Understanding the Influence of Work-Integrated Learning Experiences on Students' Identity Formation in Engineering

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Abstract

This research paper examined the factors influencing students' access to work-integrated learning experiences (WILs; i.e., internships and co-operative education). Several studies have examined how WILs enrich students' academic and career development. Yet, fewer studies examine the considerations associated with who participates in WILs and how these types of experiences shape students' beliefs about themselves as engineers or their career plans after participation. This study examines the narratives of 25 students who did and did not participate in WILs to understand why students choose to participate in WILs, the considerations and challenges to participating in WILs, and the impact of WILs on students' identity development. This research used an adapted framework of identity trajectory theory, which consists of three interlocking strands—institutional (i.e., programs, practices, procedures, etc.), networking (i.e., social networks, faculty interactions, etc.), and intellectual (i.e., field of study, learning progression, career trajectories, etc.). We used analysis of narratives to draw out key themes related to how institutional resources and students' networks facilitate their access to WIL experiences. Analysis also highlighted how WILs affect students' identity development as engineers during undergraduate education, including their career intentions upon graduation. We identified five big ideas that were expressed by the students to address the research questions. These ideas include: 1) Institutional structures and resources facilitate students' access to WILs; 2) Students utilize personal and professional networks to improve access to WILs; 3) Various commitments and responsibilities inhibited students' access and engagement with WILs; 4) WILs positively influence latently diverse students' identity development; 5) Individuals who did not engage in WILs identified supplemental opportunities to support their engineering identity. We highlight how these experiences, or lack thereof, influence students' perceptions of themselves as future professional engineers. These results have implications for practice and policies in engineering education, particularly enhancing students' access to WILs and constructing WILs that support students' identity development.

Introduction

Work-integrated learning experiences (WILs) have become a core aspect in the early socialization of engineers into the profession. As a result, students who engage in WILs enhance their understanding of the cultures, norms, and skills essential to support their success in the workplace environment [1]-[5]. In addition, these experiences tend to strengthen their technical and interpersonal skills, which in turn have the potential to translate into improved academic performance [6] and a broadened network [7]-[8]. As students work alongside engineers in the field, they can take ownership of important projects that can influence their communities and drive innovation and growth in a company [1],[7]. The recognition of their impact fuels students' increased sense of competence and confidence in their technical skills because of the significance of their work [1].

While WILs result in numerous outcomes related to academic and professional advancement, all engineering students are not afforded access to co-curricular opportunities like internships and

co-ops. Some factors that influence student access to WILs involve financial circumstances, weariness towards elongation of their program, and fear of missing out on other campus opportunities [9]. These factors inherently limit students' access to work-integrated learning environments and engineering professionals.

In this paper, we examine the factors influencing students' access to WILs and how WILs support or constrain students' identity development over time. We used narrative research methods to address the two research questions guiding this effort:

1. What factors influence students' ability to access work-integrated learning experiences?
2. To what extent do work-integrated learning experiences, or lack thereof, influence students' identity development in engineering?

Early on, we characterized WILs into two classifications—cooperative education (co-op) and internships. The distinctions between the varied classifications of WILs allowed us to identify studies concerned with WILs in engineering education. Below, we describe how we used the adapted theoretical framework, identity trajectory theory, and narrative research methods to examine the "restoryed" case narratives. This work provides the engineering education research community with implications for policy and practice that can be used to enhance engineering students' access to WILs.

Literature Review

There is a growing body of literature that focuses on student engagement in WILs. WILs integrate academic learning with practical applications in the workplace [10]. These experiences may include various opportunities such as internships and co-operative education (i.e., co-ops), that are either embedded into the curriculum, highly encouraged by faculty, or independently sought out by the student [11]. WILs allow students to reinforce and broaden their understanding of concepts introduced in their coursework [1]. In particular, these structured WILs enrich a student's professional acumen by further developing their interpersonal and technical skills through hands-on and meaningful work.

