineering. And then now intro to civil engineering. Um in all of those courses, we've talked a lot about the code of ethics and um how to deal with ethical issues and just keep in mind that, or just keep that in the back of our minds at all times. Um because that's definitely an important part of succeeding professionally, is having a good reputation and um having good intentions. *Participant 13*

In these examples, participants described multiple factors that must be considered beyond the externally imposed requirements of the customer or client. These considerations, which included

perspectives of the participant as well as perspectives from others, demonstrated a broader and more internalized understanding of the factors that affect engineering designs and solutions beyond the requirements described in the Required level.

4.2.2.1.2.3 Level 3: Impact

In the Impact level, participants described an understanding of their own role in engineering designs and the impact that engineering solutions have on society. In both the Required and Considerations levels, participants described considerations that influence engineering designs. But in the Impact level, participants described the role that engineers play in making decisions based on those considerations, as illustrated in the following excerpt:

> In classes, we've talked a lot about, just examples of different common problems that engineers do face, and how it's not just black and white, like ethical and non-ethical. There are a lot of tricky situations that require a lot of judgment. Um which I guess I didn't have much experience, or no one had really talked to me about that before coming into engineering, um that a lot of judgment goes into engineering. Like it's not all math and science and like correct and incorrect. A lot of it is, okay, like money and safety and the employ-, like what the employer wants and what society needs and like what your company wants, and what your, you know, all of that. Um and how it gets really, really complicated. Um we hadn't, I hadn't really been exposed to all of those sorts of problems. *Participant 13*

This excerpt demonstrates the perception that engineers must take into account a variety of considerations and use their judgment to make a decision based on those considerations. These decisions and engineering work, then, impact companies, people, and larger societies. As illustrated in one segment, engineering designs impact the company that makes a particular product and anyone who may use that particular product or design:

> [Professional development involves] realizing that your work not only affects you, but could affect the whole company and a whole corporation and all the people that, let's say like if you're building a part, and that part is faulty, and then it affects tons of products. All--, also taking into consideration all your work also affects all the consumers and how large of a, I guess like span that what your work will do, how many people it will reach. *Participant 14*

These excerpts highlight a more internalized understanding of the role that engineers have in broader societies. In these excerpts, participants acknowledged that engineers make decisions based on a variety of considerations, and those decisions impact those who make the product as well as those who use the product.

4.2.2.2   Skills related to Job Performance

The second subdomain within Job Performance included categories of skills necessary to successfully operate in an engineering workplace. The skills described by participants included Time and Task Management, Working with Others, Communication, and Self-Presentation (Figure 9).
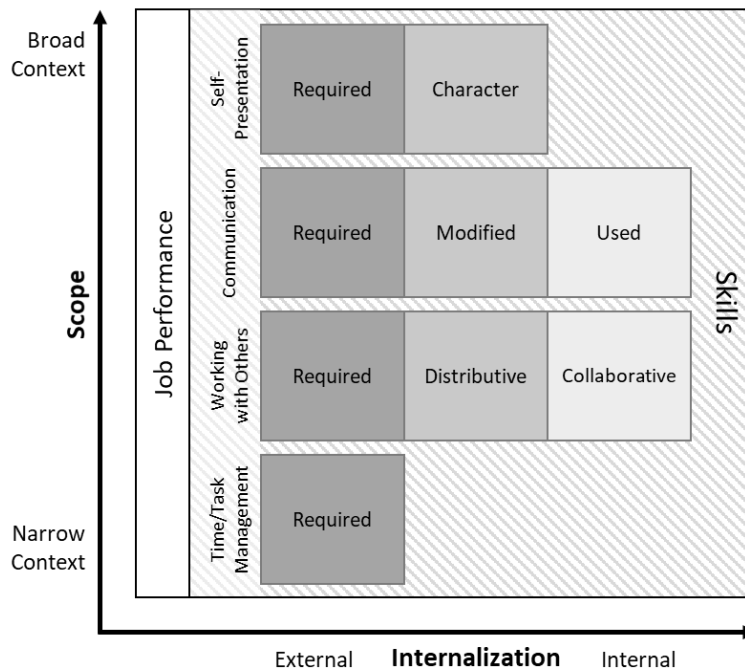
Figure 9. Skills subdomain in Job Performance domain

The Time and Task Management category has the narrowest context because it focuses on managing individual responsibilities. Working with Others is broader in scope as participants described the importance of this skill in collaborative problem solving contexts. Descriptions of professional development in the Communication category were applicable in not only problem solving contexts but also more broadly across workplace interactions with co-workers. Self-presentation has the broadest scope in that these practices were described as applicable across all work contexts in the work environment.

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4.2.2.2.1 Time and Task Management

As noted, the category with the narrowest scope in the Skills subdomain is Time and Task Management. Time and Task Management was described as a required skill in order to complete the necessary work and meet imposed deadlines. Because this skill was described as pertaining to individuals and was primarily relevant in contexts where domain-specific knowledge is applied, this category has the narrowest scope.

Unlike other categories, the Time and Task Management category consisted of only one level. Participants described time and task management as a requirement of an engineering job that involved being able to meet deadlines, plan and schedule their own time, and complete tasks that were assigned. In engineering workplace settings, participants stated that they needed to balance their individual workload and be able to complete the requirements provided by external sources. The following excerpt illustrates this perceived need:

Interviewer: […] So you mentioned this idea of kind of being on top of things. Um could you expand on that idea a little bit?

Participant 18: I guess what I mean by being on top of things um, when somebody gives you a task um, to do it and to turn it in on time. I know um time is a huge thing in the business world. And being prompt um, to your job, with assignments that's given to you, um maybe with like conference calls or things just like that. Um just being on top of it and um really balancing your time so that you do, you do take care of everything that needs to be taken care of.

Because participants described being able to manage their own tasks in response to imposed deadlines, this level was external. Despite the potential for other levels, such as prioritizing tasks or setting individual priorities, participants did not describe these more internalized approaches to Time and Task Management.

4.2.2.2.2 Working with Others

The second category in the Skills subdomain of Job Performance was Working with Others. Similar to Time and Task Management, participants described working with others as an important skill in contexts where domain-specific knowledge is applied. This skill, however, was

broader in scope because working with others involved not only individual tasks but also tasks and contexts where multiple people worked together.

At an external level (Required), participants described working with others as a requirement in the engineering profession as defined by an external source such as a recruiter or an instructor. In the intermediate and internalized levels (Distributive and Collaborative levels), participants perceived working with others not only as a requirement but as a useful skill in developing solutions to complex problems. However, the Distributive and Collaborative levels differed in the approaches described. In the intermediate level (Distributive), participants described distributing work among individual team members in engineering job contexts and then combining ideas and pieces into a final solution. In this level, participants described each person on a team as having a role on the project where the final solution was a summation of efforts. In the internalized level (Collaborative), participants described team members as working together to generate new ideas collaboratively. In this collaboration, working with others was not solely a combination of efforts; it was necessary to generate new and better solutions that were more than a summation of efforts.

4.2.2.2.2.1 Level 1: Required

At a Required level, participants described working with others as a required part of engineering positions. Working with others was described as "something that [was] going to come eventually, because it is inevitable" (Participant 16), because engineers "never work alone" (Participant 15). These excerpts illustrate the perception that engineers are externally required to work with others in the profession. As a result, learning how to work with others was described as a necessary part of professional development.

In some instances, participants described the requirement to work with people who were in different disciplines or fields. As illustrated in the following excerpt, some participants perceived that engineers are required to work with people in different specializations:

> I think like especially as an engineer, you're never going to be like working on your own. Like you always have to work with people who like have other specializations or other majors and backgrounds, working with like people in business like who maybe don't understand the technical side as much. And being able to like still work together and kind of like accomplish your goals. Um and working with people who are, maybe you don't

like so much or that you disagree with or just are like different from you. That's always going to have to be something you're going to have to do. So that's really important.
Participant 25

This excerpt highlights the perception that engineers are required to work with people who have different disciplinary backgrounds or have differing views. In contrast to more internalized levels (described below), this required view of working with others, including those with different backgrounds, was not described as adding value or leading to better solutions. It is just "something you're going to have to do."

4.2.2.2.2.2 Level 2: Distributive

In the Distributive level, participants viewed working with others as not only a requirement, but as a skill that could be used to distribute the work and combine efforts and ideas, which was a more internalized level. Segments in this category described the importance of learning to work with others where everyone had a role and "everyone's doing what they need to do, um, to get the overall goal" (Participant 18). These distributive descriptions of working with others were similar to a "divide-and-conquer" approach where each group member contributed their part and the final group product was a summation, or combination, of the individual parts, as illustrated in the following excerpt:

[Working with others is] how you get the work done, is with other people. And so if I want to achieve something, I need to like communicate what my part is going to be, like what our vision is for the overall project. How we can split it up. How we can work together. Because like no one person just writes code. Like people work together and they um combine their efforts. Because there's people, like if I'm just doing front-end stuff, like you can't have a front-end without a back-end. So someone's going to have to do that.
Participant 15

This excerpt highlights the perception that engineering work is completed by splitting up the work and ensuring that everyone does their part. The final product, then, is a combination of multiple people's efforts. In this distributive view of working with others, participants described the importance of working with others in order to meet the goals set by others.

4.2.2.2.2.3 Level 3: Collaborative

In the Collaborative level, participants described working with others collaboratively to generate new or better ideas. This collaboration moved beyond a basic requirement (Required level) and beyond a tool for combining efforts (Distributive level) to emphasize bringing together diverse perspectives to create something new or different. This creation of something that is more than just the sum of individual parts differentiated the Distributive and Collaborative levels. For example, one segment detailed the importance of avoiding the "go fix it attitude" that engineers often have when working in international contexts and instead "actually [work] with the people who are there and like [talk] with them and [get] their knowledge and like their help on the project. Like overall it becomes a better result." (Participant 23). This excerpt highlights the benefit of collaborating with others who have a differing view to create a better solution that is more than the summation of individual efforts. This collaboration involved incorporating diverse views and perspectives to create better solutions.

4.2.2.2.3 Communication

The third category in the Skills subdomain was Communication. Similar to the Working with Others category, communication was described as an important skill in contexts where domain-specific knowledge is applied. However, participants also described communication as an important skill in broader contexts within the workplace such as in interactions with co-workers.

At an external level (Required), participants described communication as a required skill imposed or introduced by an external source, such as a recruiter or an instructor. The intermediate and internalized levels (Modified and Used levels) moved beyond an external requirement imposed by others to a skill that could help achieve a particular goal. However, these levels differed in the origin of the goal. In the intermediate level (Modified level), participants described communication as a skill that could to be modified depending on the context or audience to meet the goals of others. In the internalized level (Used level), participants described communication as a skill that can be used to meet their own goals or needs, reflecting a greater degree of internalization.

4.2.2.2.3.1 Level 1: Required

At the Required level, participants described communication as a necessary and required skill in engineering. This external level of communication was similar to the external level of working

with others because both were required by employers in the engineering profession, as illustrated in the following excerpt:

> The communication part, um … is so important […] so we can communicate with everyone that we're working with once we have the job, um, which is very important. And then specifically within engineering, um it's been stressed to us a lot that companies are looking for um engineers who can communicate, because we're often lacking in that field in general. Um and so that's why that's most important, it seems to me. *Participant 13*

As this excerpt highlights, the ability to communicate was perceived as a requirement by engineering employers. The importance of communication, in particular, was emphasized because participants perceived engineers as typically lacking communications skills.

In addition to talking about communication broadly, participants talked about the requirement to use various modes of communication, such as reports and presentations, in performing engineering work. As one participant explained:

> The communications aspect of [engineering] is super important because again you're going to have to make presentations, you're going to have to communicate with your boss, um with your colleagues, with your project teams, um … And especially when you're working in a team, communication is super important. *Participant 22*

This excerpt highlights the perception that a part of professional development is learning how to use various modes of communication, such as reports and presentations, because these forms of communication are required in the engineering profession. This excerpt also highlights the idea that communication is applicable in contexts where technical knowledge is applied, such as when working with a team on a project, and in broader contexts such as interactions with colleagues.

Importantly, when describing communication as an external requirement, participants did not describe potential uses for the communication. Instead, they described communication as a skill needed to complete the necessary work, paralleling the requirement to work in teams. Both were described as skills that employers were looking for in engineers and therefore was an external requirement.

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4.2.2.2.3.2 Level 2: Modified

In the Modified and Used levels, communication was described as not only a requirement but a skill that could help achieve a particular purpose. The Modified level focused on tailoring communication to meet the needs and goals of others. In the Used level (discussed below), communication could be adapted to meet the needs of the participant.

In communication that was modified, participants described adjusting communication to the audience or context to meet the needs of others. Modifications included being able to "talk about [engineering concepts] with people who are maybe in other specializations or like majors that maybe don't understand all the technical stuff" (Participant 25). Similarly, participants described the need to modify how information is displayed and represented, for example during presentations, to make information easier to understand for diverse audiences, as illustrated in the following segment:

> So [clients] have a problem, and a lot of times like the client themselves can't, like they can't fix it. So they're coming to you because you have technical expertise. And sometimes you'll have an idea but like you can't just describe it in words. So you want to have like data visualization so you can like make sure everyone is on the same page. And so you can describe it with numbers, you can describe it with pictures. So you have different types of learners and they're like learning. Um you can make sure that everyone's like on the same page of stuff. And also it makes like the large datasets a lot easier to understand. *Participant 20*

This excerpt illustrates the need to not only communicate through various formats (as was described in the Required level), but also to modify and adjust the material being communicated so that the those with different backgrounds, such as clients, could more easily understand it.

4.2.2.2.3.3 Level 3: Used

In the Used level, participants described using communication skills to meet their own goals as an engineer, rather than the needs of those being communicated to, suggesting a more internalized view of communication. Thus, segments in the Used level describe communication as a tool that is helpful when negotiating between groups that have differing priorities or when convincing others to adopt a particular idea. For example, one participant was interested in

pursuing a career in alternative energy sources and described the importance of using communication to gain public acceptance:

> I feel like being able to talk to people will be really important because one of the biggest restrictions with changing sources of energy is public acceptance. And I know that that's been a big thing in the past. Like I know like solar panels and wind turbines and things like that, a lot of people think they're so ugly. And so like that's something that, you know, it is, it is a possibility of being our future. I mean with a lot of improvements to them. But um, so like being able to talk to the public and convincing them that, hey this is a good thing, will also be an important thing. And I think that's where like public speaking will come in handy, and being able to make those promotions to the public will be another big thing that will be important. *Participant 16*

In this excerpt, the participant described a desire to implement alternative energy sources and viewed communication as a helpful tool in achieving that goal.

4.2.2.2.4   Self-Presentation

The fourth category in the Skills subdomain was Self-Presentation. This skill was the broadest skill described by participants in the Job Performance domain. Similar to communication, participants described the relevance of self-presentation in broad contexts in the engineering workplace. The Self-Presentation category also included descriptions of character, which were relevant in all contexts within the work environment.

In this category, participants described the need to present themselves appropriately in professional workplace settings. At an external level (Required), participants described the need to present an appropriate appearance in workplace settings based on the culture and environment of the workplace, and participants often described the need to understand the required appearance as well as the required behaviors in workplace settings. At an intermediate level (Character), participants described not only behaving appropriately but demonstrating specific character traits through interactions in a workplace environment, reflecting a more internalized perspective of Self-Presentation.

4.2.2.2.4.1 Level 1: Required

At the Required level, Self-Presentation, as a part of Job Performance, related to appropriate and required appearance and behavior in a work setting. This level was similar to the Required level in the Interactions category in the Job Acquisition domain. While the required behaviors and appearances in the Job Acquisition domain pertained to situations where participants were seeking employment, the Required level within the Self-Presentation category was described as necessary when working as an engineer.

Participants described the need to know acceptable appearance, primarily "what's appropriate to wear" (Participant 20), taking into account the environment of the workplace. They also described learning appropriate ways to behave in workplace settings as being a part of professional development, including knowing how to interact in professional settings (Participant 23), knowing proper etiquettes (Participant 18), and "learning a new way to act" (Participant 15). For example, in the following segment, the participant described the proper etiquette required in a workplace setting, stating that:

> […] what that looks like is like, um eye-contact, uh making sure that you are listening, um maybe relaying the information back. Um … when somebody tells you to do something, um make sure that it is on time. Um and just like the small things like, like that. I think that is very professional. *Participant 23*

As this excerpt suggests, these required appearances and behaviors were dictated by the formality of the workplace environment and were externally imposed behaviors that students were required to learn.

4.2.2.2.4.2 Level 2: Character

In the Character level, participants described the benefit of and need to display certain character traits – including being confident, respectful, kind, and hard-working – in engineering workplace contexts. Because these character traits move beyond surface behavior, this level of Self-Presentation is a more internalized level. Examples of character traits discussed by participants are included in Table 10.

Table 10. Examples of character traits described by participants as important in a workplace setting

Character Trait	Example Quote
Confidence	I think it goes back to communicating and um feeling confident about yourself so that other people will want to be around that. *Participant 18*
Respect	Professionalism is like a way you act to a client and how you act to the people who are also in your field. It's like everyone wants to be respected. And so it's like definitely putting respect as the forefront. But there are other things, like in order to be respected you have to give respect yourself. *Participant 15*
	Professional development, like you have to learn to respect other people's ideas because a lot of times you won't agree in a real-life setting. *Participant 14*
Kindness	Being cordial and being kind. Um because it's the little things that people like really noticed about somebody's character. *Participant 18*
Hard-Working	Always keep your work ethic high, always work your hardest, and that way like everyone around you can see that you're working hard. And so wherever you do want to go in the future, then you can get there because you continuously worked hard. *Participant 19*

These traits were described as characteristics that were important to the participant and would create respectful environments where others would want to work with them.

This level of Self-Presentation parallels the Confident Interactions level in the Job Acquisition domain. In both levels, participants described the importance of being confident in engineering environments, both when applying for a job and once in a job. Whereas Confident Interactions pertained to presenting oneself confidently when applying for a job, the Confidence in Self-Presentation pertained to more sustained confidence in workplace settings.

4.2.3   Personal Development Domain

The third domain of participants' descriptions of professional development is Personal Development (Figure 10). While participants' descriptions of the Job Acquisition and Job

Performance domains were relevant to specific workplace settings, categories in Professional Development, while relevant in these workplace settings, extend to broader contexts outside of work. This domain consists of two categories: Career Choice and Lifelong Learning. With respect to Career Choice, participants described exploring possible career paths and pursuing individual interests in their career. This navigation of career choice is broader in scope than categories in the job acquisition and job performance domains because students described exploring their individual interests to understand the type of work and the work environments that they enjoyed as opposed to merely adapting themselves to a given context. Even more broadly, the Lifelong Learning category included descriptions of continued improvement and self-awareness relevant in many contexts in participants' lives, only one of which was professional. Because this lifelong learning was not limited to a workplace setting, it forms the broadest category in participants' descriptions of professional development.
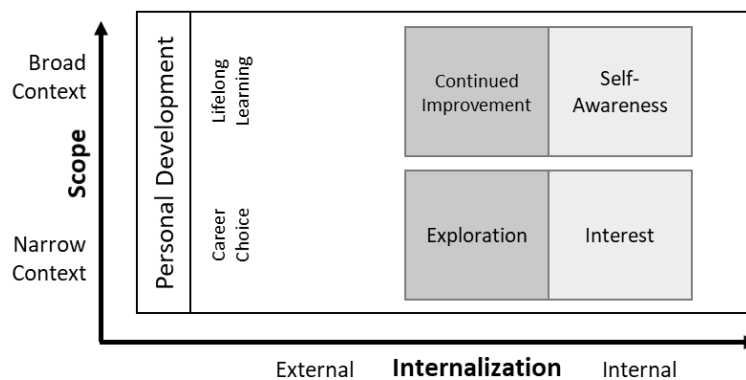
Figure 10. Personal Development domain

As with other domains, the two categories within the Personal Development domain consist of multiple levels that increase in internalization. However, in contrast to other domains, both categories consist of only two levels each and there is no external level. The more external level is not an externally imposed requirement but is rather a more prescriptive description of steps to take. The more internalized level, in contrast, is more individualized and relates directly to participants' individual interests, goals, strengths, and weaknesses. Each category, and the levels within each, are described below.

4.2.3.1 Career Choice

The first category in the Personal Development domain was Career Choice. Segments in this category described the benefit of exploring personal interests to identify a career path that aligned with those interests. Thus, while categories in the job performance domain were specific to one workplace context, the career choice category involved exploring multiple workplace settings to identify the one(s) most interesting to the individual participant.

The Career Choice category consists of two levels: an intermediate level and an internalized level. There is no external level in this category. At an intermediate level (Exploration), participants described gaining a variety of experiences to explore different career options and paths available in engineering. This level was often described as a prescriptive, or trial-and-error, approach of gaining experiences such as internships and research experience. Through these different experiences, participants could determine what they liked and did not like in order to narrow down career possibilities. Because this exploration was described as beneficial for exploring personal interests, this level was an intermediate level. At an internal level (Interest), in contrast, participants described developing an individual interest or passion when making a career choice. Participants also described the importance of liking their career choice because of the percentage of one's life spent at work. This interest and passion was specific to the individual participant and was an internalized view of Career Choice.

4.2.3.1.1 Level 2: Exploration

In the Exploration level, participants described steps for exploring career options in order to determine what careers they were interested in pursuing. This exploration included gaining a variety of experiences during their undergraduate education to better identify their career interests. As illustrated in one segment, the participant described wanting to gain internship experience "because different experiences just give you a whole like set of, I do want to do this, or no I don't want to do that" (Participant 20). As another segment highlighted, it was important to "work for as many companies as you can [during college] because […] you will know exactly what you want to do" (Participant 24). These excerpts demonstrate the importance placed on gaining experiences to help explore career options available after graduating from an engineering program.

Notable, however, is that these descriptions of gaining experiences for career exploration were predominately a trial-and-error approach. Participants stated that the more diverse experiences they had, the more they would understand what they did and did not enjoy, suggesting that they were using external inputs to help define their goals.

4.2.3.1.2 Level 3: Interest

At an internalized level, participants described the importance of not only exploring career options but also pursuing a personal interest or passion for a particular field. As one segment illustrates:

> [Professional development is] important because this is your whole life. And it better be something that you really want to do. Um and if you're gonna--, if it's something that you really want to do and that you enjoy, it should be--, you should try to be the best at it that you can. And all of it kind of builds up to [your career]. *Participant 22*

As this excerpt illustrates, participants described a career as a long-term choice. Because of the time spent in a career, participants stated that it was important to identify a career that they were excited and passionate about. This interest, then, could serve as a foundation for future development. As one participant explained, the other aspects of professional development are "all for nothing if I don't have like the basis of like what I actually want to do in my professional career" (Participant 17). These interests, then, were also described as beneficial in identifying additional professional development that aligned with and supported those interests.

4.2.3.2 Lifelong Learning

The second category in the Personal Development domain was Lifelong Learning. Segments in this category described the role of lifelong learning in a wide variety of contexts, including professional, academic, and personal. Due to the range of contexts in which participants described lifelong learning, this category was the broadest in scope of the categories identified in the PD^2 Model.

Similar to the Career Choice category, the Lifelong Learning category consists of two levels. At a more external level (Continued Improvement), participants described the need to continually improve, whether that is in a work setting or in other areas of their lives. Because this level was more generic, it was the most external level in the lifelong learning category. At an internalized

level (Self-Awareness), participants described the importance of a self-awareness of their own strengths and weaknesses, pointing to an internalized understanding of their own development. This category did not have an external level.

4.2.3.2.1 Level 2: Continued Improvement

In the Continued Improvement level, participants described the need to continually learn and improve, both in engineering careers and in situations more broadly. As one segment illustrates, engineers must continually learn and develop professionally throughout their career:

> I'm learning as much as I can right now and I'll learn more in the future. And hopefully, like I'll just continue to develop as a professional throughout my entire career. I feel like you can't really like learn all you need to know about professional development. I feel like there's always more to learn. *Participant 23*

This excerpt illustrates the idea that an engineering education cannot provide students with all of the knowledge and skills necessary in an engineering profession. It is necessary for engineers to continue to learn and develop throughout a career.

