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Work-in-Progress: Alumni and Employer Perceptions of Workplace Preparedness in Graduates of a Co-Op-Based Engineering Program

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Introduction

Engineering education in the United States has continually balanced the theoretical and practical sides of engineering according to national demand. This balance guided U.S. engineering education away from an apprenticeship model toward a technically-focused series of courses, and maintaining the integration and balance of theory and application has been a continual issue for engineering educators [1]-[3]. One strategy recognized in the recent Engineering Mindset Report [4] is to incorporate Work-Based Learning (WBL) into traditional engineering education. WBL programs typically allow engineering students to receive credit for completing technical engineering work concurrent with traditional courses through co-ops, internships, or apprenticeships. These programs have grown in the U.S. over the past several decades and show promise as a solution to some challenges that result from integrating technical knowledge and professional practice. However, the relatively small number of WBL programs in the U.S. has resulted in these models being understudied. Further, WBL programs often focus on strengthening specific competencies that traditional models do not; as a tradeoff, they may underdevelop other competencies that traditional models strengthen. To explore this idea further, we began a study at Iron Range Engineering (IRE), a small WBL program in the Midwestern U.S., considering alumni and employers' perceptions related to program alumni's realization of engineering competencies, especially as they transition into the engineering workplace.

Background. Prior work on alumni perceptions of their own workplace preparedness primarily considers self-assessments and employer assessments against ABET outcomes or other given criteria. For example, before the adoption of EC2000 [5], Katz [6] interviewed professionals in various engineering fields who work with entry-level engineers. In this study, the employer participants stated that graduates lacked teamwork and communication skills and had mismatched expectations about daily work tasks. In a more recent study, Passow [7] asked recent graduates of a traditional engineering program to rate the importance of ABET outcomes in their work. Overall, participants identified teamwork, communication, data analysis, and problem solving as the most important outcomes in their daily tasks. A prior study of IRE alumni supervisors, conducted before IRE transitioned from project-based learning to WBL, used a Likert scale to assess workplace preparedness of alumni based on criteria developed from ABET outcomes. This study found that graduates were rated the highest in "'performing on teams', 'being professionally responsible', and 'leading and managing projects,'" and lowest in "'modern tools use', 'leading and managing people,' and 'entrepreneurial thinking'" [8]. Across these studies, the use of ABET outcomes allowed for comparison across contexts, but did not allow alumni to describe their experiences in their own words and may overlook unique, contextualized ideas.

While the aforementioned studies on workplace preparedness provide valuable observations for the traditional undergraduate context, little work to date has explored the preparedness of WBL program graduates, and fewer have specifically observed co-op program graduates who have the unique experience of performing full-time engineering work before earning their college degree and transitioning into a post-graduation workplace. In the limited studies to date, prior work has shown positive relationships between co-op experience and ABET outcomes of alumni described using Davis' [9] engineering profile framework. However, these were not explicitly tied to workplace preparedness [10]. Prior studies have also identified positive relationships between co-op experience and both work self-efficacy of engineering students [11] and students' self-assessment on the graduate outcomes defined by the Canadian Engineering Accreditation Board [12]. Mandel & Edwards [13] studied the workplace preparedness of engineering alumni from an Australian co-op engineering program and found that employers rated co-op graduates higher overall than the national average for engineering graduates, particularly in the "Professional Attributes" category. These prior findings allow us to examine whether our findings are consistent in a different educational and workplace context.

Purpose. We assert that implementing and improving co-op programs to provide a pathway for students seeking to integrate engineering theory and practice requires a contextualized understanding of how program graduates perceive their realization of competencies for professional engineering work. Further, considering these perceptions from the perspective of an employer will enable engineering education researchers and practitioners to better understand similarities and differences between recent co-op graduates' and employers' professional expectations. To direct our research toward achieving these goals, we developed the following Research Questions (RQs):

1. What competencies do co-op program alumni and engineering industry employers identify as important for engineering workplace preparedness?
2. How do co-op program alumni and their employers describe co-op program alumni engineering workplace preparedness?
3. How are co-op program alumni and their employers' perceptions of workplace preparedness aligned with each other and with ABET outcomes?

Researcher Positionality. We acknowledge that the positionality of the research team affects not just our interpretation of results, but also the questions we choose to ask and how we choose to ask them [14]. The research team consists of three faculty members at IRE, two of whom have a background in engineering education research and one of whom has a discipline-specific engineering background. Our interest in this subject area stems from our experience selecting and working in a WBL program with a strong focus on career development, and we acknowledge that our interest in nontraditional educational settings may lend us towards seeking to validate our personal investment in our work and our students; this positionality is addressed through reflexive practice [15]. The first author conducted the initial interviews and completed coding for the pilot study. Her lived experience transitioning out of an educational setting into various workplaces and back into academia motivated her curiosity about important competencies for those transitions. Her background is in quantitative research, which influences her instincts for methodology in collecting, analyzing, and reporting data.