Since they were established, internships and co-ops have become a key component of engineering culture and the stepping stone into life as a practicing engineer in the workforce. WILs have been fundamental to the development of undergraduate engineering students' access to mentorship [1],[4],[7],[12], learning outcomes [1]-[5],[12], persistence and academic performance [6],[13], employability [3]-[5], and transition into the workforce [5]. In addition, several factors influence the outcomes of WILs such as student classification (i.e., first-year, second year, third year, or fourth year) [14], WILs structure [1], the amount of recognition awarded [7], and the individual's mindset [1]. For example, Major et al. [14] described how students who engage in WILs prematurely do not have sufficient foundational knowledge and skills to make meaningful connections between concepts learned in the classroom and practical applications exercised in the work environment. While positive WILs can lead to a boost in self-confidence [2], these experiences may also enable students to reframe their career goals [5] or even withdraw from STEM altogether [15]. As a whole, WILs have directly influenced students' understanding of how they fit within the world of engineers [4],[16].

Existing studies draw on both quantitative and qualitative research methods to understand how WIL's support students' professional and technical development. However, little work captures the perspectives of students who do not engage in WILs. As a result, there is an opportunity to examine how the lack of engagement in WILs influences students' identity trajectories and understand what factors influence their access to WILs. This paper will help the engineering education research community identify factors that support or constrain student access to supplemental experiences that enhance their practical understanding of engineering.

Theoretical Framework

Identity Trajectory Theory

Identity Trajectory Theory was developed by McAlpine and Amundsen [17] to examine the identity development of graduate students and early-career academics. This framing of identity development emphasizes how learning and development occur over time and is influenced by an individual's past, present, and imagined future [18]. Specifically, identity trajectory theory draws on an individual's personal and professional experiences through three interconnected strands (i.e., intellectual, institutional, and networking). We draw on an adapted framework of identity trajectory theory to understand how work-integrated learning experiences influence latently diverse students' identity development [19]. Within the context of this study, the intellectual strand represented the benefits students perceived from their experiences and skills acquired along the way. The institutional strand represented the resources provided by universities and specific structures implemented to encourage accessibility to work-integrated learning experiences. The networking strand referred to how students were utilizing their personal and professional networks to gain references and insights into WILs. Mapping student identity trajectories in relation to their participation in WILs allowed us to further understand the intricacies of their journeys while also retaining the authenticity of their accounts, experiences, and emotions.

Methods

Data Source and Recruitment

The data for this study comes from a larger mixed-methods study focused on characterizing latent diversity in engineering. Latent diversity is defined as the attitudes, mindsets, and beliefs that are not readily visible in a classroom that may inform our understanding of how to foster innovation and inclusion in engineering [20]. The first phase of the larger project involved distributing a survey to 32-ABET accredited institutions, across the United States, measuring early career engineering students' incoming attitudes, mindsets, and beliefs [21]. Students who completed the survey were asked to provide their contact information (i.e., email address) to participate in the next phase of the project. We recruited students with varied underlying attitudes, beliefs, and mindsets to participate in the longitudinal narrative interviews to understand their identity development and pathways through engineering over time.

A total of 25 participants were interviewed in the first round of interviews in the Fall of 2018. For the larger study, students were asked to participate in interviews each semester through

Spring 2022. Three students left engineering to switch to different academic majors (i.e., health data science, business, and secondary science education) at various stages of the data collection process. In this study, we focused on the narratives of 18 undergraduate engineering students who described their involvement, or lack thereof, with internships, co-ops, and/or research. Table 1 consists of each student's pseudonym, major, and whether they were involved in work-integrated learning experiences at some point within the data collection of rounds 1-3 of interviews.

Table 1. Participant Information

Pseudonym	Major	WILs Participation	Gender Identification
Gary	Electrical Engineering	Co-op	Male
Anna	Electrical Engineering	Co-op	Female
Bob	Civil Engineering	Co-op	Male
Susan	Mechanical Engineering	Internship	Female
Robin	Engineering Science	Internship	Female
Adriana	Electrical and Computer Engineering & Math	Internship	Female
Briggs	Nuclear Engineering	Internship	Male
Josh	Mechanical Engineering	Internship	Male
Joy	Mechanical Engineering	Internship	Female
Thomas	Mechanical Engineering	Internship	Male
Lauren	Mechanical Engineering	Internship	Female
Frances	Biomedical Engineering	None	Male
Jamie	Chemical Engineering	None	Male
Tchuck	Biomedical Engineering	None	Male
Yetti	Aerospace Engineering	None	Not Listed
John	Mechanical Engineering	None	Male
Steve	General Engineering	None	Male
Allen	Biomedical Engineering	None	Male