In addition to describing this continued improvement necessary in a workplace setting, participants described continued learning in all aspects of their life, which could then be translated to a professional setting. For example, one participant stated:

> Everything I do is a learning thing. Like whatever I do wrong I can learn from it next time. So I think anything that I do wrong, anything I do right, like it's something I'm learning from. And that can move you into [a] professional environment in any sense. *Participant 8*

In this excerpt, continued improvement was not limited to a workplace setting. Instead, it was a broader aspect of personal development that could be translated to a workplace setting but was not limited to that context. And this continued improvement was based in women's individual experiences and was based on individual needs. So while the idea of continued improvement may be externally imposed by instructors or employers, the improvements necessary were individualized. This level, then, was an intermediate level in the PD^2 Model.

4.2.3.2.2 Level 3: Self-Awareness

In the Self-Awareness level, participants described the importance of self-awareness, which was an understanding of individual strengths and weaknesses and an identification of areas that could be improved upon in lifelong learning.

In some instances, this self-awareness related to other aspects of professional development, such as being aware of their own communication abilities. But often, this self-awareness was more general and related to a better understanding of themselves. For example, one segment described self-awareness as "being able to identify your own strengths and weaknesses, […] knowing what you need to do to improve yourself, […] [and] recognizing what steps you need to take to get to that professionalism that you want to reach" (Participant 16). While some participants connected this self-awareness to particular skills, such as public speaking skills, some students described it as a broader understanding and knowledge of themselves.

4.3   Summary of the PD^2 Model

The PD^2 Model captures the categories of professional development described by women engineering students after participating in an engineering LLC. Domains of professional development, and categories within each, range in scope from narrow to broad contexts. Levels within each category range from externally imposed requirements to internalized approaches that meet personal goals. Combined, this model captures the scope and depth of women's views of professional development in engineering (Figure 11).
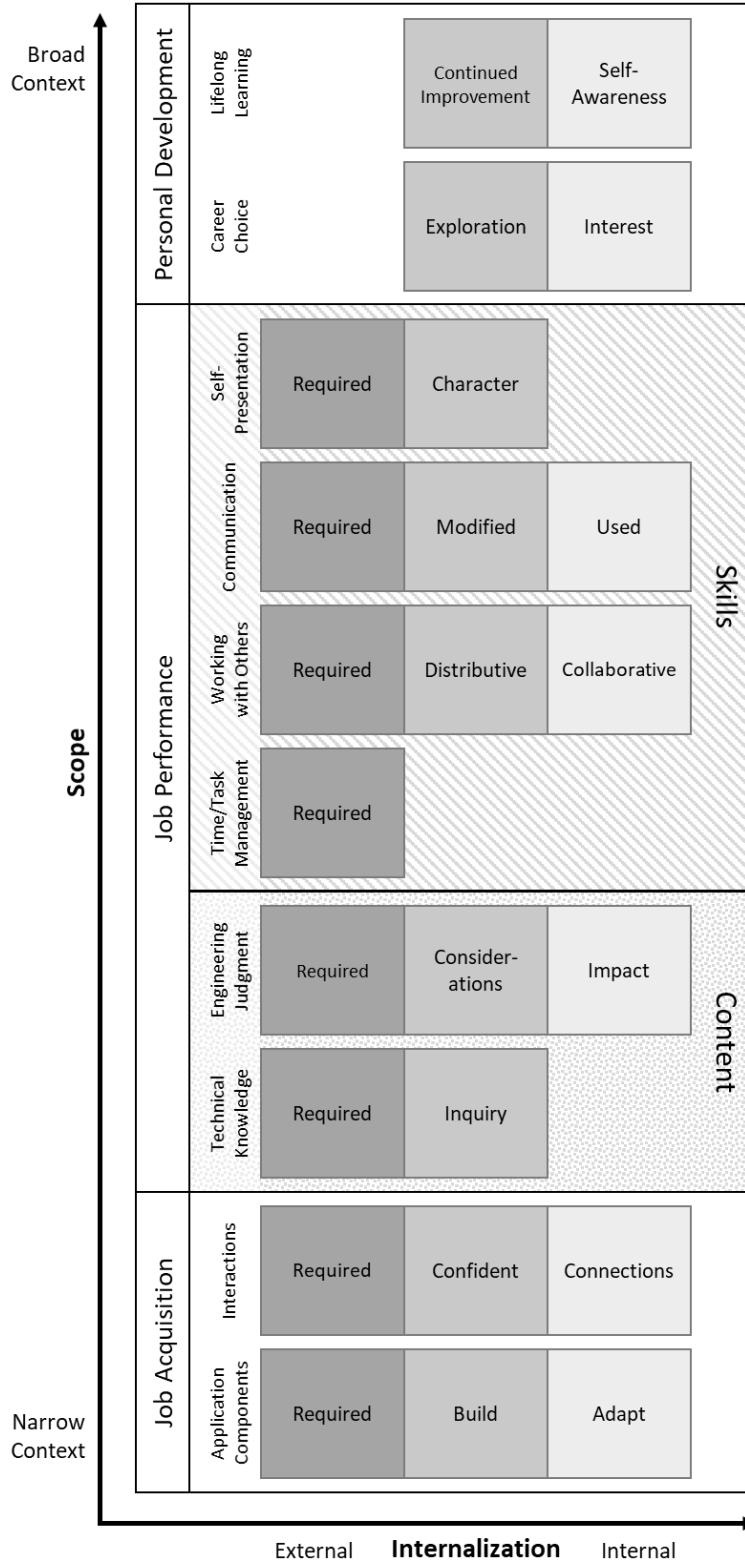
Figure 11. PD² Model

<h2>Chapter 5: Beneficial Professional Development Experiences</h2>

5.1 Introduction

As described in Chapter 4, women's descriptions of professional development included a variety of competencies that grouped into three domains of professional development: Job Acquisition, Job Performance, and Professional Development. These descriptions are depicted in the PD^2 Model. In addition to describing professional development, participants described beneficial experiences that supported their professional development within the context of a living-learning community (LLC) for women in engineering. These descriptions of beneficial experience were analyzed to address my second research question: What features of experiences within an LLC for women in engineering do these women perceive as contributing to their professional development? The results of this analysis are captured in the LEEPD (Learning Experiences for Engineering Professional Development) Model, which identifies five features of beneficial experiences described by women. These features were described in a variety of combinations to create beneficial experiences for students. The LEEPD Model focuses on features, rather than specific experiences within the LLC, to facilitate the transferability of these results to other contexts.

This chapter provides an overview of the features of beneficial professional development experiences for women in engineering in the LEEPD Model. In addition to describing the LEEPD Model, this chapter provides specific examples of beneficial experiences within WIE-LLC. Specific examples are provided to demonstrate the flexibility of these features and how they can be combined to create a variety of beneficial learning experiences. This chapter also combines the results from RQ1 and RQ2 to demonstrate how features and experiences can align with and support students' professional development within the three domains of professional development identified in the PD^2 Model.

5.2 LEEPD Model

The living-learning community incorporated a variety of activities and experiences, and participants described experiences that they believed were beneficial for their professional development. Features of these beneficial experiences are depicted in the LEEPD Model (Table 11) and include 1) exposure, 2) practice, 3) feedback, 4) reflection, and 5) revision. In WIE-LLC,

beneficial experiences consisted of one or more features. Each of these features will be described in the following sections.

Table 11. LEEPD features of beneficial professional development experiences

LEEPD Feature	
Exposure	
Processes	
Strategies	
Environments	
Engineering Practice	
Connections	
Opportunities	
Practice	
Developing	
Implementing	Casual Environment
	Low-Stakes Environment
	Authentic Environment
Feedback	
Reflection	
Revision	

5.2.1   Exposure

The first feature of beneficial experiences in the LEEPD Model is exposure. When describing experiences that were helpful for their professional development, participants discussed activities and events that exposed them to processes, strategies, environments, engineering practice, connections, and opportunities (Table 12).

Table 12. Types of experiences that provided exposure

Type of Exposure Experience	Description	Example
Processes	Exposure to steps involved in the job acquisition process.	Introducing students to the various components that are needed when talking to recruiters at a career fair.
Strategies	Exposure to strategies to develop job application components.	Providing students with templates and examples for résumés, cover letters, elevator pitches, etc.
Environments	Exposure to different environments encountered during the job acquisition process.	Having students attend a career fair to become familiar with the setup, pace, and setting.
Engineering Practice	Exposure to different aspects of engineering practice.	Presenting on topics such as business in engineering and working with people from diverse backgrounds.
Connections	Exposure to contacts and connections.	Providing opportunities for students to interact with faculty and/or company representatives.
Opportunities	Exposure to opportunities within educational and professional settings.	Providing students with information on opportunities available in a university or professional setting.

5.2.1.1   Exposure to Processes

The first type of exposure was exposure to processes in the job acquisition domain of professional development. Participants described a knowledge gap in the steps involved in the job acquisition process as well as the steps involved in particular elements of this process, such as interviews. Experiences that exposed participants to processes outlined what steps were expected in specific parts of the job acquisition processes as well as in the process overall.

For example, participants described the benefit of learning about the job acquisition process in a seminar course associated with the LLC. As part of the seminar, participants learned how to prepare for the engineering career fair, what steps were involved in attending, and what components they needed to prepare as a part of the process. As illustrated in the following excerpt, participants described the importance of learning what was expected in the process of attending a career fair through activities incorporated into the LLC seminar.

Participant 23:   [Preparing for the career fair in the seminar] got me thinking more about what would sound good to a recruiter. Like we had to do our elevator speech prep. Like you have like three minutes to introduce yourself. Like how are you going to get your point across and leave them interested? That was something we learned. […] So basically when you'd have time with the recruiter, like you wait in line and you really have like 2 minutes to introduce yourself like when you go after the handshake. Like okay, now it's time for you to like spill what's on your résumé, but like do it in an interesting way. So that way they seem interested in you. So we literally would write out a speech [in the seminar] being like, "hi my name is [name], I'm a sophomore in mechanical engineering, I am minoring in biomedical engineering." […]

Interviewer: So can you explain a little bit to me kind of why that was helpful and beneficial?

Participant 23:   Yeah. So I mean if I hadn't known that I was supposed to go out and like say a bunch of stuff about myself, I probably would have just shook the recruiter's hand and said like "hi my name is [name], how are you today?" And like I wouldn't have continued the conversation. Like I wouldn't have known to continue talking. But now that I know that I'm supposed to like give a little like pitch about myself. Like I knew that going up there, what I was supposed to say and that they were expecting me to say stuff like that. So that was good. And also just knowing what I should put in and what I shouldn't. Like some of this stuff, like my scholarships don't need to be said out loud. Like yeah, they're on my résumé, but I don't need to say that. Say what I'm interested in, say why I'm interested in it, and like maybe a fun fact about myself just so that way, I stand out.

As illustrated in this segment, the participant described the importance of being exposed to the process of attending a career fair and the steps expected by the recruiters. This exposure was facilitated through the LLC seminar class where participants learned that the career fair process

entailed waiting in lines, shaking hands with the recruiter, introducing themselves in an interesting way, and continuing the conversation after the initial introduction. Because many students had not participated in a career fair prior to attending college, participants described the benefit of learning about the process in a seminar class before attending a career fair environment.

5.2.1.2   Exposure to Strategies

In addition to being exposed to the job acquisition process, participants described the importance of being exposed to strategies that would help them develop the various components that were necessary in this process. The second type of exposure, then, was exposure to strategies. These experiences provided participants with templates, guidelines, tips, and suggestions and typically were related to the development of job application components (part of the Job Acquisition domain in the PD^2 model).

Strategies were typically provided to participants in the form of direct instruction in the seminar class associated with the LLC. In this direct instruction, participants were given resources, suggestions, and guidelines to help them develop job application components. As illustrated in the following excerpt, one participant described the benefit in being exposed to the development of résumés, a necessary artifact when applying for jobs, and being given templates and suggestions for what to include and how to format these documents.

> I didn't personally know maybe what I was doing [for the résumé]. And so talking to professionals and seeing, looking at their eye-, um insight on how, how my résumé should look was extremely helpful. And then the, the check sheet of what should be on there um and where everything should just be placed so that it looks, it looks outstanding and professors will be able to see, or not professors, companies will be able to see right away um what stands out on the paper that you have done. […] When I came here, I didn't know that you were supposed to put like events in like chroni-, chronological order from like the present to like in the past. So that was helpful. […] [In the seminar,] they give you like descriptive words to put next to maybe a job that you've had or like soft skills that you, that you focus on. And so um just the descriptions are really helpful. And they give you like a book […] and like there's so many examples in there of like résumés, cover letters, anything and everything, business attire, um and all that good stuff. And I

think, I know, I think [LLC] gives out those books as well from [the career services office] and that is a huge help. *Participant 18*

This instruction through the LLC seminar provided participants with information, resources, and strategies that would help them create and improve job application components such as a résumé, as illustrated in the above example.

While the strategies were often provided by instructors in the LLC seminar, participants also described learning strategies from other students, including peers, upper-class students in the community, and mentors. These students would sometimes share their own job application components or strategies with others in the LLC. As illustrated in the following excerpt, one participant sought out help from a peer when preparing for an interview:

When I had an interview, I think, last year, and I didn't know what to do, I just like knew like there's upperclassmen that had interviews, that had internships. Like I was like "hey, I need help." […] And like one girl who was my year but she had an internship, she just sent me all this information. Like behavior questions, how to answer those, how to like do all this. So it was like really nice that like there's other people who had been through it and they'll send you help if you need it because you're, they just want to see you like do really well wherever you go. So that's really nice. *Participant 8*

In this example, the participant sought out help and advice from another LLC participant outside of the required LLC seminar. This peer provided additional information and resources to further help the participant learn about and prepare for interviews. As illustrated in this example, the participant was exposed to strategies, such as how to answer interview questions and the types of questions that might be included in an interview, by talking to peers who had been through similar experiences recently. Peers in the LLC environment could share their experiences, resources, and strategies with other students.

5.2.1.3   Exposure to Environments

The third type of exposure was exposure to environments. In addition to being exposed to processes and strategies, participants described the importance of being exposed to environments, particularly environments that are encountered during the job acquisition process.

As part of the LLC seminar, students were required to attend the fall engineering career fair during their first semester in college. As part of this requirements, students were required to not only prepare for the career fair by learning about résumés, elevator speeches, and the process of attending a career fair, students had to attend the fall engineering career fair and talk to a certain number of recruiters. By going to job acquisition environments such as career fairs, participants learned what these environments were like, which made the environment more familiar and comfortable. This exposure to environments is illustrated in the following excerpt:

Participant 10: But being part of [LLC], they require you to at least go and get exposure to it and you know, get a business card, talk to people. So just that was one thing that I think helped out a lot was just making me go. Because I probably wouldn't have if I wasn't required that first-year. Cuz I mean you look at the list and [companies are] not looking for freshmen. And so I feel like that helped me just going up and talking to [recruiters], even though they weren't as open. It was still getting a feel for how the environment would be for the following year. So like when I went back this year I was a lot more comfortable. I kind of knew what to expect. I saw what people were wearing, so I was like I can blend in a little bit more with that. So just the whole, they do a lot of different things that almost lead up to that. And then that way you have that basis for the following years to come. Which is nice.

Interviewer: […] and then a little while ago you mentioned kind of this idea of, you know, doing the résumé and going to Expo was really good for building on for like future years. Could you expand on that a little bit?

Participant 10: Yeah I mean it's more just the exposure, like I was saying for Expo. Because going into it for like the first time, you don't really know what to expect. So if you've already kind of got those, I wouldn't say get the nerves out, but like kind of got that first initial shock of all these different companies all set up, everybody all dressed up, you

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have an idea of what you're going into. So that second time around you can more focus on having a résumé that's more professional, presenting yourself, having that elevator pitch. Cuz you've seen, you kind of heard what other people are saying when they walk up to different recruiters. And you have a good feel for it at that point. So in future years, you kind of--, just sets you up so you know what to expect, you know how to talk to the recruiters at that point.

As this excerpt highlights, experiences such as attending a career fair exposed participants to new environments that were unfamiliar. By being exposed to environments early in their education, participants could learn what these environments were like and how the environment was different from their expectations. This exposure to the environment allowed participants to become familiar with the environment and learn from their own experience as well as from others who were also at the career fair. When attending subsequent job acquisition settings, participants were able to focus less on navigating the environment and focus more on how they presented themselves.

5.2.1.4   Exposure to Engineering Practice

The fourth type of exposure was exposure to elements of engineering practice, including the work that engineers do and the skills that are needed in the engineering profession. While exposure to processes, strategies, and environments were typically required assignments in the LLC seminar and were related to Job Acquisition, experiences that exposed students to elements of the engineering field included both required and optional experiences that pertained to Job Performance and Personal Development.

Several participants described the importance of being exposed to engineering practice and the work that engineers do on a daily basis. This exposure to engineering practice was incorporated in the LLC seminar as well as optional professional development events put on by the LLC. In one experience that was a required assignment in the LLC seminar, participants interviewed a practicing engineer to learn more about the engineering profession, the experiences of practicing engineers, and the paths that engineers took in their career. In this assignment, students identified a practicing engineer to interview and identified questions to ask in order to learn about a variety

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of aspects of the engineering profession. Several benefits of talking to a professional engineer are illustrated in the following excerpt. In this instance, the participant chose to interview a female engineer and ask about her selection of a major and about her experiences related to being a female in a male-dominated field.

Participant 22: Uh so we had like an email interview and I thought that was really interesting. Because I learned a lot. Like I've met her before but I learned a lot about like her experience in college and how like it got her on track to being a professional mechanical engineer, like working for a company. And I thought it was interesting because she told me a lot of stories about um her struggle being a woman in engineering. Which was, I, I hadn't like felt any of the effects of that yet. So it was really interesting for me to hear like how sometimes like her male colleagues wouldn't take her seriously or like um a client would like talk over her to like one of her male colleagues instead of like talking directly to her, even though she's like the senior um one in the group. So that was really helpful. Um I think she kind of influenced my choice of mechanical engineering as well. […]

Interviewer: […] So why was hearing about her experiences so helpful?

Participant 22: Um … hm. Just like …so I, I guess, I guess it kind of prepared me a little bit more for like the real world. Because not that I'm there yet but even, even just the jump from last year to this year. Like last year I was so surrounded by girls because my floor was all girls and I lived with all the [LLC] girls. Um whereas like this year, I go to class and there's like four girls in the class of 60. And like I definitely feel the presence of all the men in engineering now. Um although I haven't been like, I haven't felt the negative effects of it yet. Um but just hearing about her like bad experiences as a woman in engineering kind of made me feel like I definitely want to do this and go for it and like kind of show the world, be one of the like few in the sea of guys to make it. […]

Interviewer: So how did you determine like what question do you ask during the interview?

Participant 22:   […] I guess I just kind of thought about like the things we were learning in class. How, and then like kind of thought about what the point of it was. So like, in my mind, the point of doing the interviews was to talk about like how to get where you're going um, like get advice on like the steps along the way. Um and then my big thing was like how did you choose your major and like advice along those lines because that's what I wanted to know. That's what I've been, I've been talking to as many people as possible about that. Because I was so like confused and didn't know what I wanted to do kind of thing. Um so those types of things. Um and also asking like what she does on like a day-to-day basis. Because at this point, I was still like pretty confused about what an engineer actually does at their job. Like I get the, I get the concepts that like engineers are like designing and building and manufacturing. But just there's, it's so broad and like so all over the place that I didn't actually know what like an engineer does when they go to work.

In this excerpt, the participant described learning about the work that engineers do, workplace environments, and challenges associated with being a woman in a male-dominated field. In this example, the participant found it beneficial to hear about the struggles of the person she interviewed and to relate that to her own experiences in engineering courses. For example, the practicing engineer described challenges with her male colleagues, and while the participant had not experienced those effects in the courses she was taking, she did notice the transition from the LLC community, where she was constantly surrounded by and interacting with women, to her mechanical engineering classes where there were very few women. In the LLC, this participant had a support network of other women, and this LLC environment differed from her in-major engineering courses where students were predominately men. In this segment, the participant was motivated to be one of only a few women to pursue a degree in mechanical engineering, but she described the benefit of learning about potential challenges she might face in a male-dominated engineering workforce.

In addition to learning about the challenges of the workplace environment for women, this participant described the benefit of being exposed to the path of becoming an engineer and work that engineers do on a daily basis through talking to a practicing engineer. This excerpt described

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the value in being exposed to advice on how to choose a major and what steps and experiences can be helpful in the path to becoming a practicing engineer. In addition, the participant described the need to learn what engineers do daily because her exposure to the engineering profession was fairly broad and limited, despite having a close family member who was an engineer.

Participants also described the importance of experiences that exposed them to different aspects involved in performing engineering work, including working with team members in different contexts and business considerations in engineering. This exposure was often supported through optional events hosted by the LLC. In addition to the required LLC seminar, students who participated in the LLC were required to participate in a certain number of professional development events. Each individual event was optional and the requirement stated only that participants attend a certain number of events. Therefore, students could select which events to attend in order to satisfy that requirement. The following excerpt highlights an experience that exposed the participant to aspects of engineering work, including business, marketing, and managing. In this experience, an invited speaker from an engineering company gave a presentation on the role of business in engineering, as described in the following excerpt:

Participant 23:   Yeah. So we like every once in a while, there would be like certain companies that would be like, "oh, can we give a presentation to some of the kids in the living-learning community?" And you would just sign up and like boys and girls, like both [partner LLC] and [LLC] could like come down and they would present to us like in the second-floor lounge of our building. And like they would teach you about their company and how--. This one was about marketing, so they teach you about like how certain marketing aspects are paired with engineering and like how like some of them go hand-in-hand. And like you should think about how business influences your job. Because like, yeah you're an engineer. But there's also a business side to engineering which some people don't consider. And then afterward you can talk to them if like you want a job there or if you wanted to like make a contact with them. Like of course. They are very nice and they give you business cards and stuff.

But it was cool because it was really just us, like no one else was allowed to come. So it was pretty exclusive.

Interviewer: So why was that event particularly helpful?

Participant 23:   I... like in my professional development?

Interviewer: Yeah.

Participant 23:   I guess it was, I'm trying to think how I developed more. I guess I learned more about my job from that one, because I learned like oh there's a whole aspect of engineering that you like haven't considered before. Which was definitely like, I don't really want to go into the business side but it's still something to consider. And I know someone who's actually minoring in business now because he's like, "yeah, engineering, like if you go up high in the ranks, like you're not doing like the coding stuff, you're doing business and like you're overseeing people and managing and stuff." So, I guess, definitely made me more aware of where my job could go if I wanted to go that way. And like certain aspects of the field that I hadn't thought of before.

As discussed in this excerpt, the participant described the benefit of learning about various aspects of the engineering profession from practicing engineers. Through a presentation provided by an engineering company, the participant was able to learn more about the roles and responsibilities in an engineering job. In this particular example, the participant was exposed to the business side of engineering, which was an aspect of the engineering profession that the participant had not yet considered or been exposed to.

In this excerpt, the participant described the importance of not only learning more about the engineering profession but getting to make connections with company representatives. At this event, which was only accessible to students in the LLC, the participant described the opportunity to make connections with the presenters. This exposure to connections is the fifth type of exposure, as described in the next section.

5.2.1.5   Exposure to Connections

The fifth type of exposure was exposure to connections. Through the LLC seminar and the optional events sponsored by the LLC, participants described the benefit in making contacts and connections with their LLC seminar instructor, other faculty at the university, and representatives from engineering companies. As illustrated in the following segment, the seminar associated with the LLC provided students with a connection to their LLC instructor who could introduce them to other connections and opportunities.

> Uh I had a great professor, [instructor]. She was very helpful to me and I got on a very professional level of getting to know her and would be comfortable speaking with her at any time. And she saw the amount of time that I had been spending in the [collaborative studio] and [residence hall]. And she was the one who directly uh recommended me to come to the [research] lab. So on her own time outside, she says like "I have connections to the [research] lab and I think it would be great for you as a match, as a person, to go there, volunteer, work, do whatever you think you would like to do. Because you have this strong interest in it." Like I did not reach out to her. She reached out to me on that. And I think that networking directly through the instructors as they know other [LLC] students that have done research or clubs or anything in the past, like connections to companies. They say like "I know a girl who had these same interests as you and they worked there." So she can get me in touch with people like that. *Participant 5*

In this excerpt, the participant described getting to know her instructor in the LLC seminar. Through that connection with her instructor, the participant was introduced to connections beyond the class and the LLC. By getting to know her instructor, she was able to connect not just with the instructor but with campus and industry organizations more broadly.

As another participant described the LLC "really encouraged [participants] to just go out there and make connections, go to events" (Participant 21). Through events, such as guest speakers in the required seminar and optional presentations from industry representatives, participants described the benefit in meeting people that they would otherwise not meet. Through these connections, participants could learn about opportunities available in the university and at various companies. This exposure to opportunities was the sixth type of exposure, as discussed in the next section.