Methods

Study Context. IRE is an ABET-accredited, upper-division undergraduate engineering program located in the Midwest United States. Students transfer into IRE after completing most of their lower-division pre-engineering work at community colleges or other universities around the U.S.. The first semester of IRE is an 'Academy' semester where students take technical classes, receive career development training, and work on semester-long design projects in small teams [16]. A primary objective of the Academy semester is to provide students with mentorship as they prepare for, apply for, interview for, and ultimately accept co-ops for the upcoming semesters. For their remaining time at IRE, students work full-time (40 hours/week) in paid engineering co-ops. They take their technical classes remotely in the evenings and earn course credit by documenting the design and professionalism learning they do in their work. IRE is an Integrated Engineering program, and students have the option to focus their electives in a particular subdiscipline. The first class of graduates from IRE's co-op program graduated in Fall 2021.

Data Collection. In accordance with an approved IRB protocol, prospective participants were recruited from a list of recent alumni (purposeful sampling 0-4 years post-graduation) who had previously responded to a survey indicating interest in continued connection with IRE after graduation. The recruitment list included 36 alumni who completed the co-op program, and they were emailed directly and invited to share the recruitment email and interest form with their supervisors. Five alumni and two supervisors completed the interest form, and all candidates who completed the interest form were interviewed. To maintain anonymity, participants self-selected pseudonyms. Alumni pseudonyms are: AJ, Casper, James, Loren, and Ryan. Supervisor participant pseudonyms are: Alexander and DM. A summary of the alumni participants' work histories is included in Appendix 1. All participants were interviewed individually by the first author via audio call using a semi-structured interview template. The interviewer asked follow-up questions for clarification and to expand on responses. Interview questions focused on the following prompts, with minor wording changes for alumni vs supervisor participants:

- Tell me about your experience transitioning from school to the engineering workplace (alumni). *–or–* Tell me about your experience working with recent graduates of a co-op based program (employer).
- What do you see as the most important aspects of workplace preparedness?
- In what areas were you/your employee most and least prepared to enter the engineering workplace?

Data Analysis. Prior to coding, the first author reviewed the auto-generated transcripts for accuracy and removed identifiable information. Filler words (e.g., "um", "like") and stutters were removed in the direct quotes included here. Due to the open-ended nature of the interview responses, portions of the transcript were not immediately relevant to the RQs and were not included in coding (e.g., description of company-specific team organization, graduate program class schedule, supervisor participant asking interviewer questions about co-op program, etc.). Sections of the transcript that were identified as relevant were collected to form the initial codebook. The first author then performed two rounds of coding. First-round coding used in vivo coding of interviewee responses. This method was selected to allow researchers to observe participant perspectives in interviewees' own words, since the objective of the study is to allow

participants to express their own attitudes about the importance of different areas of preparedness. Second-round coding used values coding to identify attributes that participants described as important. Themes were developed from the values codes and allowed to evolve during analysis. The full transcripts will be revisited in the ongoing study as themes emerge and RQs evolve.

Results and Discussion

Major Themes. Four major themes related to RQ1 and RQ2 were present in discussions with all seven participants. These themes included communication, self-directed learning, professional growth, and familiarity; they are well-aligned with ABET outcomes and with findings in prior literature. Additional codes are included in Appendix 2.

Communication: Participants discussed both written and verbal communication, as well as presentation skills. Every participant highlighted communication, and DM listed this as the "biggest thing" for workplace preparedness: "What is a really vital skill to have above everything is: can you communicate person-to-person? Can I feel like I can connect with you? Can I feel like I understand what you're saying?"

Self-Directed Learning: This theme included asking questions, curiosity, quick learning, resourcefulness, and learning from failure. Alexander described the importance of new employees learning "how to find stuff themselves." AJ stated that asking questions "helps you get your feet under you a lot faster, and then you can start adding more value to the team more quickly."

Professional Growth: All alumni indicated that they were well-prepared for a focus on long-term personal and professional goals early in their careers. Alexander described an IRE alum standing out in their interview by asking questions about work culture and "Looking at the work experience as being more than just a job, [but] a place that you can grow." In addition, their responses highlighted an early-career focus on value creation for their employers.

Familiarity: Participants described that their apprehension about workplace transitions reduced with repetitions of the onboarding process and starting new jobs. The transition into a new job becomes more dependent on team and project specifics. This helped participants to build confidence and take ownership of their new roles. In Casper's words, "I have done this before, and I have accomplished so much in an extremely demanding position. Like, I can do this."