Narrative Research

Narrative research is a rich methodology that draws from participants' accounts to narrate a story true to their perspectives and experiences. Kellum et al. [22, p. 26] described the power of narrative inquiry as an "opportunity to uncover the essence of a large system," often creating an avenue for researchers to capture more "complex phenomena" such as underlying emotions and attitudes [22]. The power of narrative research comes from the voices of the participants where their stories are presented in ways that are consistent with their point of view and remain intact with thow they were originally stated. Narrative research is critical to maintaining invariable sources of information over time for the sake of continuity, consistency, and clarity. It is through

our narrative research that we can use the construction of narratives to condense longitudinal interviews into digestible portions while still retaining the complexity of our participants' stories.

Narrative Interviews

Individual virtual interviews were conducted typically by one researcher, via Zoom, approximately every six months for 60 to 90 minutes. The first round of interviews was designed to understand students' backgrounds and pathways into engineering. The second and third rounds of interviews involved asking students to complete a journey map to depict the highs and lows since their previous interview. During the interview, we asked the students to describe their experiences over the past approximately six months using the journey map elicitation tool. This process allowed the students to reflect on their curricular and co-curricular experiences while navigating engineering. Following the journey mapping activity, the interviewer asked clarifying questions to bring out more details about the students' experiences. Then, the researcher followed up with standardized questions from the interview protocol that probe into students' classroom experiences, interactions with faculty in engineering, as well as how they navigated the highs and lows of their journey map. The subsequent items are example questions and prompts used to understand how each student navigated their institution, network, and intellect:

1.) Tell me about your classroom experiences in your third year. (*Intellectual Strand)*
2.) Thinking about the low points on your journey map, how did you navigate through that experience? (*Institutional Strand)*
3.) Tell me about your interactions with faculty and staff in the college of engineering. (*Networking Strand*)

We continued to use journey maps to elicit students' identity trajectories and probed further into their short and long-term goals and current educational environments. Each participant was given a $20 gift card as an incentive for their participation in each interview, as approved by the Institutional Review Board.

Data Analysis

Following each interview, the audio recordings from each session were transcribed verbatim with a professional service and reviewed for accuracy by a research assistant. Below, we discuss the techniques used to examine how students' gained access to WILs and how these experiences influenced their identity development.

Narrative Construction

Narrative construction is a tool utilized to provide a reader with essential information from an extensive account from the narrator's point of view. This method "allows the researcher to focus on the nuances of an individual's unique story," inevitably providing depth that exceeds other research methods [23, p. 4]. In this paper, we utilize restoryed case narratives to depict the identity trajectory of latently diverse students as they draw on institutional resources and networks to explore opportunities to engage in WILs.

We constructed the narratives from the first-person point of view, primarily including direct quotes from the narrative interviews [22]. This approach prioritizes the participant's voice rather than a third-person approach where the researcher narrates the larger story [22]. We included extra text to provide clarity within the narrative where student responses were unclear. These modifications are shown in italics to distinguish between the voice of the participant and researcher.

To improve the clarity of the narratives, without compromising the credibility and reliability of the story, narrative "smoothing" must take place [24]. This process is where a researcher will minimally edit a quote, with the evident distinction of the narrator and researcher voice, or rearrange the order of the details to remove redundancy and ensure cohesion. The end goal is to enhance readability to improve the receptiveness of the story for the reader while also maintaining the integrity of the participants' statements. Following the construction of narratives, we utilized analysis of narratives to conceptualize the shared attitudes and experiences of the students as they searched for opportunities to engage in WILs.

Analysis of Narrative

Analysis of narrative, specifically thematic analysis, takes what is said in narratives and draws connections based on themes, shared experiences, or attitudes shared by participants. The use of this method helps preserve the integrity of the narratives while maintaining the reliability and validity of the statements [22]. In this paper, we are communicating the narratives to our readers based on their (in)experience with WILs. Their stories were tied together by identifying overarching themes of students' experiences and attitudes amongst the 18 participants, highlighting the commonalities resulting from their (in)access to WILs.