5.2.1.6   Exposure to Opportunities

The sixth type of exposure was exposure to opportunities in an undergraduate environment and the engineering profession. Participants described one event where faculty members and industry representatives met with students in a lounge located in the residence hall. In this event, which was hosted once a week, faculty and industry representatives were invited to attend the event and give a brief introduction of their work to LLC participants in attendance. Following these brief introductions, participants could engage in casual conversations with the presenters to learn more about the presenters' fields and their work. In this experience, participants were exposed to different career options in engineering and opportunities that they could get involved with during their time in college, as discussed in the following excerpt:

> I mean some of the events that they put on um through [LLC], like they call it the [event name]. They'll have different professors that would come in to like the [lounge] for example. They would kind of talk about their research that they're working on and after they kind of go through and talk about what they do, you can go up to them and ask them questions. So I mean it's more so getting to know what different research opportunities are out there as well. So if you, if something interests you, you have the opportunity to talk to the professor right there and even possibly get yourself involved with that project. So I mean that's, again with more exposure, because that's the main goal of the program, is just to give you that exposure to different aspects. *Participant 10*

Because multiple faculty members and presenters volunteered to attend, this event exposed participants to opportunities in an environment where faculty and practicing engineers were easily accessible and approachable. At this informal event, participants could learn about opportunities, immediately follow up on potential opportunities to learn more, express interest, and make connections. Through this event that highlighted research and careers in engineering in a variety of disciplines and fields, women could learn about different opportunities that they would not have otherwise encountered.

In summary, the first feature of beneficial experiences within engineering living-learning communities was *exposure*. Exposure experiences introduced students to processes, strategies, environments, engineering practice, connections, and opportunities. These experiences related to the job application process, engineering career paths and opportunities, and the work that

engineers perform in the workplace. This feature often served as the basis for the remaining features described below.

5.2.2   Practice

The second feature of beneficial experiences in the LEEPD Model was practice. After being exposed to new ideas and opportunities, participants discussed the importance of gaining practice with the ideas to which they were exposed. This practice typically followed exposure to strategies, processes, and environments. As one participant described, "practicing is the, how you get better, not listening to PowerPoint" (Participant 21). As this segment highlights, practice was important for improvement. This practice often built on an initial exposure experience.

Experiences that incorporated practice were related to the Job Acquisition domain of professional development and provided opportunities for participants to practice developing and implementing job application components. When implementing these components, participants described the benefit of practicing in casual, low-stakes, and authentic environments. Practice experiences, as well as the various environments in which practice occurred, are summarized in Table 13.

Table 13. Types of experiences that provided practice

Type of Practice Experience	Description	Example
Developing	Practice developing and creating job application components.	Students practice creating a résumé, cover letter, professional email, elevator pitch, etc.
Implementing	Practice implementing job application components, which often includes implementing multiple components at the same time.	Students practice implementing multiple job application components in a career fair setting.
Environment of Practice	**Description**	**Example**
Casual	Practice in more casual/less formal environments.	Students practice their elevator speech in a casual environment, such as a classroom.
Low-Stakes	Practice in an environment where there are little to no consequences for errors.	Students practice interacting with faculty, recruiters, and/or industry professionals to learn about potential opportunities.
Authentic	Practice in authentic environments that are not classroom based.	Students attend career fairs and practice interacting with recruiters.

5.2.2.1 Practice: Developing

After initially being exposed to the job application components, participants stated that it was beneficial to practice developing those components. This practice was often a required activity in the LLC seminar that followed an initial introduction to a topic. For example, women in the LLC seminar were introduced to résumés, elevator pitches, and cover letters which are important when attending career fairs and applying for a position in engineering. Following this introduction and exposure, students in the seminar would practice creating and developing those components for use in the future. Participants in the present study described the benefit of drafting résumés and cover letters and practicing elevator speeches during the seminar. As illustrated in the following excerpt, one participant stated that she thought she would know what to include in these job application components, but practicing her elevator speech was different from her initial expectations.

> Um and then also like, we like spent a whole class period doing like an elevator speech. And I think like we might have even had to submit one too. But like just cuz like, it, you know, you always think like, oh like I'm going to know what to say, I'm going to know what to say. And then you like go off and you like don't know what you're going to say. So it's like really helpful, you know, like practicing like with a partner during class. Cuz like we all know like you're not going to do that outside of class. You know you're not going to sit with your hall mates and practice. *Participant 12*

In this excerpt, the participant articulates the importance of not only learning about the various job application components, such as the elevator speech, but also the importance of practicing developing the components because the actual implementation is often different than initial expectations. This practice helped participants try out different approaches and determine what to incorporate into their job application components.

5.2.2.2 Practice: Implementing

In addition to practicing developing components, participants described the benefit of practicing to implement their job application components. This typically involved incorporating multiple job application components into a career fair setting. As described previously, one assignment in the LLC seminar was to attend the fall engineering career fair and talk to a certain number of

recruiters. In attending the career fair, participants had to practice implementing multiple job application components when talking to a recruiter, as illustrated in the following segment.

> For me [the beneficial experiences were] all the events related to [the engineering career fair]. Because I'm like, oh I'm just a freshman, I don't think I'm going to get an internship. I don't have enough experience. But the point was, is that they encouraged us to go for the experience. They wanted us to make a résumé, make a LinkedIn, um work on our elevator speeches, handshakes, all sorts of things that, you know, I've kind of had in the back of my mind. I was just mainly focused on getting classes and getting the grades. Because anyone can get the grades it's just, it's a game making yourself look competitive compared to other people. And that's something that this class does really well in teaching and not a lot of the other people who aren't in the living-learning community get this um practice unless they decide to do it on their own. Um they kind of have to take the initiative whereas for us, it's provided. They say we have to do it so we do it. *Participant 6*

This excerpt highlights the importance of not only practicing to develop the job application components but also practicing to implement them. In this example, the participant had to practice using a variety of components, including a résumé and elevator speech, in a career fair setting to make herself look more competitive and stand out. Though many first-year students do not attend career fairs due to a lack of relevant engineering experience, the LLC required women to attend in order to practice. As described in section 5.2.5, by gaining practice early in their education, women were then able to make revisions and improvements in future career fairs.

5.2.2.3   Environments

When developing job application components, this practice typically occurred in a classroom setting or was completed as a homework assignment. When gaining practice implementing these job application components, on the other hand, participants described gaining this practice in a variety of environments, including casual, low-stakes, and authentic environments.

5.2.2.3.1   Casual Environments

Participants described the benefit of being able to practice implementing what they were learning in environments that were casual. Casual environments, as described by participants, included classroom settings in academic buildings on campus and informal settings, such as student

lounges and dorm rooms located in the residence hall. Casual environments were more familiar to students and allowed informal interactions with peers. These environments provided spaces for LLC participants to practice what they were learning and figure out what they wanted to include in the various job application components, such as résumés and elevator pitches, before they entered authentic environments. As illustrated in the excerpt below, this casual environment provided a space for participants to make mistakes and practice multiple times.

> I didn't even realize, it's like all this little planning in going to a career fair that I didn't realize goes into it. So it's like the résumé and then the elevator pitch. And so it was really helpful because I didn't even realize that it was a thing. So I was just like okay yeah I figured I'd just walk up and say "hey I'm [name], like tell me more about your company." And then they'd be like "tell me more about you." And so it was really helpful because I wouldn't have even introduced myself correctly if I hadn't have gotten that lesson. And also during the class it was, that class specifically was more like going up and just practicing on each other. And so it was just like normal, like a normal casual setting. We were just walking around and you just go up to a random girl or one of your friends and be like "hey." And then you would just practice your elevator pitch on each other. And so just that casual atmosphere of just getting your wording down right and like, sure if you mess up or you stutter it doesn't matter because we're all friends. So you just laugh it off. And then you just try again. So just like that casual atmosphere of like first getting it down and first writing it down and first practicing it definitely helps prepare yourself for when you were actually getting ready for [the career fair] and like okay I have to get this down pat. So definitely that helped out a lot. *Participant 19*

This excerpt highlights the benefit of practicing job application components, such as the elevator pitch, in a casual classroom environment with peers. In this environment, the participant was able to make mistakes, practice multiple times, and refine her elevator pitch before she needed to give the elevator pitch in an authentic environment such as a career fair setting.

5.2.2.3.2 Low-Stakes Environments

Participants also described the importance of being able to practice what they were learning in a low-stakes environment where there were little to no consequences for errors. This practice in low-stakes environments typically involved practicing interactions with others in more

professional settings. Whereas casual settings typically involved practice with peers in familiar environments, low-stakes environments typically involved practice interacting with faculty and industry professionals in environments that were more unfamiliar yet informal. For example, participants described interacting with faculty members in a weekly meet-and-greet event. In this event, faculty members were invited to talk about their field and their research in the residence hall lounge. Participants described these environments as low-stakes settings where they could push themselves, get out of their comfort zone, try new things, and reduce their fears, as illustrated in the following excerpt:

> I really like, don't like, like talking to recruiters, talking to professors, like oh that stuff is like so out of my comfort zone. And you know again, it's like only like a month-and-a-half into school. And like I like had to go to the [meet-and-greet event], and like I was so scared. Because like you have to like talk to these people. Um and so like that was really before, too, I had ever like really like been to office hours or anything like that. So like going to [event], again, it's like a chance to like get out. I think one of the best things that [LLC] does is it provided a lot of opportunities to get out of your comfort zone in a really low-stakes environment. Cuz like talking to some professor, like I mean it's like so low-stakes. Like they are the ones giving up their Friday afternoon, like they want to be there. They want to talk to you. Um so [event] was definitely like a good experience. Like it was great, you know, hearing about like all the different research opportunities and like classes and stuff like that. But also like just having an opportunity to like talk to your professor, like talk to a department head, that like really took a lot of like the fear out of that situation. Um and like made me more comfortable like going to office hours, going to things like that. *Participant 12*

This excerpt highlights the benefit of experiences where women could practice what they learned, such as how to interact in professional settings, in low-stakes environments. These environments were described as low-stakes because faculty were volunteering their time and interested in talking to students and the event was designed to facilitate informal interactions between students and presenters. While this event could lead to connections and opportunities, these environments were described as low-stakes because the emphasis was on interaction with faculty to learn about opportunities as opposed to being hired for a position. This contrasts with

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several authentic environments, such as career fairs, where the primary purpose of the event was to get hired for an internship or position. Authentic environments are described in the following section.

5.2.2.3.3 Authentic Environments

In addition to low-stakes environments, participants described the benefit of practicing in authentic environments. Authentic environments included career fair settings which were environments that women would encounter whenever they were searching and applying for a new position. As described previously, attending the career fair was a required portion of the LLC seminar. This requirement forced students to practice what they learned in other environments, such as in the LLC seminar, in authentic environments. In these authentic settings, participants discussed the benefit of implementing and using multiple components that they had developed in the LLC seminar, as illustrated in the following excerpt:

Participant 14:   Like a really big part of the grade [in the LLC seminar] was you had to go to the uh career fair, [name of career fair]. And [the LLC instructor] made you get, I believe it was 2 to 3, I don't actually remember, but it was at least one or two business cards from people to show that you actually tried to talk to like recruiters. And that was really helpful because it just kind of, again that, now you're in an actual recruiting setting. And it made you, you had to dress up really nice. So like that was a whole thing that some people might not have ever had to actually do. And you had to like present yourself in a way that would seem appealing where they might actually want to hire you. Because they actually were hiring people. So making us go to that I thought was helpful because now I know how they work and I know how to approach them for the future. […]

Interviewer: Were there other aspects of [the career fair] that were particularly helpful, or like having to go to that?

Participant 14:   Um. It is, like I would say [the career fair] was like a whole thing that's like very--, until you experience it, you're, like a career fair, like as a freshman, you'd have no idea like what it actually feels like. Because it's very overwhelming. There's like hundreds of kids just all dressed in suits and you're all being like

"well that guy could get the job that I want." And you got to sell yourself in 30 seconds to some recruiter. And so that was like definitely a new experience. But it was beneficial to make us go as freshmen.

Interviewer: So what do you think were the benefits of kind of having to go as a freshman?

Participant 14: Um I think the benefits were just um getting us to know how they work and practice our elevator pitches, practice building a résumé, presenting the résumé. So that like you could maybe highlight the points that you wanted to. And that, and just being able to really promote yourself and what you are able to do but in a really, really short time frame to someone you've never met and honestly has hundreds of more people to talk to. And you are just 1 in 100 and you have to make yourself stand out.

In these authentic settings, participants described having to use multiple components that they had been exposed to and practiced, such as how to present themselves and interact, how to give their elevator pitch, and how to present their résumé. These authentic environments provided opportunities to gain experience and practice in environments that participants will encounter when they are applying for internships, co-ops, and full-time positions throughout their undergraduate careers.

Authentic environments were sometimes described as low-stakes environments as well if practice in these authentic environments were viewed as having little to no consequences for errors. For example, participants sometimes stated that attending an authentic career fair environment early in their undergraduate career was also low-stakes because recruiters were not looking to hire first-year students and therefore the participant was not expecting to receive anything through these interactions. In these situations, participants could still practice and make mistakes with little to no consequences for errors.

In summary, in addition to being exposed to new concepts and ideas, participants found benefits in experiences that allowed them to gain practice developing and implementing those ideas. Through experiences that involved practice, participants gained a better understanding of a particular topic and its complexities. Practice occurred in a variety of settings including casual environments where participants could practice multiple times with peers, low-stakes

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environments where there were little to no consequences for errors, and authentic environments situated in a real-life context.

5.2.3   Feedback

The third feature of beneficial experiences in the LEEPD Model was feedback. Feedback included evaluation from external sources and helped participants understand what they did well, what they could improve upon, what they could change, and alternative ways to present information. This feedback during participants' first year in a university allowed them to continue to improve throughout their undergraduate careers.

Participants described getting feedback from peers, senior students, instructors, and recruiters. And many participants described the benefit of getting feedback on job application components such as résumés and elevator speeches. Feedback was a required component of certain assignments in the LLC seminar. For example, when developing job application components, such as the résumé and elevator speech, students in the seminar had to get feedback from either other students in the class or other individuals outside of the seminar. The following excerpt highlights the benefit of getting feedback first from more senior students, but also from recruiters, when developing and improving their résumé.

Participant 6:   I guess if I were to just go to [the engineering career fair] with no prior training or anything that was provided by [LLC], um I don't think my résumé would have looked as good, I'm sure I would have sent it to my dad and he would have given me some feedback or something. But it's just a lot more helpful getting it from people who are um making these for [the career fair] and putting their classes and talking to other engineers today. It's just cuz, [second-year students in LLC] had to do this last year so it's rel-, more relevant feedback. […]

Interviewer: […] Who primarily did you get that feedback from?

Participant 6:   Um from, primarily it was upperclassmen that would, I would hand [my résumé] to them because we had a requirement, okay get your uh résumé looked at before you turn it in. And send a copy of the edited version in. So I would have sophomores look at it and give me feedback. But I would also get feedback at [the career fair] themselves. Um some of the recruiters, they knew that we were

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freshmen, and even this year when I went to the [computer science] career fair, um some people were like "oh I like how you put this, but in the future, once you do this, you should put this here." And they also gave feedback as to what they're looking for, what they want you to do in the future, what you're doing right, what you should probably fix, which is really helpful.

As illustrated in this excerpt, feedback on components such as the résumé was required, and participants also got additional feedback from industry representatives during the career fair. This feedback helped participants identify opportunities for improvements as well as identify aspects of their job application components that were done well. When gaining feedback on components such as résumés, cover letters, elevator speeches, and professional emails, participants could learn alternate perspectives on ways to present information and experiences which could help them improve in future years.

In beneficial experiences, feedback was provided by a variety of sources including peers, senior students, career center staff, instructors, and recruiters, and it could be incorporated in the various environments participants described. This component was a helpful element for further refining and improving the job application components with which women were gaining practice.

5.2.4 Reflection

The fourth feature of beneficial experiences in the LEEPD Model was reflection. Some participants described the benefit of reflecting on their experiences to consider what went well and what could be improved upon. The reflection feature was similar to the feedback feature in that it allowed women to identify improvements that could be incorporated into future situations. However, reflection differed from feedback in that reflection was based on internal beliefs whereas feedback was based on input from external sources. Reflection was both a required element of certain assignments in the LLC seminar and a component that participants described outside of required seminar assignments.

When developing job application components, some participants discussed reflecting on how to best present themselves both in writing and in person. Participants often reflected on their own experiences when building off of basic guidelines and examples provided by the LLC in order to

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tailor job application components to highlight their experiences and their strengths. This reflection in the development of an elevator speech is highlighted in the following excerpt:

> I think my, our teacher like, she like, she said, um she showed us some elevator speeches and like her elevator speech. Like she gave it to us and she was like this is what I would say. And it kind of helped because like she was like these are the different things you can talk about. This is--. Because like not everyone has the same elevator speech which is like really cool but like kind of hard. Because when you don't know what an elevator speech is, you're like how am I going to like pick and choose. There is no template to follow. And I think that's like what she like focused on. She was like you can do whatever. Like you can say whatever you want as long as it's like professional, then it's fine. And I was like okay. So like I just kind of like tried to figure out a path. And like I realized that like, after hand [sic], like this path is not working. I cannot sell myself in this way. And I couldn't talk about myself for that long. And so my mom was like, go to a company and just throw in something that you love. And so like talking to her and like realizing that like you can definitely sell yourself in a different way than certain ways. And I thought that was really cool about like, I learned that [the LLC instructor] did something completely different and my mom does something completely differently and then like the ones I looked up were completely different. Like you can do it any way and you're still doing an elevator spe--, pitch whatever. *Participant 8*

In this excerpt, the participant describes first learning about elevator pitches, getting feedback from her mom, and then reflecting on how to promote herself in a way that was authentic. This involved reflecting on what aligned with the participant's interests and personality and then adjusting the job application component based on that reflection.

In addition, some participants described reflecting on their experiences after attending their first career fair, which was part of an assignment in the LLC seminar course. This reflection was described as important for women in order to be able to better present themselves at future career fairs, as illustrated in the following excerpt:

Interviewer: Were there any aspects of that kind of like recording what happened [after the career fair] that were particularly helpful?

Participant 22:   I mean I think it was a little helpful because um, in that type of situation, I probably wouldn't have thought about it too much after the fact. So just like thinking about it and thinking about like what I said, what they said, you know, can make you think like what I could do differently to make myself like sound more confident or like more articulate. I'm not very, as you can tell I'm not very good at like words. Just like picking the right words to say in situations. So I guess thinking about it after the fact was good for that. Just reflecting on how I could make it better in the future. Which I think, I think it helped. I think this year I was a lot more comfortable talking to representatives and like, was better at articulating what I wanted out of like a potential internship or something.

As described by this participant, reflecting on her experiences at the career fair, while a requirement in the seminar, was beneficial for becoming more comfortable in career fair environments and for improving in future years.

5.2.5 Revision

The fifth feature of beneficial experiences in the LEEPD Model was revision. Experiences that incorporated revision allowed or encouraged students to make modifications or revisions based on feedback or reflection.

Revision often involved making changes to components, such as a résumé, based on feedback. This revision of job application components was often a required element of activities in the LLC seminar. For example, participants in the seminar had to create a résumé, get feedback on their résumé, and revise their documents based on the feedback they received. This revised version of their résumé was submitted as an assignment in the seminar. As described in the following excerpt, women found it helpful to not only get feedback on the content and format of their résumé but to also have an opportunity to incorporate that feedback.

We um, I guess it was about a month before the career fair, [the LLC instructor] said like you need to write, you know, you need to start drafting a résumé, like a college one. Because really the last one I had was like a high school one, which is very different from like a college one. So um they of course talked to us like about good layouts to have and what you should have on there and what you shouldn't have on there. And you know, like some high school stuff but not too much. Um you don't want to have like too many things

on there. You want to only put things that you, like you know, are actually involved in. And so they just talked us through how to make one. And then we submitted a draft and we had, we got a lot of feedback of how to fix it and correct it. And I think I went down to the um the lounge on the second-floor of [residence hall] and got my résumé like personally reviewed like on the spot in person. Um and we had time and then we had to turn in the final copy a while before the career fair. So we had like plenty of time to perfect our résumé before going to the career fair instead of like frantically trying to come up with one the night before. So that was helpful. *Participant 13*

In this excerpt, the participant described getting feedback from multiple sources. Once receiving the feedback, the participant had time to make revisions to the résumé before using it in an authentic job application environment. An important element of the revision feature was having time to make the revision. As illustrated in the above excerpt, participants described the importance of having structured assignments in the LLC that incorporated time to make revisions. Participants additionally described the importance of gaining experiences early in their undergraduate career so that they had opportunities to make revisions and continue to improve in future years.

5.2.6   Overview of LEEPD Model

Combined, the LEEPD Model identifies features of beneficial professional development experiences for women in engineering (Table 14). These features include exposure, practice, feedback, reflection, and revision. Features can be combined in a variety of combinations to create beneficial experiences that meet the needs of students. In discussing beneficial experiences in the LLC, women described a variety of experiences that incorporated one or more features. Example experiences are described in the next section to demonstrate different combinations of features within beneficial experiences and to demonstrate the flexibility of the LEEPD Model.

Table 14. Overview of features in the LEEPD Model

LEEPD Feature		
Exposure		
Processes		
Strategies		
Environments		
Engineering Practice		
Connections		
Opportunities		
Practice		
Developing		
Implementing	Casual Environment	
	Low-Stakes Environment	
	Authentic Environment	
Feedback		
Reflection		
Revision		

5.3   Examples of Beneficial Experiences

Women described a variety of experiences in the LLC that they perceived as beneficial for their professional development. These experiences consisted of one or more features from the LEEPD Model. Features were sequenced in a variety of combinations, and certain features, such as practice and feedback, were often repeated in beneficial experiences.

Most experiences that participants described as beneficial pertained to the Job Acquisition domain of the PD^2 Model and began by exposing women to a particular topic. These experiences additionally incorporated various combinations of practice, feedback, reflection, and revision. In contrast, some experiences built on students' prior knowledge and thus started with practice. And in other experiences, the only feature that was incorporated was exposure. Four different

examples are described below to highlight different combinations of features into beneficial experiences. In these examples, portions of the participant quotes are bolded and indicated with a number in order to identify relevant segments that correspond to features of the LEEPD Model. These examples are not inclusive of all possible configurations of features present in the data; rather, they highlight different ways in which the features can interact to create beneficial experiences for women in engineering.

5.3.1   Experience A: Interview Thank You Letter

Experience A, which covered how to write a thank you letter following an interview, exposed women to the topic, provided opportunities for them to practice developing their own version, and incorporated multiple iterations of feedback combined with revision. As described by one participant, this experience was beneficial because it included multiple steps that guided her through the process of developing a thank you letter, as described in the following excerpt.

> We had to, I believe [the thank you notes] were homework assignments. ❶ **Like we would go over like a presentation in class** and ❷ **then they'd be like, okay now you can like start writing it and then email it to us by tomorrow or whatever**. So ❸ **we would [turn the letter in] and [the instructor] would like grade it very lightly**. And ❹ **then we can make changes and then turn it in again**. Then like ❺ **okay wow this is good, this is good**. So we would do that. *Participant 21*

This experience included elements of exposure to strategies, practice developing the letter, feedback, and revision, as shown in Table 15, and the numbers indicate the order in which features were sequenced. This experience exposed participants to the interview thank you letter through a presentation (❶) followed by an opportunity to practice writing a letter during the LLC seminar (❷). Women then turned in their drafted letter so that the LLC instructor could provide feedback (❸). Once the students received the initial feedback, they revised and resubmitted their letter a second time (❹). After the resubmission, the instructor would return additional feedback (❺). Learning how to write thank you letters was described as beneficial for helping the participants stand out from other applicants after an interview.

Table 15. *LEEPD features in interview thank you letter experience*

LEEPD Feature		Order
Exposure		
Processes		
Strategies		1
Environments		
Engineering Practice		
Connections		
Opportunities		
Practice		
Developing		2
Implementing	Casual Environment	
	Low-Stakes Environment	
	Authentic Environment	
Feedback		3, 5
Reflection		
Revision		4

5.3.2   Experience B: Elevator Speech

In Experience B, which related to the development of elevator speeches, women not only gained practice developing a job application component, they gained practice implementing the component in a casual, classroom environment. In addition, this experience incorporated feedback to help participants improve their elevator speech. In contrast to Experience A, which incorporated feedback from the instructor, Experience B utilized feedback from peers.