The major themes identified in the pilot study show alignment between alumni and supervisor perceptions of workplace preparedness of IRE alumni. Interestingly, no conflicting perspectives were identified in the data. Two of the three primary themes identified as important – communication and self-directed learning – were directly aligned with ABET Student Outcomes 3, "An ability to communicate effectively with a range of audiences," and 7, "An ability to acquire and apply new knowledge as needed, using appropriate learning strategies" [12]. In addition, findings were consistent with prior literature on alumni preparedness from WBL programs. The perception of communication as a top competency for the engineering workplace is also consistent with the findings of [7], which found ABET outcome g: Communication (from the previous a-k model) in the top cluster of important competencies. The focus on professional growth aligns with El-Sayed's [10] observation that co-op experience helped students develop in the role of "Self Grower" in Davis's [9] framework of behaviors of an engineer. The prior IRE

alumni study [8] under its former model also found alumni were rated higher in the "communicate effectively" and "efficient learner" competencies [8]. Although the alignment with ABET outcomes and prior literature is expected, it provides a helpful backdrop to observe other emerging themes and lines of inquiry.

Emerging Inquiry. Beyond our original investigation, we also identified several additional themes that are particularly interesting for further discussion and investigation.

Specialization: Two alumni described using PE preparation, and one alum a master's degree, to get more specialized training than they received in their general engineering program at IRE. All three alumni framed this as an opportunity to specialize, but it could also be interpreted as a missing piece of their undergraduate education. In James's words, "I wanted something to really show that, yes, I have this generalist engineering degree, so I'm kind of a generalist, but also I have a specialist degree so I can do the specialist route, too." The supervisor perspectives, too, revealed some ambivalence regarding generalist versus specialist training. DM said, "With the co-op, you might not get as much exposure initially to the concepts and the theory that you would in the academic world, but there's pluses and minuses both ways." But Alexander shared that he did not see any lack of technical skills in the co-op alumni employee. Future work will explore the motivation and decision to pursue specialization following graduation from a co-op program.

Spare Time: Three alumni participants described the experience of finding they had unexpected spare time after the challenging schedule of working full-time while taking a full course load. In AJ's words, "It's a little bit like, oh, what do I do with myself in my spare time, you know?" Casper connected this rigorous time commitment to the community that formed out of it, and spoke of needing to "fill that space" after graduation. The participant experiences, in general, tended to center around their transitions *out of school*, rather than *into the workplace*, because being in the workplace was a part of their school experience. While the sample is small for this pilot, it will be taken into consideration in the development of a refined interview protocol and the interpretation of future results.

Redefining Workplace Transition: Another unexpected finding was the language that participants used around the workplace transition itself, which challenged the researchers' preconceived notion that the transition into the engineering workplace would occur at or after graduation. This was most notable in the two alumni participants, James and Loren, who transitioned directly from a co-op or internship into a full-time role at the same company. In James's words, "It was pretty much seamless. The only difference was that I got paid more, because now I had my college degree." As Loren described it, "It was just kind of a change of scenery." This description of the minor transition post-graduation stood in contrast to the language James used to describe his transition into his first co-op: "I remember being just frightened just because I'm leaving my home, I'm driving to another state by myself, it's all on me." Participants who moved from co-op work at one company to full-time work at a different company after graduation described similar experiences. Casper described their first experience as very important for their growth and preparation for post-graduate work: "It's almost like it was demystified for me. [...] [It] made me feel like I really did have a sense of belonging, and that I was a competent individual who's able to offer a lot." The participants' definition of the workplace transition and its relationship to identity formation will be a subject of ongoing study.

Conclusions and Future Work

In this WIP study, we explore the perspectives of co-op-based engineering program alumni and their supervisors on workplace preparedness. We have thus far completed a series of pilot interviews to test data collection and analysis methods. Major themes include communication, self-directed learning, professional growth, and familiarity with the job transition process. Preliminary results suggest good agreement between alumni and supervisor perspectives on important competencies and alignment with the ABET outcomes.

This pilot study's small sample size limits our ability to draw broad conclusions about the perspectives of co-op-based engineering program alumni and their employers. It serves as a pilot for the data collection and analysis methods and a guide for developing further inquiry but is not designed to identify trends across contexts. In addition, we expect a self-selection bias to influence these results. No incentives were offered for participation, and the recruitment pool was limited to alumni who had previously indicated some interest in continued connection with the IRE program. Thus, the recruitment pool likely trends towards alumni who had more positive experiences within the program and/or wanted to discuss their transitions into the engineering workplace due to positive experiences finding and transitioning into engineering work. Finally, because supervisors were invited to participate by their employees, there may have been a bias towards employees with positive employee-supervisor relationships. These biases will be taken into consideration in the study design and interpretation of results of the ongoing study.