We used an adapted framework of identity trajectory theory to understand what factors influenced students' access to WILs and how WILs influenced their identity development over time. Preliminary analysis involved identifying students who described their involvement with internships and co-ops and those who lacked WILs experiences. During the first cycle of coding, we utilized deductive coding to apply our theoretical framework by using three codes (institutional, intellectual, and networking) to identify instances in which they were interacting with their network or institutional resources to gain a WILs position, spoke about their motivations for attaining WILs, or reflected on their perception of themselves as engineers, specifically within the second round of interviews. The second coding cycle was based on inductive coding that allowed for new codes to arise as a result of the shared experiences and attitudes of the participants. This process allowed for the emergence of more specific codes like frustration while looking for WILs positions, graduation requirements instated by institutions, and the need to take summer courses or look for a summer job. Participants under the same WILs/Non-WILs classification group mentioned similar resources and experiences that shaped their identities as engineers. Based on the most common experiences across each group, we selected five big ideas that best encompassed the shared experiences of the participants.

Findings

This paper reports our findings involving how students gain access to WILs and how WILs ultimately influence their identity trajectory. Below, we describe the experiences of students who participated in WILs and those who have not to emphasize the contrast in experiences and influence on their identity development. We identified five big themes that were expressed by the students to address the research questions: 1) Institutional structures and resources facilitate students' access to WILs; 2) Students utilize personal and professional networks to improve access to WILs; 3) Various commitments and responsibilities inhibited students' access and engagement with WILs; 4) WILs positively influence latently diverse students' identity development; 5) Individuals who did not engage in WILs identified supplemental opportunities to support their engineering identity. We highlight how these experiences, or lack thereof, influence students' perceptions of themselves as future professional engineers. We have organized these themes by how they answer each of the research questions.

RQ1: What factors influence students' ability to access work-integrated learning experiences?

Institutional structures and resources facilitate students' access to WILs

Some students were required to participate in an internship or co-op as a graduation requirement. These institutional structures created a space in which WILs were a necessary and normal right-of-passage within engineering education. For instance, Bob described his experience searching for an internship with the facilitation of his co-op instructor during the beginning of his second year in college:

> Also, at my institution, we have to do a co-op for our program. I was looking for one near my house, so I asked our co-op faculty who helps us find co-ops if she knew anyone at a certain company. She had this email, so I emailed them and then they set up the interview for like a week later, which was really fast for me, especially considering this was fall. It was like early fall. Then, during the interview, all we really talked about was what I would be doing and what I'd be working on. Then, I got a job offer either, I think it was two days after the interview. It's going to be a construction management intern job. I really like it because every two weeks or so I'll switch projects. I'll be able to see a bunch of different projects instead of just one for the entire summer, which would be a great experience.

Bob's institution required engineering students to identify and complete an internship or co-op to graduate. He leveraged his faculty's network to access an internship within proximity to his home. Similarly, Gary utilized a career portal to identify available positions to ensure he fulfilled his graduation requirement.

> At my university, we have *a* co-op *requirement,* which is a full-time, 40-hour-a-week job where you get paid and everything, and we have a huge database of companies that we already have partnerships with. I applied to 25 jobs and got two interviews which is kind of ridiculous to me.

Gary explained how extensive a search for an internship or co-op can become. While he applied to 25 distinct listings, he only received two opportunities to interview for a co-op, highlighting the frustrations many undergraduate engineering students may face throughout this process. Other students like Anna, Josh, and Joy experienced similar pressures from their institutions to engage with internships and co-ops.

Students used various resources to build their network and make meaningful connections with engineering professionals including career services portals, student organizations, and career fairs. Adriana engaged with an identity-based student organization for women and attended the career fair at their annual national conference. Adriana indicated how "that conference is such an incredible opportunity because there are hundreds of companies there and they're all there to hire women, which is not something that you get usually in engineering." Since this conference was geared specifically for women in engineering, Adriana felt comfortable and confident while networking with recruiters at the networking events.