In this experience, participants described the benefit of being exposed to the concept of elevator speeches, which was often an unfamiliar concept. As illustrated in the following excerpt, one participant described the benefit of first being introduced to the concept of elevator speeches through the LLC seminar course (❶).

We had to do our elevator speech prep [in the LLC seminar class]. Like you have like three minutes to introduce yourself. Like how are you going to get your point across and leave them interested. That was something we learned. […] I like haven't had a professional job ever and like I didn't know what to do. And then ❶ **the fact that [the LLC seminar] went over this is how you should go about this, like definitely was a good aspect of [LLC]**. *Participant 23*

When elaborating on the benefit of this experience, the participant then described getting the opportunity to practice, get feedback, and reflect, as illustrated below.

❷ **So we literally would write out a speech being like, "hi my name is [name], I'm a sophomore in mechanical engineering, I am minoring in biomedical engineering." Like you would write it all out** and ❸ **then practice on other students in the class** ❹ **and try to like help them improve their speech and they would give you tips and stuff.** And some people had to go in front of the class and do it, which I wasn't one of those people but other people did. And it was really fun listening to other people and like how they chose what they wanted to say in their speech. Because some people brought up their extracurriculars, while other people brought up like some traveling that they've done that they thought made them a more unique individual. ❺ **So you kind of got to see how your speech compared to theirs and what you wanted to add and take away.** So that was kind of cool. *Participant 23*

This experience, then, incorporated practice developing an elevator speech during the seminar (❷) and practice implementing it with peers in the seminar (❸). By practicing with peers, the participants were able to give and receive feedback (❹). Additionally, by listening to the elevator speeches of others, this participant described the benefit of being able to reflect on her own speech and compare her approach to that of others' (❺). The features of this experience, as well as the order in which they were implemented (indicated by the number), are shown in Table 16. In this experience, participants were further exposed to different approaches to the elevator speech through practicing with peers. Features such as practice and feedback, then, can lead to additional exposure.

Table 16. LEEPD features in elevator speech experience

LEEPD Feature		Order
Exposure		
Processes		
Strategies		1
Environments		
Engineering Practice		
Connections		
Opportunities		
Practice		
Developing		2
Implementing	Casual Environment	3
	Low-Stakes Environment	
	Authentic Environment	
Feedback		4
Reflection		5
Revision		

This experience differs from Experience A in that it incorporated practice implementing the elevator speech, in addition to developing it. And in contrast to Experience A, the feedback in Experience B was less structured and was provided by peers. These interactions with peers helped facilitate reflection, which was not a structured element of the activity but something that could grow out of the feedback from peers.

5.3.3   Experience C: Résumé Review

While the previous two examples began with an initial exposure, this was not the case for all experiences. In some instances, participants had already developed a particular job application component and beneficial experiences helped them improve and revise what they had already developed. For example, several participants described entering college with a résumé. In these

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instances, beneficial experiences provided opportunities for the participants to receive feedback and revise their existing résumé, as illustrated in the following segment.

Participant 16:   I think one thing that I think, that really helped me was like [the LLC] really pushed résumé reviews. And so that was something, ❶ **like in high school we did, we made résumés and you know they were mediocre.** But then getting here, [the LLC] know[s] what companies are looking for because they have those connections. And you're working with, or you're looking at people who got an internship and people who got co-ops and are like "oh you should put like this at the top" or like "this isn't really needed" and "note on like these skills" and things like that were just really helpful to me. […]

Interviewer: […] How [was the résumé review] structured in [LLC]?

Participant 16:   […] So you have to submit your draft résumé. And then you submit your reviewed résumé. And then submit another final résumé. ❶ **So the original one is actually reviewed just by sophomores. And so you're getting multiple sophomores to look at your résumé to kind of tear it apart**. And ❷ **then you can put it back together.** And ❸ **then your instructor looks at the final one to give you the final, final recommendations.**

This example demonstrates a beneficial experience that started with an existing job application component that the participant had developed previously. As described in this excerpt, the participant entered college with a résumé made during high school (❶). Beginning with this initial résumé, the participant received feedback from sophomore students in the LLC community (❶). Using this feedback, the participant then revised and improved the résumé (❷) and that revised résumé was submitted to the LLC seminar instructor for additional feedback (❸). Because the participant already had developed a résumé, the experience in the LLC built off of this prior practice. The features of this experience, as well as the progression of these features, are shown in Table 17. In this example, the zero indicates a feature that occurred prior to the LLC experience.

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Table 17. LEEPD features in résumé review experience

LEEPD Feature		Order
Exposure		
Processes		
Strategies		
Environments		
Engineering Practice		
Connections		
Opportunities		
Practice		
Developing		0
Implementing	Casual Environment	
	Low-Stakes Environment	
	Authentic Environment	
Feedback		1, 3
Reflection		
Revision		2

Depending on women's prior knowledge and experience, beneficial experiences can start with a LEEPD feature other than exposure. For example, this experience began with the practice feature from the LEEPD Model. This approach is particularly relevant when an experience extends prior experiences either in the same context or prior experiences from a different context.

5.3.4   Experience D: Presentation on Working with Others in Engineering Practice

Certain experiences in WIE-LLC, particularly those related to Job Performance, exposed students to particular topics without incorporating other features from the LEEPD Model. For example, one experience exposed participants to the importance of being able to work with people in other countries, as illustrated in the following excerpt:

We are all required to go to professional development events […] One of the events that stood out to me, it was just more informational, didn't help out a lot honestly because I haven't had experiences with it yet, but I know ❶ **the one girl did a presentation on how to deal with international clients. And so just like she just went over general culture, cultural stuff, just had a really nice PowerPoint. And just like this is typically what people in Asian cultures would deem appropriate in like a different culture. It was mainly just more cultural stuff and how like something that's offensive in the United States would not be offensive somewhere else and vice versa.** And so just kind of more that, that really helped me out professionally because I'm like okay yeah, like I have to think about other cultures too. I can't just say I'm in the U.S., everyone is going to just form to our culture. Like no, you have to be prepared for working alongside other people from international countries and just bringing that whole thought process in to mind. Because I'd only ever associated with Americans. And so I'm just like okay, yeah I'm going to be in the industry one day. I'm going to have to deal with people from different countries. And I'm going to have to be prepared for what that can encompass. So that really helped me out, just getting me thinking about it. The presentation was only an hour long and so she could only choose from like so many countries. So she just did like general ones, like typical countries in Europe, like Japan, different stuff like that, maybe France. So just kind of like, it wasn't the specific information she displayed but just more getting the idea that yeah, I will have to deal with international people one day and their customs are different from mine. So I've got to prepare for that as well. *Participant 19*

Through a presentation (❶), this experience exposed the participant to aspects of Working with Others (a category in the Job Performance domain in the PD^2 Model) in engineering practice (Table 18). While the experience did not include other features of beneficial experiences from the LEEPD Model, such as practice, this exposure was beneficial in getting the participant to start thinking about broader aspects of engineering. Because this experience helped women begin to think about competencies in the engineering profession, this experience could then serve as a foundation for future development.

Table 18. LEEPD features in working with others in engineering experience

LEEPD Feature		Order
Exposure		
Processes		
Strategies		
Environments		
Engineering Practice		1
Connections		
Opportunities		
Practice		
Developing		
Implementing	Casual Environment	
	Low-Stakes Environment	
	Authentic Environment	
Feedback		
Reflection		
Revision		

It is interesting to note that the participant in this excerpt stated that the experience was not as helpful because it did not incorporate practice. This statement emphasizes the importance of practice in beneficial experiences. While experiences that provided exposure to different topics were described as beneficial, the women in the present study articulated the importance of being able to practice developing and implementing the topics that they were exposed to.

These experiences, A, B, C, and D provide examples of just a few of the possible combinations of features from the LEEPD Model. The examples are intended to illustrate a range of possible combinations in beneficial experiences and demonstrate that experiences can begin with varying features depending on students' prior experiences. Additionally, features can be sequenced in a

variety of ways and repeated. Many other component combinations in beneficial experiences were described by participants in this study, and many other combinations are possible.

5.4 Connections between Experiences and Professional Development Categories

These examples demonstrate various combinations of features that were incorporated into beneficial professional development experiences in the LLC as well as the flexible combination of these different features. While the previous sections described the features of beneficial experiences and illustrated those features through examples, Table 19 lists additional examples of experiences that participants found beneficial for professional development. This list incorporates the most salient experiences that participants discussed within the LLC context. To explicitly connect the beneficial experiences with categories of professional development identified by participants, the category of professional development from the PD^2 Model is mapped to each example experience. This table, then, connects the results from RQ1 and RQ2.

Table 19. Beneficial professional development experiences and corresponding categories from the PD² Model

LEEPD Feature	Example Experience	PD² Category	PD² Domain
Exposure			
Processes	Students learn about the various steps involved in attending a career fair.	Components	Job Acquisition
Strategies	Students use examples, guidelines, and/or templates to create job application components such as résumés, cover letters, elevator speeches.	Components	Job Acquisition
Environments	Students attend career fairs and gain exposure to the overall environment.	Interactions	Job Acquisition
Strategies	Students learn about writing, including writing professional emails.	Communication	Job Performance
Engineering Practice	Students learn about working with others in international contexts.	Working with Others	Job Performance
Connections, Opportunities	Students learn about the engineering profession by talking to and interviewing a practicing engineer.	Career Choice	Personal Development
Connections, Opportunities	Students talk to professors about engineering, opportunities in a meet-and-greet setting.	Career Choice	Personal Development
Opportunities	Students listen to guest speakers talk about career paths and opportunities in engineering.	Career Choice	Personal Development
Practice			
Developing	Students practice developing job application components in a classroom environment.	Components	Job Acquisition
Implementing	**Casual Environment**		
	Students practice interacting with recruiters in a casual environment (e.g., information session).	Interactions	Job Acquisition
	Low-Stakes Environment		
	Students practice attending a career fair and focus on the experience rather than getting hired.	Interactions	Job Acquisition
	Students practice interacting with recruiters and/or industry professionals in a meet-and-greet setting.	Interactions	Job Acquisition
	Authentic Environment		
	Students attend career fairs during their first year in order to practice in authentic settings.	Interactions	Job Acquisition
Feedback			
Students receive feedback on job application components from different sources, such as peers, instructors, recruiters.		Components	Job Acquisition
Reflection			
Students reflect on their experiences at a career fair (e.g., what went well, what could be improved upon).		Components, Interactions	Job Acquisition
Students reflect on their strengths and experiences when creating job application components.		Components	Job Acquisition

LEEPD Feature	Example Experience	PD² Category	PD² Domain
Revision			
	Students revise components and/or interactions based on feedback/reflection.	Components, Interactions	Job Acquisition
	Students attend career fairs during their first year in order to adjust interactions at future fairs.	Interactions	

As shown in the table, exposure experiences corresponded to multiple categories across all three domains in the PD² Model. For example, experiences exposed students to job application components in the Job Acquisition domain, exposed students to aspects of communication and working with others in the Job Performance domain, and exposed students to career opportunities in the Personal Development domain. While exposure experiences corresponded to various categories within all three professional development domains, the remaining features corresponded only to the Job Acquisition domain.

On the other hand, several categories of professional development included in the PD² Model were not related to beneficial experiences in the LLC. For example, participants did not describe experiences within the LLC that related to Technical Knowledge within the Job Performance domain or Continued Improvement within the Personal Development domain. In describing professional development during interviews, participants often drew on experiences in other educational courses including introductory engineering courses, study abroad programs, internship experiences, and other out-of-class experiences. So while the beneficial experiences were grounded in the context of the LLC, women's descriptions of professional development, which informed the PD² Model, were grounded in multiple experiences, one of which was the LLC program.

5.5   Summary

This chapter summarized the features of experiences that participants described as beneficial for professional development in the context of an LLC. Women's descriptions of beneficial experiences consisted of five features: 1) exposure, 2) practice, 3) feedback, 4) reflection, and 5) revision. Combined, these features make up the LEEPD Model.

In describing beneficial LLC experiences, women discussed experiences that consisted of one or more features from the LEEPD Model. Some experiences only provided exposure while other

experiences incorporated multiple features in a variety of combinations. By incorporating multiple features, LLC experiences exposed women to new ideas and concepts and allowed them to practice and further develop. This flexibility in the features incorporated into experiences as well as the starting point for these experiences allowed for a variety of experiences that were tailored to a variety of student needs. At the conclusion of this chapter, examples were provided to illustrate specific experiences that were incorporated into WIE-LLC and to demonstrate the connection between beneficial experiences and women's understanding of professional development from the PD^2 Model. By describing features, as opposed to specific experiences, the LEEPD Model can more easily be transferred to other contexts.

Chapter 6: Discussion

The focus of this work was to understand professional development experiences within living-learning communities (LLCs). To that end, this study examined 1) the ways in which women engineering students perceived professional development after participating in an LLC for women in engineering and 2) the experiences within this context that helped them achieve that development. The results provide two major contributions: the PD^2 Model describes professional development from the perspective of women engineering students, and the LEEPD Model provides insight into the features of LLC experiences that women find beneficial for supporting their professional development. This chapter describes the contributions of these two models and is divided into two sections: the first section addresses RQ1 and situates students' descriptions of professional development in the larger context of literature related to the professional formation of engineers; the second section addresses RQ2 and describes the contributions of the LEEPD Model.

6.1   Women's Descriptions of Professional Development

While there is broad agreement on the need for professional development in engineering, previous research and reports have described a variety of necessary professional competencies associated with this development. Despite this variation, commonalities amongst these different conceptualizations provide a foundation for professional development in engineering from the perspective of experts such as educators and professional engineers. But much of this existing literature on professional development focuses on what students *should* learn. Little work has focused on understanding the professional competencies that students *do*, in fact, develop and what competencies students *think they need* to develop. To further our understanding of the student perspective, this study examined women's perceptions of the professional competencies that are important in the engineering profession.

In particular, this study explored the perspectives of women engineering students after participating in an LLC designed for this population of students. Identifying the professional development that women perceive as relevant is important in not only preparing women for their future careers but also in broadening their understanding of who engineers are and what engineers do. This development can support the persistence and retention of women, who still remain underrepresented in engineering programs, not only in undergraduate programs but in

engineering fields. With an understanding of the perceptions of women, in addition to that of experts, learning experiences can be intentionally designed to further students' development and provide them with competencies needed in their careers.

To that end, the first research question addressed in this study was, "How do engineering students describe professional development after participating in an LLC for women in engineering during their first year in college?" In answering this question, participants' descriptions of professional development fell into three domains: Job Acquisition, Job Performance, and Personal Development. Each of these domains included multiple categories of professional competencies. Professional development related to Job Acquisition included the components and interactions necessary to acquire a job or internship as well as to move from one position to the next. Professional development related to Job Performance included the knowledge and skills necessary to perform the work in an engineering position. The last domain, Personal Development, included categories that were relevant to a work environment but extended to other aspects of an individual's life as well. Each of the categories within the three domains was described to different levels of internalization. In some instances, competencies were described as externally imposed requirements. In other instances, the competencies were more internalized and could be used to support individual goals and interests.

Many of the categories described by participants align with professional development competencies previously identified in the literature, as shown in Table 20. In particular, several competencies common in prior studies were also present in this study (as indicated by a filled circle), including technical skills, communication, and continued growth and development. Certain competencies were not explicitly described by participants but were embedded within descriptions of other competencies within the PD^2 Model. These competencies (e.g., creativity and adaptability) were partially present in women's descriptions, as indicated by a half-filled circle. Despite these alignments, women's descriptions of professional development in the present study highlight several contributions to the existing literature, including differences between student views and views of experts such as practicing engineers and educators as well as additional competencies identified by the women in this study but not experts. These comparisons with existing literature and the contributions of the PD^2 Model will be discussed in more detail below.

Table 20. Categories of professional development

Competency \ Source	Present Work	Engineer of 2020 Attributes (National Academy of Engineering, 2004a)	ABET professional skills (ABET, 2016; Shuman et al., 2005)	Professional Development Ability/ Attribute (Davis et al., 2010)	Professional Development Categories (Scott et al., 2010)	Professional Formation Competencies (Walther, Kellam, et al., 2011)
Networking	●	○	○	○	●	●
Technical Skills and Analysis	●	●	○	●	○	●
Problem Solving	○	●	○	●	○	●
Interpretation	○	○	○	●	○	○
Awareness of Constraints	●	●	○	○	○	●
Engineering Judgment	●	○	○	○	○	●
Importance of Multiple Perspectives	●	○	○	●	●	●
Engineering Responsibility	●	●	●	●	○	●
Impact	●	●	●	○	○	○
Adaptability	◐	●	●	●	○	●
Manage Self	●	○	○	●	○	●
Work-Life Balance	◐	○	○	○	○	●
Planning	○	●	○	○	○	●
Manage Others/Projects	○	●	○	○	○	○
Creativity	◐	●	○	●	○	●
Working with a Team	●	○	●	●	○	○
Communication	●	●	●	●	●	●
Empathy	○	○	○	○	○	●
Leadership	○	●	○	●	○	○
Understanding the Organization	◐	○	○	○	○	●
Understanding of Professional Role	●	○	○	○	●	●
Accept Feedback	◐	○	○	○	○	●
Continued Growth and Development	●	●	●	●	●	●
Understanding of Self	●	○	○	○	●	●
Understanding the Educational Context/Process	○	○	○	○	●	○

Note: Circles indicate whether a particular competency was present in a study (● = present, ◐ = partially present,

○ = not present).

6.1.1 Professional Development from the Student Perspective

The PD^2 Model makes several contributions to the literature on professional development in engineering. First, it identifies categories of professional development from the student perspective, and many categories align with competencies from previous literature. This alignment highlights the ways in which young women in this study perceive the holistic professional development relevant in engineering. Second, the PD^2 Model provides much needed nuance in descriptions of professional development through the identification of levels of internalization for each category of professional development. Third, through comparisons with existing definitions of professional development, the PD^2 Model highlights differences between student and expert conceptualizations of professional development that identify needs of these young women that may be easily overlooked. By understanding differences between student and expert views, opportunities can be identified to use out-of-class experiences like LLCs to further prepare young women for competencies necessary in the engineering profession. And by understanding additional categories that women consider important that are not included in expert views, opportunities that meet the needs of students can be identified.

6.1.1.1 Categories of Professional Development

In comparing the categories in the PD^2 Model with those from prior literature, women in the present study discussed many of the same competencies as experts (e.g., practicing engineers, educators), indicating a broad awareness of relevant skills in the engineering profession. As shown in Table 21, many of the categories of skills in the PD^2 Model align with expert conceptualizations of professional development. For example, Engineering Judgment (a category in the PD^2 Model) aligned with awareness of constraints, use of engineering judgment, importance of multiple perspectives, engineering responsibility, and impact of engineering in broad contexts. While many competencies were directly aligned, certain competencies described by participants were embedded within descriptions of other competencies. In these instances, there was partial alignment between the PD^2 Model and expert descriptions, as indicated by a partially filled circle in Table 21. These competencies that were partially aligned indicate opportunities for further development and will be discussed in detail below.

Table 21. *Mapping of professional development categories with competencies from literature*

Domains of Professional Development	Job Acquisition		Job Performance						Personal Development	
Category / Competency	Application Components	Interactions	Technical Knowledge	Engineering Judgment	Time/Task Management	Work with Others	Communication	Self-Presentation	Career Choice	Lifelong Learning
Networking		●								
Technical Skills and Analysis			●							
Problem Solving										
Interpretation										
Awareness of Constraints				●						
Engineering Judgment				●						
Importance of Multiple Perspectives				●						
Engineering Responsibility				●						
Impact				●						
Adaptability	◐							◐		
Manage Self					●					
Work-Life Balance					◐					
Planning										
Manage Others/Projects										
Creativity						◐				
Working with a Team						●				
Communication							●			
Empathy										
Leadership										
Understanding the Organization							◐	◐		
Understanding of Professional Role									●	
Accept Feedback										◐
Continued Growth and Development										●
Understanding of Self										●
Understanding the Educational Context/Process										

Note: Circles indicate whether a particular competency was present in a study (● = present, ◐ = partially present, ○ = not present).

In general, this alignment between women's descriptions of professional development and that of experts demonstrates that women were gaining a broad view of professional competencies in engineering after participating in WIE-LLC. As a reminder, participants in this study were in their second year of an undergraduate program, just beginning their in-major courses, and had participated in WIE-LLC in their first year. Despite a lower academic level, participants described a variety of competencies related not only to shorter-term goals of getting a job but also longer-term goals of performing the work in an engineering field. Even though there were differences between student and expert views, the results from this study indicate that LLCs can help support women's awareness of broad professional development competencies in engineering. In addition, women's descriptions of professional development highlight categories of competencies that experts may overlook. In particular, women discussed the importance of professional development related to Job Acquisition, which was not often incorporated in expert views. This addition will be discussed in greater detail below.

6.1.1.2   Levels of Internalization of Professional Development

In addition to identifying categories of professional development, the PD^2 Model identifies varying levels of internalization within categories. Many women discussed categories of professional development as an external requirement, particularly when describing Job Performance competencies. These descriptions of external requirements indicate opportunities for students to further develop. Other participants described how competencies support specific goals, which was a more internalized level. These variations in internalization capture important nuances of professional preparation for engineers.

When describing professional development, participants often discussed professional competencies as an external requirement as opposed to an integral skill in engineering. In these descriptions, participants struggled to articulate the applicability of the required competencies they identified. This required view of professional skills aligns with results from prior studies which indicate that engineering students do not always understand how skills learned in a school setting are applicable in a workplace setting (Atman et al., 2010; Dunsmore et al., 2011). For example, women in the current study frequently discussed the need for engineers to work and communicate with others as a requirement in engineering due to the complexity of a project (e.g., an engineer working on one system must work with and communicate to an engineer working on

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another system) as opposed to an essential part of engineering and designing better solutions. Dunsmore and colleagues (2011) similarly found that students perceived that engineers work with and communicate to others, but these skills were necessities imposed on engineers to avoid errors rather than an integral part of engineering practice. The view of professional skills as an external requirement in the present study could be due, in part, to the academic level of participants. The women who participated in this study were early in their educational careers and may not have been exposed to the role of these professional skills in practice. In particular, because engineering students in this study were enrolled in general engineering during their first year, participants were in their first semester in a particular engineering discipline at the time of the interview. As a result, participants may have had a more general perspective on engineering, and the necessary competencies, compared with students who are farther along in their major. Additionally, programming within WIE-LLC focused primarily on professional development related to Job Acquisition, and skills such as teamwork were not as heavily emphasized. The general structure of LLCs, with the flexibility in program activities and focus on individual development, may not provide as many opportunities for students to practice, receive feedback, and reflect on the range of Job Performance competencies. As such, skills such as teamwork may need to be embedded in curricular experiences where students can combine their technical studies with the development of these professional competencies. With more exposure to these aspects of engineering throughout the curriculum, students may develop a more nuanced understanding of the role of these skills in engineering. However, the study by Dunsmore, which included sophomore to senior students, indicates a more widespread issue where students do not perceive the role of professional skills in "real" engineering work. Combined, these results indicate a need for students to develop a deeper understanding of the role of professional competencies in the engineering workplace and to gain experience using these skills in authentic learning environments during their undergraduate careers.

In addition to this required view, participants discussed professional competencies to different depths (levels), which highlights the complexities of these competencies. In previous descriptions of professional development, broad competencies that incorporate multiple facets are often identified. But the nuances and the complexities of these skills in practice often are not made explicit. The PD^2 Model begins to identify the complexity and nuances of these competencies from the perspective of students. For example, communication is described as an

essential skill in engineering (ABET, 2016; National Academy of Engineering, 2004a; Walther, Kellam, et al., 2011). However, research on communication skills in engineering indicates that perspectives on the role and importance of communication vary along a continuum (Leydens, 2008). This "continuum of rhetorical awareness" (to use Leydens' term) ranges from a denial of rhetoric in engineering to a view that rhetoric is an important aspect in engineering practice. Towards the denial end of this continuum, writers are perceived to convey objective data and readers are recipients of information who make decisions based on that information; towards the other end of the continuum, writers use rhetoric as spokespersons for change. In moving toward an understanding of the importance of rhetoric, which often occurs through situated workplace experiences, communicators consider the needs and expectations of the audience and make claims and proposals with supporting data. This continuum, as described by Leydens, aligns with the levels of internalization within the Communication category in the PD^2 Model. At an external level, women in the present study described communication as a required skill used to convey objective data to others and did not include elements of influence. This requirement aligns more with the denial end of the continuum of rhetorical awareness. At an internal level, women in the present study described communication as useful for persuading others to achieve a particular purpose. This internalized description of communication demonstrates more awareness of the importance of rhetoric in engineering communication where engineers have influence and information is not purely objective but is also subjective.