The results of these pilot interviews are actively informing a larger, mixed-methods study of recent alumni of undergraduate engineering programs. The interview protocol will be refined and the recruitment pool expanded to include candidates from a breadth of institutions. In addition to the findings expected from our original RQs, we also observed unexpected interpretations from the alumni participants of when their transition into the workplace occurred and what challenges were associated with each step. Based on this observation, future work will study participant perceptions of when the "workplace transition" takes place, what it means, and how it connects to identity formation and sense of belonging.

We will also collect quantitative data using rating scale questions in which participants will self/employee-assess the importance of listed qualities for their job and their preparedness in those areas. These competencies will be developed based on the pilot study themes and ABET outcomes. In addition, we will collect quantitative data on the number of co-ops or internships a participant completed and the time commitment and duration of their co-ops. Finally, we will collect data on the decision to specialize (whether through professional licensure, graduate programs, or both). These data will be analyzed with an interest in the relationship between co-op experience and preparedness.

These emerging results and the larger, ongoing study contribute to a growing body of work regarding the workplace preparedness of graduates of WBL programs. The knowledge gained from contextualized understanding of alumni and employer perspectives will help in the development of effective programs that integrate technical knowledge to workplace context to prepare students for professional practice.

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Appendix 1. Alumni participant workplace histories

Pseudonym	Time in current position	Other details on co-op to work transition
AJ	1 year	Completed co-ops during school but none at current company.
Casper	<1 year	Completed co-ops during school but none at current company.
James	>2 years	Completed 2 engineering co-ops at other companies, then interned at current company, then transitioned into full-time role after graduating.
Loren	<1 year	Transitioned from co-op to full-time employee at previous company and worked there for 4 years. Did not co-op at current company.
Ryan	2 years	Worked at a previous company as an intern and then full-time. Did not complete any internships or co-ops at current company.

Table 1: Alumni participant roles and work histories

Appendix 2. Additional Codes

Initiative (4/5 alumni, 2/2 supervisors): Most participants mentioned initiative, determination, agency, confidence, and independence, all of which contribute to success in the workplace transition and beyond. Ryan highlighted that this was a key to both success and job satisfaction, "Are you actually driven and motivated to do this stuff? Because the work here is hard, it is gonna be absolutely miserable if you're not genuinely passionate about what you're doing and this industry. And if you are, you're going to love it."

Workplace Culture (4/5 alumni and 2/2 supervisors): All but one participant included some description of workplace culture, but experiences were mixed and included both benefits and challenges. Two alumni mentioned specific challenges with preparedness for integration into workplace culture. AJ described that when their personal expectations about professional conduct (professional language, dress, timeliness) were not met in their first position, it took them off guard. Loren mentioned that navigating building friendships with coworkers was challenging when moving from the school environment. However, Casper described a benefit to the co-op experience as it helped them learn the "unspoken rules of corporate" that they had not been taught elsewhere. Alexander described that a IRE alum was particularly well-prepared to navigate interpersonal conflicts in the workplace, proactively having conversations to improve culture.

Professional Skills (2/5 alumni, 2/2 supervisors): This included a wide range of "soft skills" in the workplace. Both supervisor participants described the strong personal management skills, such as attention to detail and prioritization of work, in co-op program graduates. This theme also included discussions of teamwork, collaboration, and professionalism.

Application of Knowledge (2/5 alumni, 1/2 supervisors): Several participants described strong connections between theoretical learning done in the classroom and real-world applications from IRE alumni. DM highlighted this as a positive, saying, "We all have to know the engineering concepts, but the reason that the internships and the co-ops are so important is they actually see the application of that theory."

Mental Health (2/5 alumni, 0/2 supervisors): Two alumni described the challenge and importance of maintaining mental health through workplace transitions. AJ described the value of mentorship and connection: "Being out on my own and everything was a heavy mental load, and just having some additional check-ins with [mentors] after that would have helped ease that a lot."

Negotiation (1/5 alumni, 0/2 supervisors): One alum who transitioned directly from co-op work into a full-time role at the same company described the challenge of negotiating salary and benefits for their first full-time role. They felt that they had less leverage than when moving between companies and felt unprepared for this conversation.

Societal Barriers (1/5 alumni, 0/2 supervisors): One alumni participant, Casper, described how, "There's so many gaps between education and actual professional work, that it creates massive barriers in our society." The co-op program helped them understand their career options and how to succeed: "I didn't know entirely what engineering was, or what engineers did, until I started with this program that laid it out for me."