> I decided to go to a meet and greet with one of the companies. The meet and greet was pretty much food and drink and a bunch of interviewers, that's all it was, or a bunch of reps looking for people. I decided to go because I'm like, "I have nothing better to do at this point. You might as well get the jitters out and goes talk to some random people. I will not get anything from this but we'll see." I spent I think at least an hour and a half there talking to six or seven people just working my way around and it was really interesting because I almost got two interviews out of that. I had a lady from Chicago wanting to interview me and when the guy from Southern California heard about that, he's like, "Nope, I'm going to steal you, you're going to interview with me." I'm like, "Okay." I probably looked like a lost excited puppy during the entire thing.

Following this event, Adriana received multiple offers and was able to intern at a global defense company.

Requirements or strong encouragement to participate in WILs can support student engagement; however, our student's stories also emphasize that appropriate support needs to be in place to help students seek and successfully secure WILs experiences. Robust institutional resources supported many students with engaging in WILs through their institutional network and allowed students to continue building their professional network and identity as engineers.

Students utilized personal and professional networks to improve access to WILs

Throughout students' undergraduate experience, they draw upon their personal network to enhance their professional network. Several participants utilized their personal network to gain access to WILs before entering their undergraduate engineering program. However, those students who did not have connections to the field prior to college built their professional network while in college via interactions with faculty, counselors, and mentors. These connections improved students' access to WILs.

Most notably, Joy drew upon her personal network with her high school robotics team to foster a mentorship relationship that later facilitated her access to internships. She received a recommendation for an internship from an engineer she connected with through FIRST robotics.

> One of the mentors is one of the engineers of this company now. He was just hired and so he recommended me for this job which I knew robotics would pay off, and not just learning how to use a tape measure, but actually having connections that will get me jobs in the future. … He remembered me and offered to let me work there as an intern for summer, cause he thought that I would be a good fit.

Joy pulled from her past network to gain exposure to the engineering industry, showcasing the benefits of her mentorship beyond its initial project. In addition, Joy's father is an established computer scientist. Joy recounts how she was able to use his knowledge and skills to identify roles and connections.

Similar to Joy, Thomas was able to draw upon community connections to acquire an internship position. Although his process of applying to internships seemed more casual than Joy's, he explained how he was able to gain other supplemental opportunities, like a tour of the company's facilities, in addition to receiving a job offer.

> I learned about my next internship while I umpired for little league baseball. I've been doing *this* since I played. I've been doing it for years. So, I was umpiring, and I was talking to a lot of coaches and he was talking and it's like, "Oh you go to college?"
> "Oh yeah." He asked me what I was studying.
> "I'm doing engineering."
> He goes, "Oh, really. I work at a company and we do a lot of internships. Call me next winter. We're filled this summer, but call me next winter and we'll see, we'll give you an interview or something." So, I hit him up next, I hit him up over Thanksgiving break and he gave me a tour of the place. And then offered me the job. So that's how I got that one.

Thomas also leveraged a family member to gain insight about an engineering position. After he received an opportunity to interview with an aerospace company, he connected with his cousin to discuss their experience interviewing with the company. This conversation allowed Thomas to adequately prepare for his interview.

Unlike Joy and Thomas, Lauren fostered connections with faculty at her institution as an undergraduate research assistant. Her faculty mentor for her research project informed Lauren about an internship position at a national lab where she could continue her research efforts and grow as a researcher.

> The professor I work with in the lab mentioned how there was an internship at the national lab we collaborate with, the place he did the measurements, for experiments. He encouraged me to apply for the internship. I said, okay, I'll do

that. And so, I applied for it. And I got the job, the internship, the job, I'm going to be working on the same project that I'm doing here.

By engaging in undergraduate research, Lauren learned about conducting research and received mentorship. These responses illustrate how students access WILs by receiving mentorship through familial connections, industry mentors, and faculty.

Various commitments and responsibilities inhibited students' from engaging with WILs

While institutional resources and building a network helped students land internships and co-ops, some students were still unable to attain access to WILs. Several factors influenced students' disengagement in WILs. These factors include the need to enroll in summer classes, personal responsibilities, and not receiving opportunities to interview with a company. As a result, some students engaged in alternative work experiences that were not related to engineering.

Most notably, the need to take summer classes or a prior commitment to a summer job were the most common indicators of whether or not a participant would engage in a work-integrated learning experience. Steve, one of the participants who did not engage in WILs, was unable to do so because of summer courses. He said, "I'm trying to continue to take classes during the summer so I don't have to take as many during the school semester...If I do that, that would be a great help."