As demonstrated by the levels of internalization within the Communication category, the value in the PD^2 Model is not only in identifying important categories of professional development from the student perspective; the PD^2 Model also identifies variations in the ways in which women described these skills and their relevance in engineering. Because engineering communication is always situated in a context (Paretti, McNair, & Leydens, 2014), it becomes necessary to help students understand that data do not stand alone and that information must be interpreted and can persuade audiences and stakeholders. When viewed as an external requirement, communication can be perceived as separate from technical engineering work. In reality, this skill is integral to engineering work (Paretti et al., 2014). It is important, then, for students to not only know that communication is required in engineering (Level 1: Required) but to learn how to modify written and verbal communication to meet the needs of a particular audience (Level 2: Modified) and to learn the role of rhetoric in these contexts (Level 3: Used). Similarly, with other skills,

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particularly in the Job Performance domain, it is beneficial for students to understand the role and use of those skills in practice by developing a more internalized understanding of professional competencies.

When considering the level of internalization described by participants, it is important to take into account the role and focus of the LLC. LLCs, when incorporated into the first year, often support students in their transition to college (e.g., Everett & Zobel, 2012). As such, the focus is often to expose students to a broad range of skills as opposed to facilitating a deep understanding of these skills. For example, participants in WIE-LLC described LLC programming as, at most, providing exposure to skills such as teamwork which could facilitate an external view of the Working with Others skill. But many students described more internalized levels including Distributive and Collaborative teamwork. This identification of internalized levels for many of these competencies was encouraging and could indicate that exposure to a broad range of skills can then serve as a foundation for future development in curricular and other out-of-class experiences. The role of LLCs, and out-of-class experiences more broadly, is to complement and supplement curricular experiences, and necessary competencies should be incorporated into the curriculum itself. It becomes important, then, to consider the support that programs such as LLCs can provide and how experiences throughout the curriculum can build on the foundation provided previously to help students develop these professional competencies.

6.1.1.3   Differences between Student and Expert Views of Professional Development

In comparing the PD^2 Model with prior literature, the PD^2 Model can help identify differences between students' understanding of professional development and expert views. These differences can point to opportunities for further development. Differences that were identified include 1) lack of nuance within a category, 2) lack of explicit descriptions of necessary competencies, and 3) lack of inclusion of certain competencies. Student views of professional development, however, also highlight additions to expert views. Several competencies discussed by participants were not present in expert views, which indicates an opportunity to further support the professional development that students indicate that they need.

6.1.1.3.1   Gaps between Student and Expert Views

While many categories in the PD^2 Model included different levels of internalization, some categories did not, indicating a need for students to further understand the complexity of that

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competency. In particular, the Time and Task Management category consisted of only one level and included managing individual tasks and meeting deadlines imposed by others. In the present study, participants did not describe aspects of time and task management relevant in team and project settings, including coordinating and overseeing the work of individuals and projects. This ability to manage projects and manage the contributions of an entire team are important aspects of the work that engineers do, particularly in more senior-level positions (National Academy of Engineering, 2004a; Walther, Kellam, et al., 2011). The importance of managing not only personal tasks but that of teams and projects is further supported by the change in student outcomes identified by ABET, the accreditation body for engineering programs in the United States. As of the 2018-2019 academic year, a required outcome for engineering students will be to "function effectively as a member or leader of a team that establishes goals, plans tasks, meets deadlines, and creates a collaborative and inclusive environment" (ABET, 2016, p. 26). This ability to manage and lead teams is an important outcome that was lacking in the present study.

One possible explanation for this difference is that women in this study, as second-year engineering students, were in the process of learning how to manage their own time within a rigorous engineering curriculum and as a result, described similar aspects of time and task management in the engineering profession. As the women progress through their engineering programs and gain experience with engineering projects, time and task management related to managing projects and coordinating their work with that of others may become more prevalent.

A second reason for this difference may be related to the specific activities incorporated into the LLC and the LLC's focus on individual development. In describing beneficial LLC experiences, participants described activities that helped them develop skills necessary in managing their coursework and preparing for the job acquisition process. Participants, then, were able to see how individual time and task management could also apply in workplace settings. Authentic design projects, where students often develop additional time and task management skills related to projects, are typically incorporated towards the end of an engineering curriculum (Atman et al., 2014). LLCs, then, can provide initial support for students that complements experiences students will encounter at other points in the curriculum, such as large group projects where team management skills are more readily learned and applied. As a result, this focus on the personal

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aspects of time and task management when describing professional development could be related to the LLC's focus on helping students transition to college and balance their own commitments.

However, a third possible explanation for the focus on individual time and task management could be that early undergraduate students are focusing on more immediate goals, such as getting a job and performing in an entry-level position, as opposed to longer-term positions, including management. Learning to manage others and manage entire projects, then, may be perceived as a skill that engineers learn later in their careers. Due to this lack of nuance and because entry-level engineers often feel unprepared for managerial aspects of their work (e.g., R. Martin et al., 2005), further exploration is needed to determine if and how students gain these managerial competencies.

In addition to this lack of nuance within a category, women sometimes struggled to articulate specific nuances within a level. In the Considerations level within Engineering Judgment, for example, women listed a variety of considerations that must be recognized and accounted for in engineering designs but had a hard time clearly articulating and differentiating those considerations. For example, some women stated that multiple perspectives must be considered but did not identify specific groups, individuals, or stakeholders whose perspectives must be taken into consideration. In the field of engineering, engineers make decisions and must consider the impact of solutions on diverse groups (ABET, 2016; National Academy of Engineering, 2004a; Walther, Kellam, et al., 2011). In preparation for this role in the engineering workplace, students must learn how to address ill-structured problems that have vague or unclear goals, are evaluated against multiple criteria, and require judgment (Jonassen, Strobel, & Lee, 2006). Because the development of engineering judgment is often incorporated into design courses where considerations are weighed to make decisions (Weedon, 2016), students in the present study who were early in the curriculum may not have had many engineering design experiences nor encountered the range of considerations impacting engineering designs. So while the women often had a hard time describing engineering judgment in detail, several described the idea that a variety of factors must be considered in engineering decisions.

In other instances, competencies identified by experts were not made explicit by women engineering students but were embedded within other competencies. For example, creativity is often viewed as an important competency in engineering (e.g., National Academy of

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Engineering, 2004a; Walther, Kellam, et al., 2011). While some participants talked about creative solutions as an outcome of working with others, creativity was not explicitly described as an important skill in their professional development. This could be due, in part, to the narrative that while engineers help address new problems which require creative solutions (e.g., National Academy of Engineering, 2004a), engineering as a field is highly technical and not creative (Kazerounian & Foley, 2007). Additionally, the development of creativity is often not included in engineering courses (Daly, Mosyjowski, & Seifert, 2014). Certain contexts, such as design projects, do allow for creativity, but time constraints and pressures to generate a solution can serve as barriers to creativity (Kazerounian & Foley, 2007). This perception that engineering is technical, combined with a lack of time to develop creativity skills, could lead to the belief that engineers solve problems and generate solutions predominantly through skills such as teamwork and technical knowledge. Out-of-class experiences such as LLCs might be a freer space for students to develop skills such as creativity since there are often fewer constraints and requirements in these contexts.

In addition to competencies that were not differentiated or made explicit, certain competencies were not discussed by participants at all during interviews. Some skills from previous literature, such as leadership (Davis et al., 2010; National Academy of Engineering, 2004a) and empathy (Walther, Kellam, et al., 2011), were not included in descriptions of professional development in the present study. These gaps in women's descriptions point to a need for program and curriculum designers to decide where these competencies belong and whether or not specific skills fall within the scope and purpose of a particular program. In identifying the intended outcomes, it is important to note that individual programs, such as LLCs, cannot provide all the professional preparation necessary for engineering students. Programs, then, must determine what subset of competencies to include. In the present study, programming within the WIE-LLC focused on the subset of competencies related to Job Acquisition and helped students prepare for experiences such as internships where students could further their development. Because LLCs are typically incorporated early in an engineering program and curricular experiences often incorporate competencies related to Job Performance, this focus on the Job Acquisition domain of professional development is an important outcome of LLCs. While the focus of WIE-LLC was on Job Acquisition, women described beneficial experiences related to other domains of

professional development which indicates that these programs can help provide a broad foundation for future development.

In addition to identifying competencies to include, it is important for programs to help students see the relevance of those competencies. In the case of leadership, while not mentioned in interviews, 75% of interview participants indicated in the screening survey that they gained leadership skills through participation in WIE-LLC. This disconnect could indicate that students perceived that they gained leadership skills but that those specific skills were not related to their professional development as engineers. This would indicate that LLCs can support the development of skills such as leadership but that there is further opportunity to help students understand how leadership skills developed through LLC participation can be relevant to students' future careers.

In identifying alignments and gaps, the PD^2 Model can help facilitate discussion and collaboration within and between programs in order to support students' professional development. By comparing students' perceptions of the professional development relevant in engineering with the views of experts, gaps in students' views can be identified. Once gaps are identified, programs such as LLCs can intentionally design learning experiences to help students gain exposure to and practice with competencies that fall within the scope of the program. Beyond an identification of categories of competencies, the PD^2 Model describes levels within each competency which provides detail on the complexity of these competencies. By making these levels explicit, programs can help students better understand the nuances within categories of professional development. In addition to being a useful tool within a program, multiple groups and programs can come together and identify the range of competencies covered across programs. This collaboration between groups can help engineering programs ensure that competencies are covered during students' educational programs.

6.1.1.3.2   Additions to Expert Views

In addition to identifying gaps, comparison of student descriptions of professional development with the views of experts, such as practicing engineers and educators, also highlights professional development that students considered important but that eluded experts. The most salient aspect of professional development described by women engineering students pertained to skills necessary to enter an engineering position, such as an internship or entry-level position.

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Participating in these work experiences during an undergraduate degree program can increase the likelihood of receiving a job offer prior to graduation (Schuurman, Pangborn, & McClintic, 2008) and can help students develop competencies such as ethical development and leadership (Burt et al., 2011). Helping students develop the skills necessary to be hired for these positions, then, is a critical component of students' professional development. Women in the present study discussed the challenges of getting these positions and the need to learn about and adequately prepare for the process of applying for an engineering position.

The salience of the Job Acquisition domain could be heavily influenced by the focus of the LLC and the academic level of participants. Students often participate in internships and co-ops during the middle years of the curriculum, and as a result, students in their second year of college are often in the process of exploring internship possibilities. Additionally, WIE-LLC emphasized the importance of participating in these types of professional experiences during college and incorporated structured experiences to help prepare students for career fairs and the job acquisition process. The focus of the LLC, combined with students' current stage in their education, could have helped shape students' views of the importance of Job Acquisition in engineering professional development. The salience of this domain emphasizes a need to support students' in the development of competencies related to Job Application Components and Interactions in the job search process.

6.1.2 Professional Development for Women in Engineering

In addition to describing professional development that is beneficial for engineers broadly, women in the present study described several aspects of professional development that are particularly beneficial for women who are pursuing careers in engineering fields. In particular, women described the importance of career choice, confidence, and self-presentation in their professional development.

First, women discussed the importance of career interest and exploration in professional development. These aspects of career choice can help students better understand the engineering field and support persistence and retention in engineering. Many students who pursue engineering do not have a clear idea of what engineers do (for example, Matusovich, Streveler, Miller, & Olds, 2009b), and out-of-class experiences, such as LLCs, can encourage and help students learn about the engineering profession (Anderson et al., 2011; Atman et al., 2010;

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Sheppard et al., 2010). This understanding is particularly important for women in engineering since masculine stereotypes can lead to fewer women pursuing these fields (Cheryan et al., 2017). The women in this study discussed the importance of learning about the engineering profession by talking to professional engineers, exploring different experiences during their undergraduate experience, and identifying their interests in order to choose a path that they could pursue throughout their career. By providing professional development related to career choice, LLCs can help women better understand engineering fields and see the alignment between engineering careers and their own interests. This, in turn, can support the persistence of women in engineering.

Second, women in the study described the importance of demonstrating confidence in their interactions with others, and this confidence can play a crucial role in women's retention in engineering. Women engineering students often have lower self-efficacy beliefs (the belief that one can succeed at a given task or in a given situation) and lower confidence in their engineering skills than men (e.g., Besterfield-Sacre, Moreno, Shuman, & Atman, 2001; Jones, Paretti, Hein, & Knott, 2010; Matusovich, Streveler, Miller, & Olds, 2009a). Self-efficacy has been shown to relate to students' intentions to persist in engineering (Mamaril, Usher, Li, Economy, & Kennedy, 2016; Marra, Rodgers, Shen, & Bogue, 2009), and lower self-efficacy can reduce the likelihood that women engineering students complete degrees in engineering (Cech et al., 2011; Mamaril et al., 2016). Combined, these studies highlight the importance of confidence in the persistence and retention of women in engineering. In the present study, women described the need to convey confidence in order to differentiate themselves from other applicants in job acquisition environments and when interacting with their co-workers in workplace environments. Whereas other studies have indicated that confidence and the belief in one's abilities are important for continuing in an engineering major, the results from this study indicate that displaying this confidence to others in engineering contexts is a key component of professional development, and one that LLC program designers can support.

Third, in contrast to prior literature on adaptability in engineering professional development, women in the present study discussed the importance of being able to adapt how they presented themselves. In engineering, adaptability often relates to understanding new issues and contexts (ABET, 2016; National Academy of Engineering, 2004a), being able to respond to those issues

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and apply knowledge in new ways (e.g., Davis et al., 2010), and being able to adapt and be flexible within a dynamic workplace (Walther, Kellam, et al., 2011). In contrast, when the women in the current study discussed adaptability, it was primarily in regards to adapting how they presented themselves. For example, participants discussed adapting how they described themselves in job application components (Job Acquisition) and adapting how they presented themselves in workplace settings (Job Performance). This adaptation of self-presentation may be more prevalent from the student perspective because the structure of job acquisition and workplace environments is unfamiliar for many students (Atman et al., 2010). Because of its unfamiliarity, students must learn how to present themselves in new ways, including appropriate behaviors and appearances. In engineering, in particular, learning these appropriate behaviors may be particularly salient for women. Certain behaviors help individuals fit into engineering environments, and these aspects of self-presentation are often gendered, as described in the excerpt below.

> "[The culture of engineering] values behaviors and orientations consistent with the male gender role. […] Competence as an engineer is a function of how well one presents an image of an aggressive, competitive, technically oriented person. The *style* of this interactional presentation is as important as its substance. Here gender roles are important. To be taken as an engineer is to look like an engineer, talk like an engineer, and act like an engineer. In most workplaces this means looking, talking, and acting male. Of particular importance in this presentation of self is the image of hands-on competence" (McIlwee & Robinson, 1992, pp. 20–21).

Engineers, then, must not only possess the necessary skills and competencies to complete the necessary work; they must also have the appearance of competence as an engineer. The women in the present study discussed the need to present themselves in a particular way. From an external view of self-presentation, women described learning behaviors and appearances that were expected. While not explicitly stated by participants, this could include conforming to more masculine interactions which can be problematic. Adapting how one presents themselves can be a strategy to project a professional image in order to be viewed as an engineer (Hatmaker, 2013). And in engineering, this can involve projecting a more masculine image. However, strategies to conform to a particular environment can sustain the current masculine culture in engineering

workplace contexts (Hatmaker, 2013). Additionally, the belief that engineering does not align with individual-values, interests, and sense of self can lead to more women leaving the profession (Cech et al., 2011). If women must conform to masculine behaviors in the workplace environment, they may perceive that engineering is not a good fit and choose to leave the field.

It is interesting to note, however, that from an internalized level, the women in this study described displaying not only characteristics that were expected, but characteristics, such as confidence, kindness, and technical competence, that they personally considered important. This more internalized view indicates that participants were not merely conforming to the environment in which they were in; these participants wanted to display characteristics that aligned with their personal values. This highlights an important opportunity for LLCs to help women learn to be authentic in engineering environments. While external views of self-presentation may provide students with strategies that can help them fit in to a particular environment, helping students develop more internalized views of self-presentation might help students find alignment between their own interests and values and that of engineering. In engineering, women may have to find a balance between these two views.

6.1.3   Summary of Professional Development from the Student Perspective

As described in this section, the PD^2 Model identifies aspects of professional development that students described as necessary in engineering. Several categories of competencies align with previous literature. However, several notable differences were identified. Gaps existed between student and expert descriptions, including several competencies that were not described by students. Student descriptions also articulated several additional competencies within the Job Acquisition domain that were not present in expert descriptions. Finally, several competencies described by students can be particularly beneficial in supporting women in engineering. These aspects of professional development from the student perspective identify opportunities to support students and provide further development. By identifying the student perspective, educational experiences can be designed to provide students professional development known to be necessary in engineering as well as professional development that students indicate that they need as they pursue their careers. The LEEPD Model, described in the next section, can help with the design of these experiences.

6.2   Discussion of Beneficial Professional Development Experiences

The second part of the study explores features of experiences that women find beneficial for their professional development. The research question guiding this part of the study was: "What features of experiences within an LLC for women in engineering do students perceive as contributing to their professional development?" During interviews, women described a variety of experiences, and these experiences were analyzed to identify key features. To facilitate transferability of these findings, the features, as opposed to experiences, are described in this study. These features comprise the LEEPD (Learning Experiences for Engineering Professional Development) Model.

6.2.1   LEEPD Model and Kolb's Theory of Experiential Learning

The features in the LEEPD Model both operationalize and extend previously established learning theories, in particular Kolb's Theory of Experiential Learning (Kolb, 2015). As discussed in Chapter 5, the features of beneficial experiences include exposure, practice, feedback, reflection, and revision.

Many of the features in the LEEPD Model align with the aspects of experiential learning identified by Kolb. In Kolb's Theory of Experiential Learning (Kolb, 2015), learning is a process where concrete experiences, reflective observation, abstract conceptualization, and active experimentationn transform experiences into knowledge. As described in this model (Kolb, 2015; Kolb, Boyatzis, & Mainemelis, 2001), concrete experiences occur when a learner uses their senses to experience the world around them. The learner can then observe the world and consider their experiences in reflective observation. These reflections and observations can be combined and distilled into theories and concepts that are more abstract (abstract conceptualization), which can then be tested (active experimentation). These experiments serve as the foundation for new experiences (concrete experiences). During concrete experiences and abstract conceptualization, learners take in new information. That information is then transformed during active experimentation and reflective observation. In Kolb's idealized process, learners experience all four of these stages in a cyclical process, as shown in Figure 12.
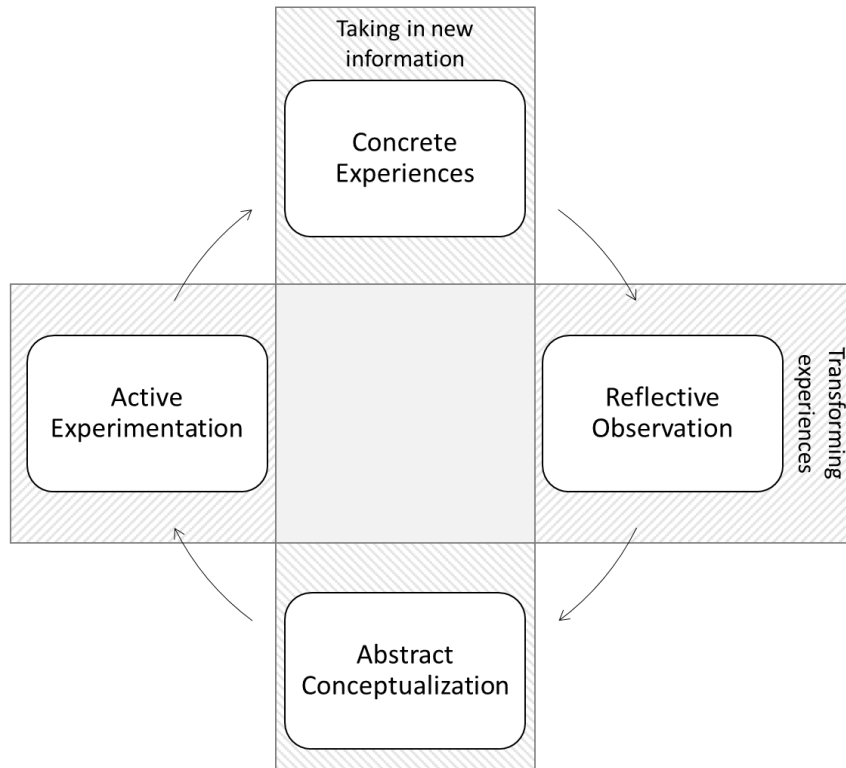
Figure 12. Kolb's Theory of Experiential Learning (adapted from Kolb (2015))

Features of the LEEPD Model align with and help contextualize several elements of Kolb's Theory while extending it in several important ways (Figure 13). One feature of the LEEPD Model was exposure, which included exposure to concepts with which students could practice and experiment. The exposure feature aligns with the abstract conceptualizations element of Kolb's theory. The second feature of LEEPD was practice, which included practice developing and implementing what was learned. When this practice involved development, participants could try using the theories and strategies that they were exposed to, which aligns with active experimentation. When practicing implementation, participants engaged in experiences where they could put into effect what they had learned to feel what it is like to not only test, but actually use, what they learned. This aspect of practice aligns with concrete experiences. The LEEPD Model additionally includes reflection and feedback. While Kolb's theory includes reflective observation, it does not explicitly include feedback. Therefore, the feedback feature that emerged in this study extends Kolb's theory. Finally, while the cyclical nature of Kolb's cycle implies revision, the LEEPD Model makes this feature explicit.
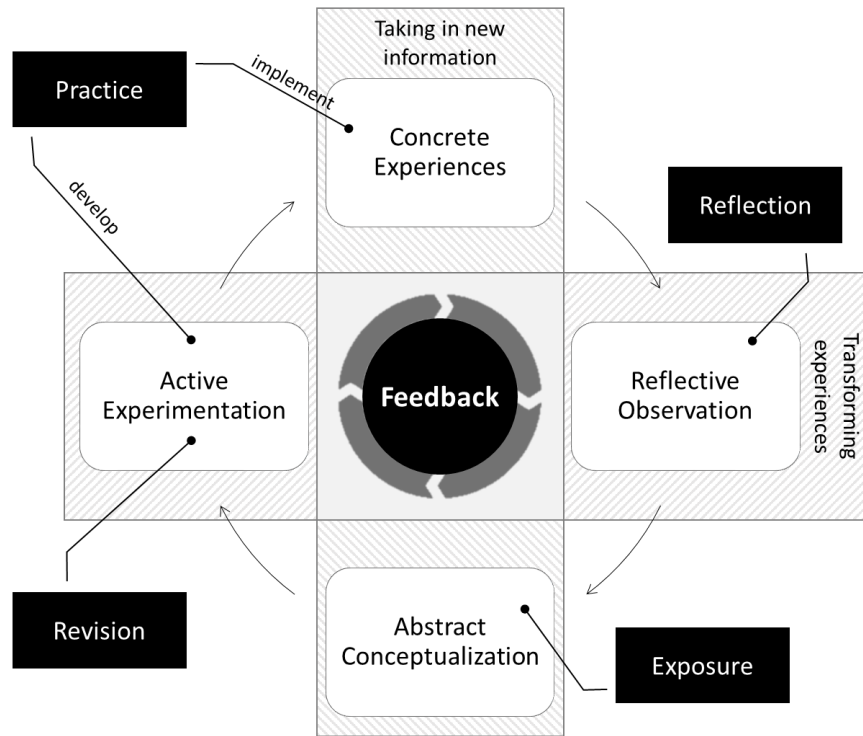
Figure 13. Mapping of LEEPD Features to Kolb's Theory of Experiential Learning

While Kolb's Theory is applicable for learning broadly, a benefit of the LEEPD Model is that it specifies features of learning experiences that support women engineering students' professional development and makes these features more specific. The first feature described in the LEEPD Model is exposure. While Kolb's theory specifies abstract conceptualization, which is similar to exposure, the exposure feature in the LEEPD Model specifies aspects of exposure that are beneficial for supporting women engineering students in LLCs, including exposure to processes, strategies, environments, engineering practice, connections, and opportunities. Whereas Kolb's Theory is beneficial for understanding learning from a broad perspective and can encompass a variety of contexts, the additional nuance provided by the LEEPD Model is beneficial when implementing learning experiences in out-of-class experiences for women in engineering.