The responsibilities of the courses compromised any time or commitment he could have dedicated to a potential WIL experience. He chose to prioritize the balance of his anticipated academic schedule at the expense of supplemental opportunities provided by internships and co-ops. Despite his efforts to pursue personal projects instead of WILs, Steve had to give medical attention to his family. He states, "I ended up not really having the time to work on the personal projects since my sister had some pretty serious medical issues. Instead, I had to take care of her and help my family." As a result of the unpredictability of his family's health, Steve was limited in the opportunities he could create for himself through personal projects.

Students' commitments to summer jobs also played a strong role in limiting their engagement with WILs. Yetti, an international Aerospace engineering student, was unable to be a part of an internship and co-op due to their commitment to their summer job at the local grocery store.

Instead of taking summer classes, I had a part-time job. I also tried to do some undergraduate research … I didn't do much in that academics part of my life but I was able to work a lot more, make some money and that way there's a lot less financial stress on me and my parents for the start of the semester.

As they mentioned, their position in a retail store allowed them to comfortably attend school without the additional stress of financial shortcomings. Yetti, like Steve, chose to prioritize their future academic schedule and workload over their exposure to external opportunities. Other participants, like Jamie, Frances, John, and Tchuck spent most of their summers working as well.

Despite having external responsibilities and commitments, students did not hesitate to apply for internships. One of our participants, Tchuck, was driven to apply to several internship listings. He insisted, "I've already started applying for internships now, and I plan to continue until I eventually land one, and even then, probably still after just to get more options." The following year, he took a similar approach and was able to receive an interview.

> Ideally, I'd like to get an internship. I got on a phone interview with someone but, ...then I didn't end up getting that one. And then, I applied to a bunch… But then, again, nothing happened there either. So, yeah. It's been a little bit of a frustrating process, but I'm still working on it right now. Don't know if anything's going to end up happening.

Despite his greatest efforts, Tchuck was unable to gain an internship position. However, he engaged in undergraduate research throughout his collegiate experience. These students were not complacent with their time. Instead, these students found external opportunities to supplement their academic knowledge. These external opportunities will be presented in the section below.

RQ2: To what extent do work-integrated learning experiences influence students' identity development?

WILs predominantly contributed a positive impact on latently diverse students' identities who participated in programs

Students who spoke most highly about their internship or co-op experiences received independence and ownership over a project or tasks which increased their performance competence. Briggs, for example, was able to work at the headquarters of an energy company focusing on a reactor design for a micro-reactor. As a result of his internship, he felt more confident in the skills he applied during the program and his ability to be successful as a future professional engineer, thus emphasizing the importance of WILs for engineering identity development.

> I think especially having an internship now has been really important because before, I've just been a student, and the only jobs I've had, have been lifeguarding. I feel like actually getting to feel like an engineer for the summer, it feels a lot more real. Being halfway through my college career now, it's starting to feel like being actually an engineer and getting out and working is right around the corner, as opposed to when I first started, it felt like a distant dream, like someday, I'll be able to work… I feel like adding that internship and focusing now on nuclear engineering courses, this is a job that I could see myself being very passionate about. It's a job that I see that I can communicate with other professionals in the field very well. So, it's made me a lot more comfortable, a lot more confident in my choice to study engineering.

This experience improved his performance competence beliefs and enabled Briggs to learn more about the implications of pursuing a career aligned with his nuclear engineering major. As a result, Briggs left his internship position with new skills, a new sense of confidence, validation

for his career choice, recognition as a future engineer, and an increased network of professionals in nuclear engineering.

> Leaving the internship, I had a lot of people offering to be referenced for future jobs, exchanging a lot of contact information for the future. It was really interesting to see that these people were a lot more than robots who sit at desks all day grinding out math problems. It was a very, very positive experience. It made me feel a lot better about going into the field of engineering.

Briggs was able to reach the learning objectives put into place by the internship program as well as gain insight into the norms and customs of an industry-based engineering environment. Similar to Briggs, Joy experienced a positive experience while in her internship position. She was able to work at a small company, which ultimately benefited her acclimation into the field and informed her of the design process.

> The engineers were very kind, and I learned a lot from them. And I'm more confident in my ability to go through the engineering process of, "We have a need. How do we solve that need," and how to get from Step A to B to C and finally putting it on the machine. Because it was a small company, I was able to actually see the very start all the way to actually shipping it out on the unit that the customer was going to use. My engineering internship was a lot of fun, and kind of helped me regain my confidence in my engineering abilities and just kind of get myself out of the academic mindset.

Although she did experience an overall positive experience, it should be noted that Joy, along with Robin and Anna, felt unrecognized at the beginning of their internships. Whether it was a superiors' lack of understanding of their breadth of skills or a lack of trust for women in their discipline, these women were not able to engage with meaningful work until they spoke out about their intent to create progress and innovation for a project, the company/institute, and stakeholders. Despite their initial barriers, changes were made in all cases to help the women learn and become significant contributors to the goals of their respective positions. Consequently, the women felt more like engineers at the end of their term.

Individuals who did not engage in WILs found supplemental opportunities to enhance their identity as engineers

In contrast to students who engage in WILs, students who did not were not complacent during their apparent free time. Individuals who did not engage with WILs found supplemental opportunities to enhance their skills as engineers through means of personal projects, institutional research opportunities, or community engagements.

In addition to his summer job, Yetti was able to engage with undergraduate research experiences within their institution. Due to their lack of internships and co-ops, they chose to supplement their experiences with an opportunity to apply their skills through a practical application. In this case, they worked on applying new technologies where fluid dynamics were involved.

Recently, we received funds from the university to actually build and design this project… The biggest thing I've done so far is I've helped source parts and materials for the actual construction of this fuel transfer system. Over the summer, we're looking to build the system, get the sensors we need, possibly ask for more funding, because we're realizing how expensive it might be…

Regardless of their lack of WILs experience, Yetti understood the significance of these experiences in helping them apply their skills and improve future employability and acclimation into the workforce. They recounted:

I was trying to get involved somehow with the research as a way to get my foot in the door or get actual engineering related experience versus the part-time job I have which doesn't offer me any engineering experience because I'd like to get some experience in the field before I graduate and potentially enter the workforce.

Yetti found an opportunity to supplement their understanding of engineering and was able to strengthen their engineering identity with the progress and impact of their project. Similar to Yetti, Frances chose to engage in a supplemental opportunity rather than an internship or co-op experience. Frances worked at his local church to help families with any miscellaneous work that needed to be tended to in their houses.

For the most part, this summer I worked on odd jobs for people at my church and family members who needed work done… I've found it's similar to engineering in the problem-solving aspect of it, but not so much in the mathematical aspect.

Frances did not engage with WILs but found value in the work he was doing because he was applying interpersonal and critical thinking skills to his role. In addition, these jobs helped him realize the impact of his work, which would be mirrored in his future work as a professional engineer. These results highlight how WILs are not the only avenue to influence students' identity development as engineers, ultimately showcasing the value of other hands-on experiences beyond internships and co-ops.

Discussion

This study examined undergraduate engineering students' access to WILs to understand how their access and experiences influenced their identity as engineers. Specifically, we honed in on the experiences of latently diverse students to broaden the existing literature concerning how WILs support or constrain students' identity trajectories. Consequently, this study showcased how educators can enhance students' exposure to WILs and other equivalent co-curricular opportunities that enhance students' performance/competence and recognition beliefs.

Engineering programs that embed WILs as a graduation requirement increased the likelihood that students would have access to an internship or co-op compared to engineering programs with alternative curriculums. Alternative curriculums include programs that adopt an educational model where hands-on experiences are woven throughout the four-year undergraduate program (e.g., engineering clinic). Both approaches provide students with faculty mentors equipped to

provide advice, resources, and connections to engineering professionals without the need for an external search for WILs experiences. Engagement in courses like engineering clinics provide experiential learning for students but should not replace WILs experiences that link them to corporate partners and broaden their network and connections with full-time engineers.

Likewise, most institutions provide students access to career services and career fairs every six to twelve months. Our findings indicate how the graduation requirement motivated student engagement in WILs compared to students in programs without the graduation requirement. Some students delayed utilizing institutional resources provided by the career center to enhance their resume and interviewing techniques until their third year of engineering. This finding is consistent with prior work that suggests some students delay engagement based on their concerns of elongating their academic program of study and the feeling of being unprepared due to their class standing [9].