In addition to providing specificity on different types of exposure experiences, the LEEPD Model similarly identifies different types of practice and a range of environments in which beneficial practice occurs. Types of practice in the LEEPD Model include practice developing as well as implementing what is learned. These features of the LEEPD Model align with active experimentation and concrete experiences, respectively, in Kolb's theory. The LEEPD Model, however, provides additional specificity as to the environments in which this practice takes place

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and identifies the importance of practice in casual, low-stakes, and authentic environments. Research in engineering education contexts often emphasizes the importance of learning experiences, such as case studies and PBL (Project- or Problem-Based Learning) experiences, that allow students to gain practice with authentic problems (e.g., Prince & Felder, 2006), and engineering students often participate in workplace experiences, such as internships, to gain practice in authentic work environments (Brush, 2013). In the context of the LLC, participants described opportunities to gain practice with authentic problems not only in authentic environments but also in casual and low-stakes environments. This ability to practice in a range of environments, including authentic environments, is an advantage of LLCs over structured courses. To capture this variation, the LEEPD Model emphasizes the benefit of practice in these different environments which provides important nuance that is not captured in more broadly applicable descriptions of learning experiences.

In addition to providing specificity, the LEEPD Model makes aspects of beneficial experiences, including reflection, feedback, and revision, more explicit. First, the LEEPD Model explicitly incorporates reflection, which aligns with Kolb's Theory; but this reflection is often not explicitly incorporated into contexts within engineering. Reflection has been described as important in professional practice where problems are complex and practitioners must make judgments (Schön, 1987). And reflection in engineering contexts can help students examine assumptions and values as well as the impact of decisions (Cunliffe, 2004) and can help students develop professional skills such as teamwork (Hirsch & McKenna, 2008). In engineering education, there are a variety of opportunities to incorporate reflection through portfolios and reflective exercises (Turns, Sattler, Yasuhara, Borgford-Parnell, & Atman, 2014; e.g., Walther, Sochacka, & Kellam, 2011). While efforts are being made to incorporate reflection into engineering education (Thomas, Orand, Shroyer, Turns, & Atman, 2016), experiences that incorporate this feature are not necessarily the norm in engineering. Because LLCs are designed to connect various aspects of students' learning, they provide a unique opportunity to incorporate reflection on broader aspects of the engineering education experience.

Second, while not explicitly stated in Kolb's Theory, the LEEPD Model identifies the importance of feedback from a variety of sources, ranging from peers to experts, in developing professionally. Feedback, or evaluation from external sources, can help students develop

necessary skills in engineering, including design skills and professional skills (e.g., Bjorklund, Parente, & Sathianathan, 2004; Hurst & Nespoli, 2016), and the women in the present study discussed the importance of feedback in their professional experiences. Both giving and receiving feedback have been perceived as beneficial practices in engineering education contexts (Ekoniak, Scanlon, & Mohammadi-Aragh, 2015), and the participants in the current study described the value in receiving feedback from a variety of sources, including peers, instructors, and engineering professionals. These other sources of feedback can provide valuable perspectives from which students can learn. For example, through peer reviews, students can learn from other students and see alternative perspectives (e.g., Hurst & Nespoli, 2016). And in providing feedback to their peers, students not only evaluate the work of their peers, they often evaluate their own work in the process (Nicol, Thomson, & Breslin, 2014). Additionally, in the present study, feedback from recruiters was described as beneficial in providing authentic perspectives. While some have argued that feedback is implicit in Kolb's Theory and plays a part in moving the learner from one stage in Kolb's theory to another (Hill, 2007), the LEEPD Model extends this work by explicitly incorporating this feature.

Finally, while implicit in Kolb's Theory, the LEEPD Model explicitly states the importance of revision. The cyclic nature of Kolb's Theory implies that learners revise based on previous experiences and continue to repeat the cycle. However, the LEEPD Model makes this revision an explicit feature in beneficial learning experiences. Participants described the benefit of being allowed or encouraged to make modifications or changes to what they were practicing, whether that was résumés or elevator pitches, based on both internal and external evaluations (reflection and feedback, respectively). This revision helps students learn from and incorporate feedback in order to improve (Moore & Ranalli, 2015). But revision is often not explicitly incorporated into structured learning experiences such as engineering course assignments due to time constraints (Ekoniak et al., 2015). In these instances, feedback is summative as opposed to formative. The environment of the LLC can allow for revision and provides an advantage over curricular experiences in that out-of-class experiences do not face the same time constraints as curricular classes. The LLC structure, then, provides additional opportunities for students to revise and incorporate feedback.

While several of the features of LEEPD model relate to aspects of Kolb's theory of experiential learning, there are several important and useful distinctions. First, whereas Kolb's Theory identifies aspects in the process of learning broadly, the LEEPD model identifies specific features of beneficial professional development experiences for women in engineering. This specificity helps articulate aspects of experiences that can support this population in their professional development. Second, by specifying features, the LEEPD Model emphasizes the flexible combination of features to meet the needs of the student population. Cyclical models, such as Kolb's, illustrate an idealized process where each element follows the next. However, learning often is not cyclical. The intent of the LEEPD Model is to allow for features to be sequenced in a variety of combinations, repeating features if necessary, to create meaningful learning experiences that meet a variety of needs and help students further their development in a particular context. This flexibility is particularly important in out-of-class experiences such as LLCs to create a variety of experiences in which students can choose to engage. Because LLCs are often designed to provide several different options as opposed to cover a certain amount of content, the LEEPD Model better supports this adaptability.

6.2.2   Beneficial LLC Experiences

Beneficial experiences within the LLC exposed students to broad competencies within all three domains of professional development. Experiences targeting broad competencies from the PD^2 Model (e.g., categories within Job Performance and Personal Development) primarily incorporated the exposure feature of the LEEPD Model to promote awareness of the topic. This awareness can provide a foundation of professional development that students can build upon in future years. Building a strong foundation is particularly relevant for programs such as LLCs that are incorporated in the first year of an engineering program.

While experiences within the LLC exposed women to a broad range of competencies, the most salient experiences focused on professional development related to Job Acquisition. These competencies were most relevant for the student population, and beneficial experiences related to these competencies incorporated a range of features from the LEEPD Model. Since the student population in WIE-LLC consisted of first-year students, many women described the need to learn about job acquisition experiences which involved new processes that had not encountered before in unfamiliar contexts. The most salient beneficial experiences, then, not only exposed

students to this development but incorporated the full range of features from the LEEPD Model. While each individual experience included various configurations of LEEPD features and did not necessarily include all features, the combination of experiences that helped students develop competencies within Job Acquisition utilized the full range of features from the LEEPD Model.

For these experiences, both those that exposed women to broad competencies and those that were focused on narrower competencies, a benefit was the ability for students to continue to build on what they learned throughout the undergraduate education. By exposing students to a wide variety of professional development topics in their first year, students can build on this foundation and gain further development throughout their undergraduate education. For example, exposure to the idea of working with others in diverse contexts can be a beneficial experience when students get to design courses towards the end of the engineering curriculum. Similarly, by gaining experiences applying for jobs early in their college career, participants are able to continue to practice and apply what they learned in future job acquisition settings. LLCs, then, can not only cover a broad range of competencies but can incorporate focused activities that support the development of outcomes most relevant for the student population. And these experiences can support women's development throughout their undergraduate programs.

The results of this study extend and build on prior literature describing the benefits of participating in LLCs. As described in the literature review, existing research has shown that participation in these communities leads to many benefits broadly, including an easier transition to college (Everett & Zobel, 2012), increased persistence and retention (Micomonaco, 2011), increased interaction with faculty and peers (Everett & Zobel, 2012; Sriram & Shushok, 2010), and the development of specific outcomes such as leadership skills (Micomonaco, 2011). While the current study does not measure outcomes, it helps the engineering education community understand how these programs support students' professional development. The results of this study identify features of beneficial experiences within LLC contexts that participants perceive as supporting their professional development. These experiences demonstrate the potential for LLCs to incorporate professional development experiences that support women in engineering as they pursue engineering degrees.

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6.3 Summary

The results of this study provide valuable insights into professional development in engineering education contexts. The PD^2 Model identifies categories of professional development, and levels within each category, from the perspective of women engineering students. Identifying the student perspective is an important step in helping program designers better understand students' needs and beliefs. By comparing the student perspective with prior literature, gaps in students' descriptions were identified. The student perspective also highlighted categories of professional development that students view as important in their engineering programs. This student perspective provides valuable insight into the ways that LLCs can support the intended student population.

The LEEPD Model identifies features of beneficial professional development experiences within the context of LLCs. This model provides necessary specificity and makes features that are often implicit in learning experiences explicit. While experiences within WIE-LLC primarily focused on supporting professional development related to Job Acquisition, experiences additionally supporting students' professional development related to Job Performance and Personal Development. The features of the LEEPD Model, identified from beneficial experiences within the LLC context, can be combined in a variety of combinations to create meaningful learning experiences based on the needs of the students and the particular context in which the learning takes place.

Chapter 7: Implications and Future Work

This study examined women engineering students' views of professional development in engineering and the experiences within living-learning communities (LLCs) that can support that development. Women's views of professional development are captured in the PD^2 Model and features of beneficial professional experiences are identified in the LEEPD Model. These two models can be combined to help prepare professional engineers who have the competencies necessary to be successful in their future careers. The implications and potential uses of these models are discussed below.

7.1 Adaptations

While the PD^2 Model consists of multiple categories of professional development from the student perspective, this model can be modified to incorporate additional categories and levels of professional development. The y-axis of the PD^2 Model spans from narrow to broad contexts and can be used to identify additional categories of professional development that programs intend to incorporate. For example, LLCs might focus on supporting students' leadership development, which helps students develop skills for their future careers (Job Performance domain). The x-axis of the model spans from external to internal and can be used to identify variations within each category. To expand on the example of a leadership category, levels could include required, technical, and collaborative (Rottmann, Sacks, & Reeve, 2015).

Once intended categories are identified, educational experiences targeting these competencies can be incorporated into LLC contexts using the LEEPD Model. By identifying features, the LEEPD Model promotes the flexible combination of features in order to facilitate the creation of learning experiences to meet the needs of students within a particular context. This flexibility is particularly beneficial in out-of-class experiences such as LLCs, which are focused more on exposure to broad experiences as opposed to content coverage, as is the case in many engineering classrooms. LLCs can provide students with a variety of optional experiences to support students' development, and these experiences can incorporate a variety of features. Without the same time constraints that are found in curricular environments, LLCs can more easily incorporate features such as revision and practice in a variety of environments.

In addition, because features such as exposure and practice can cover a wide range of topics and include a variety of environments, the LEEPD Model provides specificity on the aspects of these

features that women found beneficial. In addition, whereas certain features, such as feedback and revision, are often implicit in theories and learning experiences, the LEEPD Model makes these features explicit. By providing specificity, identifying features explicitly, and emphasizing the non-cyclical nature of these learning experiences, the LEEPD Model can be adapted to meet diverse needs and support the development of diverse outcomes which provides several advantages over other theories such as Kolb's Theory of Experiential Learning (Kolb, 2015).

7.2 Implications

The PD^2 and LEEPD Models have several implications. The following sections describe these implications and recommendations for using these models in a variety of contexts.

7.2.1 Implications for LLCs

The PD^2 and LEEPD Models can help LLCs support the professional development of women in engineering by helping programs both identify desired outcomes for participants and intentionally structure beneficial experiences to help students achieve the desired outcome.

Because LLCs designed to support women in engineering are typically incorporated into the first year of an engineering program, these programs are beneficial sites for incorporating programming related to Job Acquisition and Personal Development. This programming can supplement and complement professional development related to Job Performance that is often incorporated into curricular contexts. However, LLCs can also be beneficial sites for exposing students to professional development related to Job Performance. LLCs aiming to support women engineering students' professional development should first determine what specific professional development outcomes are most beneficial to incorporate.

The PD^2 Model can help LLC administrators and instructors identify these outcomes for programs broadly as well as for specific experiences within the LLC context. For example, an outcome of an LLC may be to help students learn about, build, and adapt job application components to prepare them for internships during their undergraduate career. Experiences incorporated at the beginning of the LLC experience, then, may focus on exposing participants to the steps and job application components that are required when applying for an engineering job. Subsequent experiences may build on this initial exposure and focus on helping students learn how to build and adapt job application components. The PD^2 Model can help those in charge of LLC programming identify not only the category of competency intended for students to develop

but also the specific level. Identifying more specific outcomes can be beneficial when designing learning experiences targeting those outcomes.

The PD^2 Model also makes explicit several categories and levels of professional development that are particularly beneficial for women in engineering, which can be particularly helpful for programs designed to support these populations. Categories such as career choice and self-presentation and levels such as confidence in interactions can be particularly important for these populations. When determining the professional development outcomes for LLCs designed to support women in engineering, programs should consider incorporating professional development broadly as well as aspects of professional development that can be particularly beneficial for women.

In addition, LLCs should consider students' prior experience and knowledge. In some instances, the aim may be to help students develop a more internalized understanding of the competence category; alternatively, the aim may be to help students broaden their understanding of the category and gain a more external awareness of the competence category. In general, within the Job Acquisition and Job Performance domains, students typically begin with an external understanding of the intended category of professional development. LLC programming, then, should help students move from this external view to a more internalized understanding of the competency. For example, LLCs may choose to focus on outcomes pertaining to Job Application Components (within Job Acquisition). An initial outcome may be to expose students to the required components in the process of applying for a job (Level 1: Required). Final outcomes may be for LLC participants to be able to adapt their job application materials to better represent who they are in job acquisition settings (Level 3: Adapt). In categories within Personal Development, on the other hand, LLCs may incorporate activities that build on students' interests (a more internalized level in the PD^2 Model) and help students explore different careers and opportunities that align with those interests. In this example, the intended outcome is to help students develop a more external view of the career choice category by exploring the career options available. Depending on the prior experiences of participants, LLCs should consider whether the aim is to help students develop a more internalized or more externalized understanding of the competence category.

By using the PD^2 Model to identify the specific competency level when determining LLC outcomes, instructors and peer leaders involved in leading experiences for students can be more aware of the specific outcomes for those experiences which can then be communicated to students. This transparency can help students better understand the nuances and relevance of those competencies for their future goals and can help LLCs better design learning experiences to meet specific outcomes. The communication of outcomes to students is an important consideration for LLCs. In the present study, women occasionally struggled to articulate the outcomes of specific experiences and identify whether or not specific experiences supported professional development. In these instances, women typically described the experience as not very meaningful. This example indicates the importance of communicating outcomes to students so that students understand why the experience can be beneficial. LLCs should use the PD^2 Model to identify more specific outcomes in order to better support students' development. Once identified, these outcomes should be communicated to LLC participants to help ensure that students understand the intended outcomes for specific experiences.

In addition to using the PD^2 Model to communicate outcomes to students, this model can be used to communicate the benefits of LLCs to other programs and courses that support engineering students' professional development. This communication across contexts within a university setting can help ensure that students receive professional development related to all three domains of professional development, not only the development of skills related to Job Performance, and that experiences supplement each other. In some instances, participants indicated that introductory engineering courses incorporated professional development that duplicated professional development experiences incorporated in the LLC. Learning experiences throughout the university experience should allow for future experiences to build on prior ones. And the PD^2 Model can facilitate these conversations about what development is included in various experiences. In designing learning experiences for LLCs intended for women in engineering, LLCs can communicate the outcomes of experiences within LLCs to other contexts, such as introductory engineering courses, to help ensure that experiences complement and supplement LLC experiences rather than duplicate these experiences.

Once outcomes are identified, the LEEEPD Model can be used to design learning experiences that support the development of the intended outcome. In the design of experiences, LLCs should

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select and sequence features from the LEEPD Model to help support the development of the intended outcome. Expanding on a previous example, LLCs may aim to help students learn about and develop job application components, such as résumés. Depending on students' prior experience and knowledge, features of the LEEPD Model could be sequenced to create an experience where students 1) learn about the goal of a résumé and examine a variety of examples (exposure), 2) create their own résumé (practice developing), 3) review a peer's résumé (give and receive feedback), and 4) revise their résumé based on feedback (revision). LLCs should intentionally structure learning experiences and incorporate LEEPD features that can help students develop the intended outcome. The flexibility of the LEEPD Model allows LLCs to select and sequence LEEPD features in a variety of configurations to support the intended student population.

For LLCs designed for women in engineering, experiences should provide exposure to a variety of topics and allow students to practice in a variety of environments. The women in the present study described the benefit in being exposed to processes, strategies, and topics that were unfamiliar and being able to practice in contexts where it was acceptable to make mistakes. While this could be beneficial for all engineering students, this is particularly important for women who remain underrepresented in engineering. Encouraging women to practice and begin their professional development early in their careers could provide long-lasting benefits and help women see that all engineering students are continuing to learn and develop throughout their educational and professional careers.

In designing experiences, it is also important for LLCs to consider how the experience is categorized. In the present study, women often described professional development experiences that were labeled as professional development by the LLC and did not identify other experiences as supporting their professional development. As an example, when describing beneficial professional development events, participants would often list off the events that they attended in order to receive "professional development credit" (the LLC had a requirement to attend a certain number of professional development, social, and academic events). Even though other experiences could support students' professional development, as identified in the PD2 Model, participants often described these events as separate from professional development events. These student perceptions indicate the importance of how experiences within the LLC context

are presented to students. One recommendation is to not have "professional development events" but rather to have students attend a variety of events and reflect on their experience after it concludes and describe how the experience supported their professional development.

LLCs can additionally use the LEEPD Model to develop experiences that build on prior programming. LLCs can sequence experiences over extended periods of time where different experiences incorporate additional features of the LEEPD Model. For example, an intended outcome may be to help students learn how to adapt their résumés to highlight strengths. Initial experiences may help students learn first about the structure and purpose of résumés through exposure to strategies (exposure) and practice developing these components (practice). Additional experiences can be designed to build on this initial experience and help students adapt their résumés through reflecting on their experiences within the LLC and college more broadly (reflection) and through feedback from recruiters on what companies are looking for (feedback). LLCs, then, should consider the features of individual experiences in the program as well as how combinations of experiences can support students' professional development.

This flexibility in the PD^2 and LEEPD Models helps LLCs identify intended competencies to incorporate into LLC experiences and, based on the needs and prior experiences of students, design experiences that can support students' professional development.

7.2.2 Implications for Administrators

In addition to identifying outcomes and designing learning experiences within the LLC context, the PD^2 Model can be a useful resource for coordinating efforts to support students' professional development across programs and departments. LLCs provide opportunities to support students' personal development, prepare students for the job acquisition process, and provide students with a broad awareness of the professional competencies in engineering. This foundation provided by the LLC, then, can be built upon in future years and in curricular environments. However, in the present study, participants occasionally described experiences in multiple contexts that were repetitive and redundant as opposed to complementary. While repetition and revision can be beneficial in the learning process, as described previously, it is important that experiences build on and complement other experiences. Administrators can use the PD^2 Model when creating new LLCs and can use the model to coordinate the intended outcomes across curricular and out-of-class programs to provide more holistic professional development.

When developing a new LLC, administrators can use the PD^2 model to determine the outcomes (category and level) for these programs. LLCs may choose specific professional development outcomes depending on the type and focus of the program. LLCs that are designed to support women in engineering should consider incorporating professional development that can be particularly beneficial for women engineering students, such as professional development related to confidence and career choice. LLCs that support engineering students broadly may choose to provide a wide selection of opportunities and allow students to select the experiences that would be most beneficial for them. For example, some experiences may be aimed at helping students convey confidence during interactions in Job Acquisition settings; other experiences may expose students to necessary competencies in Job Performance settings. By providing a breadth of opportunities, students can identify and participate in those experiences that they perceive would be most beneficial. Depending on the focus of the LLC, administrators should identify outcomes for the program that can support the specific LLC population.

In addition, the PD^2 Model can be used to facilitate conversations between administrators in different programs in a university. Advisors, instructors, LLC program administrators, and other groups involved in supporting engineering students can use the PD^2 Model to determine the professional development in these various contexts to ensure that students are receiving opportunities to develop a range of professional competencies throughout their college experience. For example, advisors often play a crucial role in helping students explore career options and identify opportunities to engage in during their undergraduate experience; instructors of design courses often support professional development related to Job Performance, and LLCs can provide support related to Personal Development and Job Acquisition. Each of these groups should be aware of the professional development efforts in other contexts and coordinate efforts to provide complementary experiences that support all three domains of professional development. The PD^2 Model can be used to facilitate these conversations about the professional development for engineering students.

The PD^2 Model can be a useful resource for administrators and individuals across programs to examine and intentionally structure the professional development opportunities for engineering students and for women engineering students.

7.2.3   Implications for Faculty

Similarly, the results from this study could be used by faculty and instructors who incorporate professional development in curricular contexts. First, curricular contexts can support engineering students' professional development related to Job Performance, and the PD^2 Model could help faculty identify outcomes (category and level) in these contexts. The categories within the Job Performance domain are broad, and the PD^2 Model can help faculty identify more specific levels within those categories. When students learn competencies such as working with others and communication, they may not develop an internalized understanding unless learning experiences are intentionally structured to incorporate the complexity of these competencies. Through curricular experiences such as design projects, students may learn that communication is a requirement in engineering and may learn that communication needs to be modified to the particular context, but they may not understand how communication can be used to persuade or convince others unless learning experiences are intentionally structured to support this development. By identifying more specific outcomes of these broad professional development competencies, faculty can help students further their development.

Once outcomes are identified, the LEEPD Model can assist faculty in developing assignments and activities that support this development. Features from the LEEPD Model can be intentionally structured depending on the duration of the experience, the prior experience of students, and the intended outcome. To continue with the prior example, faculty of design courses may aim to help students develop communication skills and learn how communication can be a useful tool. Learning experiences, then, could expose students to concepts such as negotiation and persuasion and have students practice this communication, receive feedback on their communication, and revise their methods of communication depending on the audience. The incorporation of these features could help students learn that communication is not only a requirement in engineering, but that communication is important to meet their goals as an engineer.

Additionally, these models could be used to examine existing efforts to support students and identify opportunities for further development. Faculty could use the PD^2 Model to identify the outcomes of existing experiences in their courses and identify if additional development would be beneficial and should be incorporated. Using the PD^2 and LEEPD Models, faculty of

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introductory courses, for example, could provide students with resources on career opportunities in a particular field and encourage students to explore what careers are interesting to support professional development related to career choice. These experiences could provide additional opportunities for professional development.

Finally, faculty who teach courses across an engineering curriculum can collaborate to provide a variety of experiences that support women's professional development in engineering. Introductory courses might choose to focus on professional development related to the Personal Development and Job Acquisition domains, and courses later in the curriculum may emphasize professional development related to Job Performance. This collaboration across a curriculum can help ensure that engineering students receive necessary and beneficial professional development that can help them enter in and be successful in their future careers.

7.2.4   Implications for Students

In addition to being beneficial in the design of educational experiences, the results of this study can be beneficial for engineering students who are pursuing their degrees. The PD^2 Model can help students identify various aspects of professional development that will be beneficial for them both as they apply for engineering positions and as they prepare for their future roles in those positions. By providing an overview of the various elements of professional development in engineering, students can better understand the complexity of engineering work and gain experiences that can support the breadth of development necessary in engineering.

The PD^2 Model also can help students better describe their experiences and the competencies they gained through participation by providing language to discuss professional development. Often, students struggled to articulate the full range of benefits that they gain through participation in an activity, and the PD^2 Model can help students better describe those experiences. For example, students may have difficulty explaining the competencies that they gained through mentoring a younger student. The PD^2 Model can be used to help students see that they likely gained communication skills (for example, the ability to modify and use communication to connect with and help their mentees), time management skills (for example, when scheduling meetings with their mentee), and other professional skills (for example, leadership) through their mentoring experience. Providing this language to talk about

experiences can also help students talk about their experiences and qualifications during interviews and career fairs.

The LEEPD Model can help students think about their own learning experiences and preferences. By understanding what is helpful for them, students can seek out these features to further their own development. For example, students may realize that they value feedback from peers when developing job application components in order to understand how other people present themselves in writing and in person. This student, then, can continue to seek out feedback from others when updating components such as résumés and when preparing for different types of interviews. The LEEPD Model can help students understand various features of experiences that they find beneficial so that they can seek out and incorporate these features in future experiences.

7.2.5   Implications for the Research Community

In addition to benefiting practitioners and engineering students, the results of this study can benefit researchers who study professional development for women in engineering as well as those who study professional development in broader contexts. The PD^2 Model, in particular, can provide a systematic view of professional development in engineering education contexts which can be used in future research. Researchers can use the model to determine the effectiveness of professional development experiences by identifying the outcomes that students gain by participating. The model can also serve as a useful framework for identifying the perceptions of professional development among other groups of students. This can serve as a useful comparison to identify the most salient aspects of professional development for different groups (e.g., women, underrepresented minorities, transfer students, first-year students, etc.). An additional benefit of the PD^2 Model is that it is amenable to changes and modifications. Therefore, this model can be changed and modified based on the context and population. For example, the model can be expanded and/or adjusted to capture professional development for more senior students or students in a particular major. The LEEPD Model also provides a beneficial framework that can be used to better understand specific learning experiences in out-of-class programs, such as LLCs. This model can help educators identify the features included in experiences, both in and out of classroom environments. Researchers can additionally use the LEEPD Model when designing and evaluating experiences in engineering education contexts.

7.3 Transferability

Given the focus on a single site and a single LLC, the findings from this study are most directly applicable within this context. However, similarities between this site and similar institutions, as well as the partner program for first-year male engineering students, suggest that the results are likely applicable in other contexts.

The results of the PD^2 Model, including the domains, categories, and levels, are likely transferable to other LLCs for women in engineering as well as other contexts that support women engineering students, including support programs and student organizations (e.g., Society of Women Engineers). Because this model captures student perceptions of professional development broadly (not just professional development included in the LLC), this model has transferability to contexts designed to provide women with the professional development necessary to be successful in their careers. Several categories and levels in the PD^2 Model were more specific and applicable to women (e.g., confidence and self-presentation), and this identification of professional development for women in engineering could be useful for other organizations, beyond LLCs, that support these populations.

While the specific categories and levels of the PD^2 Model are more likely limited to contexts that support women in engineering, the domains in the PD^2 Model have additional transferability to contexts that support engineering students' professional development. The three domains of professional development capture broad aspects of professional development that are relevant in engineering, and many categories aligned with prior descriptions of necessary professional development in engineering. The PD^2 Model, and the domains in particular, likely can transfer to engineering students more broadly.

For the LEEPD Model, features of experiences were identified, as opposed to experiences themselves, to facilitate the transferability of the findings. The five primary features of the LEEPD Model likely transfer to professional development experiences in engineering LLCs as well as experiences for engineering students more broadly. In the present study, students described a variety of experiences that are common to LLCs which facilitates the transferability of the findings from the LEEPD Model to other LLC contexts. In addition, because the LLC had a partner LLC for men in engineering, these five features have transferability to LLCs for women in engineering and LLCs for engineering students. The features of the LEEPD Model – exposure,

practice, feedback, reflection, and revision – can be incorporated in a variety of experiences aimed at supporting engineering students' professional development.

While these five primary features likely transfer to professional development experiences more broadly, the specificity in the exposure and practice features likely have more limited transferability. The specificity in the practice feature, including practice developing and implementing, is likely transferrable to professional development experiences, particularly those related to the Job Acquisition domain of professional development. Practice implementing, while prevalent in Job Acquisition experiences, likely extends to experiences that target professional development related to Job Performance as well. However, most experiences described by students that incorporated practice implementing focused on professional development related to Job Acquisition. The specificity within the exposure feature (exposure to processes, strategies, environments, engineering practice, connections, and opportunities) is likely transferrable to professional development experiences for women in engineering. These aspects of the exposure feature identify different types of exposure experiences that women described as beneficial in LLC, and this nuance can be helpful for programs that incorporate professional development experiences for women in engineering.

While features of the LEEDP Model may be present in a variety of experiences, it is important to consider the timescale when determining the transferability of these features and developing learning experiences that incorporate multiple features. The incorporation of multiple features from the LEEPD Model is likely transferrable to LLCs and other experiences that allow for long-term participation. Experiences that are limited to a short period of time, such as one-time presentations, may only incorporate one or two features. For example, an hour-long résumé review experience could provide exposure to strategies for creating a résumé and then provide an opportunity for students to practice developing their own résumé. Longer-term experiences, such as those that take place over multiple weeks, would allow for the incorporation of more features from the LEEPD Model, including feedback, reflection, and revision. While feedback and reflection can be incorporated into shorter-term experiences, students may benefit from having more time for the feedback and reflection. In addition, revision often requires more time to incorporate to allow time for iterations and improvement. In sum, both the context and the timescale should be considered when determining the transferability of the LEEPD features.

7.4 Limitations

This study was situated in a large LLC for women in engineering at a large institution. Participants in the present study described their views of professional development and the experiences within LLCs that they found beneficial. The results of this study include a broad model of professional development that captures the range of scope and internalization of professional development categories. In analyzing beneficial experiences, features of experiences were identified, as opposed to descriptions of events, to promote transferability of the results. By providing rich detail about the context being studied and the experiences described by participants, it is my aim to facilitate the transfer of these results to other contexts.

However, there are several notable limitations to this study. The present study examined the experiences within one type of LLC, and other LLC structures were not included. As described previously, different types of LLCs have different structures, missions, and programming. These other contexts may provide additional perspectives, particularly in regards to features of beneficial experiences. In addition, participants self-selected to participate in the study and all participants who agreed to participate in an interview were invited for an in-person interview. Because the response rate was not sufficient enough to allow purposeful selection, the full range of participant perspectives may not be represented in the current study. An additional limitation of this study is that the effectiveness of beneficial experiences was not measured. Therefore, while participants may perceive these experiences to be beneficial, there is no measure of whether those experiences furthered students' professional development.

7.5 Future Work

While the results of this study provide beneficial insight into professional development in LLCs, this research leads to several additional questions and opportunities for future work. First, the present study focused on students' perceptions of beneficial experiences. Future work should measure the effectiveness of these activities at helping students develop professionally. An understanding of the effectiveness of professional development activities is needed so that educators can implement experiences that are not only perceived as beneficial by students but also further students' development. Second, the present study examined the perceptions of women engineering students after their first year at a university. Future work should examine perceptions of professional development at various points during an undergraduate curriculum.

In particular, research should examine the perceptions of students towards the end of their programs. This additional perspective can give insight into the professional preparation of engineering students prior to entering the engineering workforce. Third, this study focused on the perspectives of women in engineering, and future work should examine professional development and beneficial experiences from a variety of student perspectives. The perspectives of other student populations, such as underrepresented minorities and men, should be examined to better understand opportunities to support diverse students and differences between student perceptions. Fourth, future work could examine professional development from a disciplinary perspective. Certain disciplines may require professional development unique to that field and future work should examine these disciplinary differences. Lastly, future research should examine professional development from a variety of perspectives, including student, faculty, staff, administrators, and advisors. The results from such research could provide a more comprehensive taxonomy of professional development in engineering education contexts.

7.6 Summary

In closing, the present study provides insight into women engineering students' perspectives of professional development in engineering and the experiences that are beneficial for that development. The results include the PD^2 Model which describes the variation in participants' views of professional development. The LEEPD Model describes the features of beneficial experiences and allows for the flexible combination of features to meet the needs of students and to help students develop desired outcomes. Combined, the results of the present study can help LLCs incorporate beneficial professional development opportunities. By supporting the professional development of women in engineering, these students can be better prepared to enter and be successful in the engineering profession.

References

ABET. (2016). *Criteria for accrediting engineering programs: Effective for reviews during the 2017-2018 accreditation cycle*. Baltimore, MD: ABET Engineering Accreditation Commission.

Åkerlind, G. S. (2005a). Learning about phenomenography: Interviewing, data analysis, and the qualitative research program. In J. A. Bowden & P. Green (Eds.), *Doing Developmental Phenomenography* (pp. 62–73). Melbourne: RMIT University Press.

Åkerlind, G. S. (2005b). Phenomenographic methods: A case illustration. In J. A. Bowden & P. Green (Eds.), *Doing Developmental Phenomenography* (pp. 103–127). Melbourne: RMIT University Press.

Åkerlind, G. S. (2005c). Variation and commonality in phenomenographic research methods. *Higher Education Research & Development*, *24*(4), 321–334.

Åkerlind, G. S., Bowden, J. A., & Green, P. (2005). Learning to do phenomenography: A reflective discussion. In J. A. Bowden & P. Green (Eds.), *Doing Developmental Phenomenography* (pp. 74–100). Melbourne: RMIT University Press.

American Society for Engineering Education. (2013). *Transforming undergraduate education in engineering phase I: Synthesizing and integrating industry perspectives. Workshop report*. Arlington, VA: American Society for Engineering Education.

American Society for Engineering Education. (2017). *Transforming undergraduate education in engineering phase II: Insights from tomorrow's engineers. Workshop report*. Washington, DC: American Society for Engineering Education.

Anderson, K., Courter, S., McGlamery, T., Nathans-Kelly, T., & Nicometo, C. (2009). Understanding the current work and values of professional engineers: Implications for

engineering education. Presented at the American Society for Engineering Education Annual Conference and Exhibition, Austin, TX.

Anderson, K., Courter, S. S., Nathan, M. J., Prevost, A. C., Nicometo, C. G., Nathans-Kelly, T. M., … Atwood, A. K. (2011). Special session: Moving towards the intended, explicit, and authentic: Addressing misalignments in engineering learning within secondary and university education. Presented at the American Society for Engineering Education Annual Conference and Exhibition, Vancouver, BC.

Andersson, N., & Andersson, P. H. (2012). Assessment of professional engineering skills - Define, monitor and assess. Presented at the CDIO Conference, Brisbane, Australia.

ASCE. (2006). Code of Ethics. Retrieved from http://www.asce.org/code-of-ethics/

Ashworth, P., & Lucas, U. (2000). Achieving empathy and engagement: A practical approach to the design, conduct and reporting of phenomenographic research. *Studies in Higher Education*, *25*(3), 295–308.

ASME. (2012). Code of Ethics of Engineers. Retrieved from https://www.asme.org/wwwasmeorg/media/ResourceFiles/AboutASME/Get%20Involved /Advocacy/Policy-Publications/P-15-7-Ethics.pdf

Atman, C. J., Eris, O., McDonnell, J., Cardella, M. E., & Borgford-Parnell, J. (2014). Engineering design education: Research, practice, and examples that link the two. In A. Johri & B. M. Olds (Eds.), *Cambridge Handbook of Engineering Education Research* (pp. 201–225). New York, NY: Cambridge University Press.

Atman, C. J., Sheppard, S. D., Turns, J., Adams, R. S., Fleming, L. N., Stevens, R., … Lund, D. (2010). *Enabling engineering student success: The final report for the Center for the*

Advancement of Engineering Education. San Rafael, CA: Morgan & Claypool Publishers.

Banks, J. A. (Ed.). (2012). Living learning communities. In *Encyclopedia of Diversity in Education* (Vol. 3, pp. 1415–1417). Thousand Oaks, CA: SAGE Publications.

Barefoot, B. O., Griffin, B. Q., & Koch, A. K. (2012). *Enhancing student success and retention throughout undergraduate education: A national survey*. Brevard, NC: Gardner Institute for Excellence in Undergraduate Education.

Barnard, A., McCosker, H., & Gerber, R. (1999). Phenomenography: A qualitative research approach for exploring understanding in health care. *Qualitative Health Research*, *9*(2), 212–226.

Belichesky, J. (2013). *Living learning communities: An intervention in keeping women strong in science, technology, engineering, and mathematics* (Doctoral Dissertation). Loyola Marymount University.

Bell, D. (2016). The reality of STEM education, design and technology teachers' perceptions: A phenomenographic study. *International Journal of Technology and Design Education*, *26*(1), 61–79.

Besterfield-Sacre, M., Moreno, M., Shuman, L. J., & Atman, C. J. (2001). Gender and ethnicity differences in freshmen engineering student attitudes: A cross-institutional study. *Journal of Engineering Education*, *90*(4), 477–489.

Bjorklund, S. A., Parente, J. M., & Sathianathan, D. (2004). Effects of faculty interaction and feedback on gains in student skills. *Journal of Engineering Education*, *93*(2), 153–160.

Blau, G., & Snell, C. (2013). Understanding undergraduate professional development engagement and its impact. *College Student Journal*, *47*(4), 689–702.

Blimling, G. S. (2015). *Student learning in college residence halls: What works, what doesn't, and why*. San Francisco, CA: Jossey-Bass.

Bowden, J. A. (2005). Reflections on the phenomenographic team research process. In J. A. Bowden & P. Green (Eds.), *Doing Developmental Phenomenography* (pp. 11–31). Melbourne: RMIT University Press.

Brower, A. M., & Inkelas, K. K. (2010). Living-learning programs: One high-impact educational practice we now know a lot about. *Liberal Education*, *96*(2), 36–43.

Brubacher, J. S., & Rudy, W. (1968). *Higher education in transition: A history of American colleges and universities, 1636-1968*. New York: Harper & Row.

Brunhaver, S. R., Korte, R. F., Barley, S. R., & Sheppard, S. D. (2018). Bridging the gaps between engineering education and practice. In R. B. Freeman & H. Salzman (Eds.), *US Engineering in a Global Economy* (pp. 129–163). Chicago, IL: University of Chicago Press.

Brush, K. M. (2013). *Women in engineering: The impact of the college internship on persistence into an engineering field.* (Doctoral Dissertation). The College of William and Mary.

Bucks, G., & Oakes, W. C. (2011). Phenomenography as a tool for investigating understanding of computing concepts. Presented at the American Society for Engineering Education Annual Conference and Exhibition, Vancouver, BC.

Burt, B. A., Carpenter, D. D., Finelli, C. J., Harding, T. S., Sutkus, J. A., Holsapple, M. A., … Ra, E. (2011). Outcomes of engaging engineering undergraduates in co-curricular experiences. Presented at the American Society for Engineering Education Annual Conference and Exhibition, Vancouver, BC.

Cajander, A., Daniels, M., McDermott, R., & Von Konsky, B. R. (2011). Assessing professional skills in engineering education. In *Proceedings of the Thirteenth Australasian Computing Education Conference* (Vol. 114, pp. 145–154). Perth, Australia: Australian Computer Society, Inc.

Cech, E., Rubineau, B., Silbey, S., & Seron, C. (2011). Professional role confidence and gendered persistence in engineering. *American Sociological Review*, *76*(5), 641–666.

Cerbone, D. R. (2006). *Understanding phenomenology*. Chesham: Acumen.

Chafin, C. N. (2006). *The impact of a living-learning community and inquiry guided learning on first year students' emotional intelligence and academic achievement* (Doctoral Dissertation). North Carolina State University.

Cheryan, S., Plaut, V. C., Handron, C., & Hudson, L. (2013). The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women. *Sex Roles*, *69*(1), 58–71.

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others? *Psychological Bulletin*, *143*(1), 1–35.

Collier-Reed, B. I., & Ingerman, A. (2013). Phenomenography: From critical aspects to knowledge claim. In M. Tight & J. Huisman (Eds.), *Theory and Method in Higher Education Research* (Vol. 9, pp. 243–260). Emerald Group Publishing Limited.

Collier-Reed, B. I., Ingerman, A., & Berglund, A. (2009). Reflections on trustworthiness in phenomenographic research: Recognizing purpose, context and change in the process of research. *Education as Change*, *13*(2), 339–355.

Creswell, J. W. (2007). Five qualitative approaches to inquiry. In *Qualitative Inquiry and Research Design: Choosing Among Five Approaches* (2nd ed., pp. 53–84). Thousand Oaks, CA: SAGE Publications, Inc.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Thousand Oaks, CA: SAGE Publications, Inc.

Cunliffe, A. L. (2004). On becoming a critically reflexive practitioner. *Journal of Management Education*, *28*(4), 407–426.

Dalrymple, O., & Evangelou, D. (2006). The role of extracurricular activities in the education of engineers. Presented at the International Conference on Engineering Education, San Juan, PR.

Daly, S. R., Mosyjowski, E. A., & Seifert, C. M. (2014). Teaching creativity in engineering courses. *Journal of Engineering Education*, *103*(3), 417–449.

Davis, D., Trevisan, M., Davis, H., Gerlick, R., McCormack, J., Beyerlein, S., … Khan, J. (2010). Assessing professional skill development in capstone design courses. Presented at the Capstone Design Conference, Boulder, CO.

Diekman, A. B., Brown, E. R., Johnston, A. M., & Clark, E. K. (2010). Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers. *Psychological Science*, *21*(8), 1051–1057.

Diekman, A. B., Clark, E. K., Johnston, A. M., & Brown, E. R. (2011). Malleability in communal goals and beliefs influences attraction to STEM careers: Evidence for a goal congruity perspective. *Journal of Personality and Social Psychology*, *101*(5), 902–918.

Dugan, J. P., Fath, K. Q., Howes, S. D., Lavelle, K. R., & Polanin, J. R. (2013). Developing the

    leadership capacity and leader efficacy of college women in science, technology,

    engineering, and math fields. *Journal of Leadership Studies*, *7*(3), 6–23.

Dunsmore, K., Turns, J., & Yellin, J. M. (2011). Looking toward the real world: Student

    conceptions of engineering. *Journal of Engineering Education*, *100*(2), 329–348.

Edwards, K. E., & McKelfresh, D. A. (2002). The impact of a living learning center on students'

    academic success and persistence. *Journal of College Student Development*, *43*(3), 395–

    402.

Ehrlinger, J., Plant, E. A., Hartwig, M. K., Vossen, J. J., Columb, C. J., & Brewer, L. E. (2018).

    Do gender differences in perceived prototypical computer scientists and engineers

    contribute to gender gaps in computer science and engineering? *Sex Roles*, *78*(1–2), 40–

    51.

Ekoniak, M., Scanlon, M., & Mohammadi-Aragh, J. (2015). Teaching peer review of writing in a

    large first-year electrical and computer engineering class: A comparison of two methods.

    Presented at the American Society for Engineering Education Annual Conference and

    Exhibition, Seattle, WA.

Everett, J. W., & Zobel, P. D. (2012). Promoting student connections and retention through an

    on-campus residential learning community for first-year underrepresented and low-

    income students. Presented at the American Society for Engineering Education Annual

    Conference and Exhibition, San Antonio, TX.

Faulkner, W. (2015). "Nuts and bolts and people" Gender-troubled engineering identities. In S.

    H. Christensen, C. Didier, A. Jamison, M. Meganck, C. Mitcham, & B. Newberry (Eds.),

Engineering Identities, Epistemologies and Values. Engineering Education and Practice in Context (Vol. 21, pp. 23–40). Cham: Springer.

Fink, J. E., & Inkelas, K. K. (2015). A history of learning communities within American higher education. *New Directions for Student Services*, *2015*(149), 5–15.

Fisher, D. R. (2014). Fostering 21st century skills in engineering undergraduates through co-curricular involvement. Presented at the American Society for Engineering Education Annual Conference and Exhibition, Indianapolis, IN.

Franz, J., Ferreira, L., & Thambiratam, D. P. (1997). Using phenomenography to understand student learning in civil engineering. *International Journal of Engineering Education*, *13*(1), 21–29.

Gallagher, S. (2012). *Phenomenology* (1st ed.). England: Palgrave Macmillan.

Gewirtz, C., Kotys-Schwartz, D. A., Knight, D., Paretti, M. C., Arunkumar, S., Ford, J. D., … Cristian Hernandez. (2018). New engineers' first three months: A study of the transition from capstone design courses to workplaces. Presented at the American Society for Engineering Education Annual Conference and Exhibition, Salt Lake City, UT.

Gibbs, G., Morgan, A., & Taylor, E. (1982). A review of the research of Ference Marton and the Goteborg Group: A phenomenological research perspective on learning. *Higher Education*, *11*(2), 123–145.

Grays, S. D. (2013). *WISE women: A narrative study of former living-learning community participants' experiences as STEM majors* (Doctoral Dissertation). North Carolina State University.

Green, P. (2005). A rigorous journey into phenomenography: From a naturalistic inquirer standpoint. In J. A. Bowden & P. Green (Eds.), *Doing Developmental Phenomenography* (pp. 32–46). Melbourne: RMIT University Press.

Grills, C. N., Fingerhut, A. W., Thadani, V., & Machón, R. A. (2012). Residential learning communities centered within a discipline: The psychology early awareness program. *New Directions for Teaching and Learning*, *2012*(132), 43–55.

Hatmaker, D. M. (2013). Engineering identity: Gender and professional identity negotiation among women engineers. *Gender, Work & Organization*, *20*(4), 382–396.

Hill, F. (2007). Feedback to enhance student learning: Facilitating interactive feedback on clinical skills. *International Journal of Clinical Skills*, *1*(1), 21–24.

Hirsch, P. L., & McKenna, A. F. (2008). Using reflection to promote teamwork understanding in engineering design education. *International Journal of Engineering Education*, *24*(2), 377–385.

Howe, S., Rosenbauer, L., Ford, J. D., Alvarez, N., Paretti, M., Gewirtz, C., … Hernandez, C. (2018). Preliminary results from a study investigating the transition from capstone design to industry. *In Preparation*.

Humphreys, P., Lo, V., Chan, F., & Duggan, G. (2001). Developing transferable groupwork skills for engineering students. *International Journal of Engineering Education*, *17*(1), 59–66.

Hurst, A., & Nespoli, O. G. (2016). Student perceptions of value of peer and instructor feedback in capstone design review meetings. Presented at the Capstone Design Conference, Columbus, OH.

Husserl, E. (2001). *The Shorter Logical Investigations*. London: Routledge.

Inkelas, K. K. (2008). *National study of living-learning programs: 2007 report of findings*.

Inkelas, K. K. (2011). Living-learning programs for women in STEM. *New Directions for Institutional Research*, *2011*(152), 27–37.

Inkelas, K. K., & Soldner, M. (2011). Undergraduate living–learning programs and student outcomes. In J. C. Smart & M. B. Paulsen (Eds.), *Higher Education: Handbook of Theory and Research* (Vol. 26, pp. 1–55). New York: Springer.

Inkelas, K. K., & Weisman, J. L. (2003). Different by design: An examination of student outcomes among participants in three types of living-learning programs. *Journal of College Student Development*, *44*(3), 335–368.

Johnson, I. Y., & Muse, W. B. (2017). Choice of academic major at a public research university: The role of gender and self-efficacy. *Research in Higher Education*, *58*(4), 365–394.

Johnston, N., Partridge, H., & Hughes, H. (2014). Understanding the information literacy experiences of EFL (English as a foreign language) students. *Reference Services Review*, *42*(4), 552–568.

Jonassen, D. H. (2014). Engineers as problem solvers. In A. Johri & B. M. Olds (Eds.), *Cambridge Handbook of Engineering Education Research* (pp. 103–118). New York, NY: Cambridge University Press.

Jonassen, D. H., Strobel, J., & Lee, C. B. (2006). Everyday problem solving in engineering: Lessons for engineering educators. *Journal of Engineering Education*, *95*(2), 139–151.

Jones, B. D., Paretti, M. C., Hein, S. F., & Knott, T. W. (2010). An analysis of motivation constructs with first-year engineering students: Relationships among expectancies, values, achievement, and career plans. *Journal of Engineering Education*, *99*(4), 319–336.

Kazerounian, K., & Foley, S. (2007). Barriers to creativity in engineering education: A study of instructors and students perceptions. *Journal of Mechanical Design*, *129*(7), 761–768.

Knight, M., & Cunningham, C. (2004). Draw an engineer test (DAET): Development of a tool to investigate students' ideas about engineers and engineering. Presented at the American Society for Engineering Education Annual Conference and Exhibition, Salt Lake City, UT.

Knight, M. T., & Cunningham, C. M. (2004). Building a structure of support: An inside look at the structure of women in engineering programs. *Journal of Women and Minorities in Science and Engineering*, *10*(1), 1–20.

Kolb, D. A. (2015). *Experiential learning: Experience as the source of learning and development* (2nd ed.). Upper Saddle River, NJ: Pearson.

Kolb, D. A., Boyatzis, R. E., & Mainemelis, C. (2001). Experiential learning theory: Previous research and new directions. In R. J. Sternberg & L.-F. Zhang (Eds.), *Perspectives on Thinking, Learning, and Cognitive Styles* (pp. 227–247). New York, NY: Routledge.

Leydens, J. A. (2008). Novice and insider perspectives on academic and workplace writing: Toward a continuum of rhetorical awareness. *IEEE Transactions on Professional Communication*, *51*(3), 242–263.

Leydens, J. A., Moskal, B. M., & Pavelich, M. J. (2004). Qualitative methods used in the assessment of engineering education. *Journal of Engineering Education*, *93*(1), 65–72.

Lichtenstein, G., Chen, H. L., Smith, K. A., & Maldonado, T. A. (2014). Retention and persistence of women and minorities along the engineering pathway in the United States. In A. Johri & B. M. Olds (Eds.), *Cambridge Handbook of Engineering Education Research* (pp. 311–334). New York, NY: Cambridge University Press.

Light, J. (2005). *Developing and assessing a holistic living-learning community for engineering and science freshmen* (Doctoral Dissertation). Washington State University.

Lopatto, D. (2004). What undergraduate research can tell us about research on learning. *What Works, What Matters, and What Lasts*, *4*, 1–8.

Lord, S. M., & Chen, J. C. (2014). Curriculum Design in the Middle Years. In A. Johri & B. M. Olds (Eds.), *Cambridge Handbook of Engineering Education Research* (pp. 181–199). New York, NY: Cambridge University Press.

Lowden, K., Hall, S., Elliot, D., & Lewin, J. (2011). *Employers' perceptions of the employability skills of new graduates*. London: Edge Foundation.

Mamaril, N. A., Usher, E. L., Li, C. R., Economy, D. R., & Kennedy, M. S. (2016). Measuring undergraduate students' engineering self-efficacy: A validation study. *Journal of Engineering Education*, *105*(2), 366–395.

Marra, R. M., Rodgers, K. A., Shen, D., & Bogue, B. (2009). Women engineering students and self-efficacy: A multi-year, multi-institution study of women engineering student self-efficacy. *Journal of Engineering Education*, *98*(1), 27.

Martin, A., Watford, B., & Edmister, W. (2006). Hypatia: A living and learning community for freshman and sophomore women in engineering. Presented at the American Society for Engineering Education Annual Conference and Exhibition, Chicago, IL.

Martin, R., Maytham, B., Case, J., & Fraser, D. (2005). Engineering graduates' perceptions of how well they were prepared for work in industry. *European Journal of Engineering Education*, *30*(2), 167–180.

Marton, F. (1975). On non-verbatim learning: 1. Level of processing and level of outcome. *Scandinavian Journal of Psychology*, *16*(1), 273–279.

Marton, F. (1981). Phenomenography - Describing conceptions of the world around us. *Instructional Science*, *10*(2), 177–200.

Marton, F. (1986). Phenomenography - A research approach to investigating different understandings of reality. *Journal of Thought*, *21*(3), 28–49.

Marton, F. (1992). Phenomenography and "the art of teaching all things to all men." *Qualitative Studies in Education*, *5*(3), 253–267.

Marton, F., & Booth, S. A. (1997). *Learning and awareness*. Mahwah, NJ: L. Erlbaum Associates.

Marton, F., & Säljö, R. (1976). On qualitative differences in learning: I - Outcome and process. *British Journal of Educational Psychology*, *46*(1), 4–11.

Matusovich, H. M., Streveler, R. A., & Miller, R. L. (2010). Why do students choose engineering? A qualitative, longitudinal investigation of students' motivational values. *Journal of Engineering Education*, *99*(4), 289–303.

Matusovich, H. M., Streveler, R., Miller, R., & Olds, B. (2009a). Competence in engineering: A tale of two women. Presented at the American Society for Engineering Education Annual Conference and Exhibition, Austin, TX.

Matusovich, H. M., Streveler, R., Miller, R., & Olds, B. (2009b). I'm graduating this year! So what IS an engineer anyway? Presented at the American Society for Engineering Education Annual Conference and Exhibition, Austin, TX.

McIlwee, J. S., & Robinson, J. G. (1992). *Women in engineering: Gender, power, and workplace culture*. Albany: SUNY Press.

Micomonaco, J. (2011). *Living-learning communities as an intervention to improve disciplinary retention and learning outcomes in engineering education* (Doctoral Dissertation). Michigan State University.

Mohan, A., Merle, D., Jackson, C., Lannin, J., & Nair, S. S. (2010). Professional skills in the engineering curriculum. *IEEE Transactions on Education*, *53*(4), 562–571.

Moore, J., & Ranalli, J. (2015). A mastery learning approach to engineering homework assignments. Presented at the American Society for Engineering Education Annual Conference and Exhibition, Seattle, WA.

National Academy of Engineering. (2004a). Attributes of engineers in 2020. In *The Engineer of 2020: Visions of Engineering in the New Century*. Washington, DC: National Academies Press.

National Academy of Engineering. (2004b). *The engineer of 2020: Visions of engineering in the new century*. Washington, DC: National Academies Press.

National Academy of Engineering. (2008). *NAE Grand Challenges for Engineering*. National Academy of Sciences.

Nicol, D., Thomson, A., & Breslin, C. (2014). Rethinking feedback practices in higher education: A peer review perspective. *Assessment & Evaluation in Higher Education*, *39*(1), 102–122.

NSPE. (2016). NSPE Code of Ethics for Engineers. Retrieved from https://www.nspe.org/resources/ethics/code-ethics

Pace, D., Witucki, L., & Blumreich, K. (2008). Benefiting female students in science, math, and engineering: The nuts and bolts of establishing a WISE (Women in Science and Engineering) learning community. *NASPA Journal*, *45*(3), 373–383.

Paretti, M. C., McNair, L. D., & Leydens, J. A. (2014). Engineering communication. In A. Johri & B. M. Olds (Eds.), *Cambridge Handbook of Engineering Education Research* (pp. 601–632). New York, NY: Cambridge University Press.

Pasque, P. A., & Murphy, R. (2005). The intersections of living-learning programs and social identity as factors of academic achievement and intellectual engagement. *Journal of College Student Development*, *46*(4), 429–441.

Passow, H. J. (2012). Which ABET competencies do engineering graduates find most important in their work? *Journal of Engineering Education*, *101*(1), 95–118.

Pike, G. R. (1999). The effects of residential learning communities and traditional residential living arrangements on educational gains during the first year of college. *Journal of College Student Development*, *40*(3), 269–284.

Prince, M. J., & Felder, R. M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of Engineering Education*, *95*(2), 123–138.

Raelin, J. A., Bailey, M. B., Hamann, J., Pendleton, L. K., Reisberg, R., & Whitman, D. L. (2014). The gendered effect of cooperative education, contextual support, and self-efficacy on undergraduate retention. *Journal of Engineering Education*, *103*(4), 599–624.

Richardson, J. T. (1999). The concepts and methods of phenomenographic research. *Review of Educational Research*, *69*(1), 53–82.

Ro, H. K., & Knight, D. B. (2016). Gender differences in learning outcomes from the college experiences of engineering students. *Journal of Engineering Education*, *105*(3), 478–507.

Rottmann, C., Sacks, R., & Reeve, D. (2015). Engineering leadership: Grounding leadership theory in engineers' professional identities. *Leadership*, *11*(3), 351–373.

Säljö, R. (1979). Learning about learning. *Higher Education*, *8*(4), 443–451.

Samuelson, C., Litzler, E., Staples, C. L., Smith, P. E., & Amelink, C. T. (2014). Living, learning, and staying: The impact of a women in engineering living and learning community. Presented at the American Society for Engineering Education Annual Conference and Exhibition, Indianapolis, IN.

Schön, D. A. (1987). *Educating the reflective practitioner: Toward a new design for teaching and learning in the professions*. San Francisco, CA: Jossey-Bass.

Schuurman, M. K., Pangborn, R. N., & McClintic, R. D. (2008). Assessing the impact of engineering undergraduate work experience: Factoring in pre-work academic performance. *Journal of Engineering Education*, *97*(2), 207–212.

Scott, E. P., Bates, R., Campbell, R. C., & Wilson, D. (2010). Contextualizing professional development in the engineering classroom. Presented at the Frontiers in Education Conference (FIE), Washington, DC: IEEE.

Sheppard, S., Gilmartin, S., Chen, H. L., Donaldson, K., Lichtenstein, G., Eris, Ö., … Toye, G. (2010). *Exploring the engineering student experience: Findings from the academic pathways of people learning engineering survey (APPLES)*. Seattle, WA: Center for the Advancement for Engineering Education.

Shuman, L. J., Besterfield-Sacre, M., & McGourty, J. (2005). The ABET "professional skills" - Can they be taught? Can they be assessed? *Journal of Engineering Education*, *94*(1), 41–55.

Siller, T. J., Rosales, A., Haines, J., & Benally, A. (2009). Development of undergraduate students' professional skills. *Journal of Professional Issues in Engineering Education and Practice*, *135*(3), 102–108.

Simmons, D. R., Creamer, E. G., & Yu, R. (2017). Involvement in out-of-class activities: A mixed research synthesis examining outcomes with a focus on engineering students. *Journal of STEM Education*, *18*(2), 10–16.

Simmons, D. R., Tendhar, C., Yu, R., Vance, E. A., & Amelink, C. T. (2015). Developing the postsecondary student engagement survey (PosSES) to measure undergraduate engineering students' out of class involvement. Presented at the American Society for Engineering Education Annual Conference and Exhibition, Seattle, WA.

Simmons, D. R., Van Mullekom, J., & Ohland, M. (in press). The popularity and intensity of undergraduate out-of-class activities. *Journal of Engineering Education*.

Simmons, D. R., Yi, Y., Ohland, M., & Garahan, K. (2018). Understanding students' incentives for and barriers to out-of-class participation: A profile of civil engineering student engagement. *Journal of Professional Issues in Engineering Education and Practice*, *144*(2).

Smith, C. S. (2015). *The intersecting perspective: African American female experiences with faculty mentoring in undergraduate engineering* (Doctoral Dissertation). Virginia Tech.

Smith, J. L., Morgan, C. L., & White, P. H. (2005). Investigating a measure of computer technology domain identification: A tool for understanding gender differences and stereotypes. *Educational and Psychological Measurement*, *65*(2), 336–355.

Soldner, M., Rowan-Kenyon, H., Inkelas, K. K., Garvey, J., & Robbins, C. (2012). Supporting students' intentions to persist in STEM disciplines: The role of living-learning programs among other social-cognitive factors. *The Journal of Higher Education*, *83*(3), 311–336.

Sriram, R. R., & Shushok, F., Jr. (2010). Exploring the effect of a residential academic affairs-student affairs partnership: The first year of an engineering and computer science living-learning center. *Journal of College & University Student Housing*, *36*(2), 68–81.

Stassen, M. L. (2003). Student outcomes: The impact of varying living-learning community models. *Research in Higher Education*, *44*(5), 581–613.

Stout, J. G., Grunberg, V. A., & Ito, T. A. (2016). Gender roles and stereotypes about science careers help explain women and men's science pursuits. *Sex Roles*, *75*(9), 490–499.

Su, R., & Rounds, J. (2015). All STEM fields are not created equal: People and things interests explain gender disparities across STEM fields. *Frontiers in Psychology*, *6*(189), 1–20.

Szelényi, K., Denson, N., & Inkelas, K. K. (2013). Women in STEM majors and professional outcome expectations: The role of living-learning programs and other college environments. *Research in Higher Education*, *54*(8), 851–873.

Täks, M., Tynjälä, P., Toding, M., Kukemelk, H., & Venesaar, U. (2014). Engineering students' experiences in studying entrepreneurship. *Journal of Engineering Education*, *103*(4), 573–598.

Taylor, K., Moore, W. S., MacGregor, J., & Lindblad, J. (2003). *Learning community research and assessment: What we know now*. Olympia: Washington Center, Evergreen State University.

Thomas, L. D., Orand, M., Shroyer, K. E., Turns, J. A., & Atman, C. J. (2016). Tips & tricks for successful implementation of reflection activities in engineering education. Presented at the American Society for Engineering Education Annual Conference and Exhibition, New Orleans, LA.

Tigchelaar, A., Vermunt, J. D., & Brouwer, N. (2014). Patterns of development in second-career teachers' conceptions of teaching and learning. *Teaching and Teacher Education*, *41*(2014), 111–120.

Trevelyan, J. (2007). Technical coordination in engineering practice. *Journal of Engineering Education*, *96*(3), 191–204.

Trevelyan, J. (2010a). Mind the gaps: Engineering education and practice. In *Proceedings of the 21st Annual Conference for the Australasian Association for Engineering Education* (pp. 383–390). Sydney: Engineers Australia.

Trevelyan, J. (2010b). Reconstructing engineering from practice. *Engineering Studies*, *2*(3), 175–195.

Turns, J. A., Sattler, B., Yasuhara, K., Borgford-Parnell, J., & Atman, C. J. (2014). Integrating reflection into engineering education. Presented at the American Society for Engineering Education Annual Conference and Exhibition, Indianapolis, IN.

Walter, C. (2016). What are tutors' experiences with online teaching?: A phenomenographic study. *International Journal of Mobile and Blended Learning (IJMBL)*, *8*(1), 18–33.

Walther, J., Kellam, N., Sochacka, N., & Radcliffe, D. (2011). Engineering competence? An interpretive investigation of engineering students' professional formation. *Journal of Engineering Education*, *100*(4), 703–740.

Walther, J., Sochacka, N., & Kellam, N. (2011). Emotional indicators as a way to elicit authentic student reflection in engineering programs. Presented at the American Society for Engineering Education Annual Conference and Exhibition, Vancouver, BC.

Walton, S. P., Briedis, D., Urban-Lurain, M., Hinds, T., Davis-King, C., & Wolf, T. (2013). Building the whole engineer: An integrated academic and co-curricular first-year

experience. Presented at the American Society for Engineering Education Annual

Conference and Exhibition, Atlanta, GA.

Wankat, P. (2017). Perspective: Teaching professional skills. *AIChE Journal*, *63*(7), 2511–2519.

Wawrzynski, M. R., & Jessup-Anger, J. E. (2010). From expectations to experiences: Using a

structural typology to understand first-year student outcomes in academically based

living-learning communities. *Journal of College Student Development*, *51*(2), 201–217.

Weedon, J. S. (2016). Judging for themselves: How students practice engineering judgment.

Presented at the American Society for Engineering Education Annual Conference and

Exhibition, New Orleans, LA.

Wilcox, J. (2003). *Developing professional skills*. Liverpool: UK Centre for Materials Education.

Woollacott, L., Booth, S., & Cameron, A. (2014). Knowing your students in large diverse

classes: A phenomenographic case study. *Higher Education*, *67*(6), 747–760.

Zoltowski, C. B., Oakes, W. C., & Cardella, M. E. (2012). Students' ways of experiencing

human-centered design. *Journal of Engineering Education*, *101*(1), 28–59.

Appendix A: Comparison of Descriptions of Professional Development in Engineering

Full descriptions of professional skills and attributes specified as relevant to engineering and professional development.

Source / Competency	Engineer of 2020 Attributes (National Academy of Engineering, 2004a)	ABET professional skills (ABET, 2016; Shuman et al., 2005)	Professional Development Ability/Attribute (Davis et al., 2010)	Professional Development Categories (Scott et al., 2010)	Professional Formation Competencies (Walther, Kellam, et al., 2011)
Networking				"Interviewing, Networking, and Building Relationships" (p. 2)	"**Networking:** abilities and strategies to seek support in social and organizational networks within and outside the organization" (p. 740)
Technical Skills and Analysis	"Strong analytical skills. At its core, engineering employs principles of science, mathematics, and domains of discovery and design to a particular challenge and for a practical purpose" (p. 54)		"**Analyzing information**: Applying methods/tools of analysis to understand and predict conditions" (p. 2)		"**Technical Knowledge and Skills:** Application of specific technical knowledge (Calculation, analysis, etc.)" (p. 740)
Problem Solving	**Practical ingenuity:** "identify problems and find solutions" (p. 54-55)		"**Solving problems**: Formulating, selecting, and implementing actions for optimal outcomes" (p. 2)		"**Methodological Problem Solving:** Structured and analytical approach to solving engineering problems." (p. 740)
Interpretation			"**Researching questions**: Investigating, processing and interpreting information to answer important questions" (p. 2)		

Source / Competency	Engineer of 2020 Attributes (National Academy of Engineering, 2004a)	ABET professional skills (ABET, 2016; Shuman et al., 2005)	Professional Development Ability/Attribute (Davis et al., 2010)	Professional Development Categories (Scott et al., 2010)	Professional Formation Competencies (Walther, Kellam, et al., 2011)
Awareness of Constraints	"Just as important [as the core knowledge base] will be the imperative to expand the engineering design space such that the impacts of social systems and their associated constraints are afforded as much attention as economic, legal, and political constraints (e.g., resource management, standards, accountability requirements)" (p. 54)				"**Economic Awareness:** the awareness of and strategies to meet the practicalities or constraints of budget and time" (p. 739)
Engineering Judgment					"**Engineering Judgement:** the ability to make decisions under the conditions of engineering practice (time constraints, insufficient information, uncertainty)" (p. 739)
Importance of Multiple Perspectives			"**Relating inclusively**: Valuing and sustaining a supportive environment for all knowledge and perspectives" (p. 2)	**Personality Styles:** discussion of "strengths and weaknesses that are brought to the table by different personalities in an engineering environment" (p. 2)	"**Bridging Different Perspectives:** abilities to work across different cultural, disciplinary, or personal perspectives" (p. 740)
Engineering Responsibility	"the need to also possess a working framework upon which high ethical standards and a strong sense of professionalism" (p.56)	"an understanding of professional and ethical responsibility" (p. 41)	"**Serving professionally**: Serving with integrity, **responsibility** and sensitivity to individual and societal norms" (p. 2)		"**Professional Responsibility:** The awareness of personal responsibility for the result or the consequences of engineering work in practice" (p. 739)

Source / Competency	Engineer of 2020 Attributes (National Academy of Engineering, 2004a)	ABET professional skills (ABET, 2016; Shuman et al., 2005)	Professional Development Ability/Attribute (Davis et al., 2010)	Professional Development Categories (Scott et al., 2010)	Professional Formation Competencies (Walther, Kellam, et al., 2011)
Impact	**Ethical standards and professionalism:** "Successful engineers in 2020 will, as they always have, recognize the broader contexts that are intertwined in technology and its application in society" (p. 56)	"the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context" (p.41)			
Adaptability	**Dynamism, agility, resilience, and flexibility:** "Not only will technology change quickly, the social-political-economic world in which engineers work will change continuously. In this context it will not be this or that particular knowledge that engineers will need but rather the ability to learn new things quickly and the ability to apply knowledge to new problems and new contexts" (p. 56)	"a knowledge of contemporary issues" (p. 41)	"**Adapting to change**: Being aware and responding proactively to social, global, and technological change" (p. 2)		"**Pragmatic adaptability:** The preparedness to cope with practical influences in the workplace (external factors, changes etc.) that necessitate a flexible way of working" (p. 739)
Manage Self			"**Being a high achiever**: Delivering consistently high quality work and results on time" (p. 2)		"**Self-Organization:** Ability and strategies to organize and manage personal work and time on a daily basis" (p. 739) "**Self-Directed Work:** Ability to undertake independent and self-directed work over a longer period of time to solve a complex task." (p. 740) "**Work under pressure:** strategies or preparation to cope with the demands of engineering work in industry" (p. 739)

Competency \ Source	Engineer of 2020 Attributes (National Academy of Engineering, 2004a)	ABET professional skills (ABET, 2016; Shuman et al., 2005)	Professional Development Ability/Attribute (Davis et al., 2010)	Professional Development Categories (Scott et al., 2010)	Professional Formation Competencies (Walther, Kellam, et al., 2011)
Work-Life Balance					"**Work-Life Balance:** Strategies to reconcile the demands of professional engineering work and a balanced private life" (p. 740)
Planning	**analytical skills:** "stablishing structure, planning, evaluating performance, and aligning outcomes to a desired objective" (p. 54) **practical ingenuity:** "skill in planning, combining, and adapting" (p. 54)				"**Plan Task:** Ability to define the task or the problem in its nature and its boundaries" (p. 739) "**Plan Work:** abilities that support the planning of the time dimension of a complex project" (p. 739)
Manage Others/Projects	**Business and management:** "with the growing interdependence between technology and the economic and social foundations of modern society, there will be an increasing number of opportunities for engineers to exercise their potential as leaders" (p. 55)				
Creativity	**Creativity:** "invention, innovation, thinking outside the box, art" (p. 55)		"**Designing products:** Producing creative, practical products that bring value to varied stakeholders" (p. 2)		"**Flexibility and Creativity:** Cluster of competencies that contribute to flexible engineering problem solving that yields creative solutions." (p. 739)
Working with a Team		"an ability to function on multi-disciplinary teams" (p. 41)	"**Collaborating**: Working with a team to achieve collective and individual goals" (p. 2)		

Source / Competency	Engineer of 2020 Attributes (National Academy of Engineering, 2004a)	ABET professional skills (ABET, 2016; Shuman et al., 2005)	Professional Development Ability/Attribute (Davis et al., 2010)	Professional Development Categories (Scott et al., 2010)	Professional Formation Competencies (Walther, Kellam, et al., 2011)
Communication	**Communication:** "an ability to communicate convincingly and to shape the opinions and attitudes of other engineers and the public" (p. 55)	"an ability to communicate effectively" (p. 41)	"**Communicating**: Receiving, processing, sharing information in many forms to achieve desired impact" (p. 2)	"Written Communication in Technical Fields" (p. 2)	"**Professional Communication:** Skills related to formal communication in a professional context - includes writing and presentations" (p. 740) "**Tailor Communication:** The ability to select the appropriate means, form, and register of communication according to the needs of the counterpart" (p. 740) "**Engineering Documentation:** ongoing, structured and purposeful documentation of engineering projects." (p. 740)
Empathy (in interactions and communication)					"**Empathy:** Ability to perceive the attitudes, characteristics, modes of thought or the emotional states or needs of the counterpart." (p. 739)
Leadership	**Leadership:** "engineers must understand the principles of leadership and be able to practice them in growing proportions as their careers advance" (p. 56)		"**Leading others**: Developing shared vision & plans; empowering to achieve individual & collective goals" (p. 2)		
Understanding the Organization					"**Organizational Awareness:** the ability to perceive and appreciate hierarchical structures in the workplace" (p. 740)

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Understanding of Professional Role				**Purpose, Goals, and Objectives:** "The contents of this module help students understand how best to define their personal purpose and goals to achieve maximum satisfaction. The module aims to provide an understanding of what it takes to be a successful engineer in the 21st century, as well as how best to orient one's purpose and goals towards one's own personality."(p. 2)	"**Perception of Professional Self:** Aspects of the graduates' professional way of being (nature of the profession, role, motivation to be an engineer, scope of responsibility, skill set)." (p. 740)
Accept Feedback					"**Accept feedback:** The willingness and ability to positively accept constructive critique in the workplace from peers or superiors" (p. 739)

Source／Competency	Engineer of 2020 Attributes (National Academy of Engineering, 2004a)	ABET professional skills (ABET, 2016; Shuman et al., 2005)	Professional Development Ability/Attribute (Davis et al., 2010)	Professional Development Categories (Scott et al., 2010)	Professional Formation Competencies (Walther, Kellam, et al., 2011)
Continued Growth and Development	**Lifelong learners:** "to be individually/ personally successful, the engineer of 2020 will learn continuously throughout his or her career, not just about engineering but also about history, politics, business, and so forth" (p. 56-57)	"a recognition of the need for, and an ability to engage in lifelong learning" (p. 41)	"**Practicing self-growth**: Planning, self-assessing, and achieving goals for personal development." (p. 2)	**Purpose, Goals, and Objectives:** "The contents of this module help students understand how best to define their personal purpose and goals to achieve maximum satisfaction. The module aims to provide an understanding of what it takes to be a successful engineer in the 21st century, as well as how best to orient one's purpose and goals towards one's own personality."(p. 2)	"**Professional Development:** the motivation to undertake self-directed learning that contributes to the development of professional competence." (p. 740)
Understanding of Self				**Personality Styles:** discussion of "strengths and weaknesses that are brought to the table by different personalities in an engineering environment" (p. 2) **Learning Styles:** Discussion of "levels of knowing in terms of advancement in cognitive development expected or typical during the undergraduate years." (p. 3)	"**Know Self:** Includes meta-cognitive activity that is directed at improving personal work efficiency or quality" (p. 740)

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Understanding the Educational Context/Process				"History of Engineering Education" "Local University Mission" "The Role of ABET" "The Philosophy of Higher Education" (p. 2)	