In addition to institutional resources, students were able to draw on their personal and professional networks to gain access to WILs. In this paper, we defined personal network as the connections built prior to a student's collegiate career and a professional network as the connection fostered throughout a student's time in college. The majority of the students had a previous family member who was in engineering or a tech-related field. Although many of these family engineers were closely related to the students (i.e., parents or grandparents), not all students' utilized this familial network connection to their advantage. Instead, some students relied on their personal network to gain WIL positions and prioritized connections with community members who provided mentorship prior to college.

In contrast, other students drew on their collegiate professional network to gain access to WILs such that their connections to working professionals were only formed as a result of their integration into institutional opportunities, like research labs. This finding aligns with prior work that showcases how members who do not belong to resource-rich networks need to purposefully activate their social capital to strategically utilize their resources towards a goal, like becoming a professional engineer [25]. The ways in which students form their networks opens up a conversation that highlights the need for engineering educators to provide students with opportunities to build their social capital to support their identity formation and career advancement.

The students who engaged with WILs described positive outcomes and impacts on their identity as engineers. Previous literature has encouraged the need to provide students with meaningful work as a way to improve their recognition as competent engineers [1],[7]. Given that WILs experiences reinforced all of the students' perceptions of their abilities and potential to be an engineer, WILs should not be marketed solely for their ability to immerse a student in industry and grant them insight into the workplace environment. WILs should also be promoted for their ability to validate engineering students' skills and knowledge while applying them to a broader impact or cause.

In addition, half of the women in this study who participated in WILs experienced a lack of recognition within the initial portions of their internship positions. These women were not recognized until they vocalized their need for meaningful work and were able to demonstrate

their value as interns. This finding aligns with Chopra et al.'s [26] study involving gender differences in WILs, such that the greatest difference in satisfaction in women's experiences concerned the lack of recognition and exposure to overt discrimination. The experiences of these women provide the foundation for future work to examine how a lack of representation within the workplace can influence how students who are historically underrepresented in STEM, specifically women, are being treated in the workplace.

Students who did not engage with WILs were inhibited for various reasons like summer classes, external opportunities and responsibilities, co-op requirements and restrictions, and simply not being accepted for a WILs position. It should be noted that all participants disclosed their awareness of internships and co-ops and understood their value; however, how they chose to spend their summer or academic school year was molded by their anticipation of a future schedule, various opportunities that arose, or unprecedented circumstances. Instead of being complacent with the lack of experience within industry, each individual found a way to supplement their academic endeavors with an activity that helped them continue to learn engineering skills, allowed them to develop interpersonal skills, or gave them the opportunity to apply their theoretical knowledge. The inhibiting factors discussed by non-WILs participants inform us that not all students are afforded the same opportunities to engage in high-impact experiences like internships and co-ops. However, there is a need for future work to examine specific high-impact learning experiences that contribute to students' identity development.

Implications for Practice

Some students described how engineering clinics supported their professional development, like resumes and public speaking. While professional development is important, educators should also consider integrating project-based learning in the classroom. These experiences will provide students the opportunity to identify and create innovative solutions for real-world problems through the design process, similar to industry. This approach to course design creates opportunities for students to gain hands-on experience, interdisciplinary collaboration, and practice useful skills like 3D modeling, 3D printing, soldering, and laser cutting. Likewise, educators should consider partnering with local companies to enhance the experience by emulating interactions that occur within a workplace and expanding students' access to professional engineers. Incorporating hands-on experiences that resemble industry work within engineering curricula also provides an equitable environment for all students to mimic the life of a professional engineer without having to take any additional courses or search for extracurricular hands-on experiences.

Conclusion

These research findings informed our understanding of how students utilize institutional resources and networks to gain access to WILs. Our work highlights the positive influence WILs have on students who engage with these opportunities. However, WILs are not the sole source of experiential learning that contribute to students' identity development. It should be noted that by the end of the fourth round of interviews, students began addressing the impact of COVID-19 on their access to internship and co-op positions but did not dive into its effect until the next rounds. Our future work also includes examining how the pandemic influenced students' access to WILs,

as well as how the pandemic influenced the nature of engineering work and workplace interactions.

Acknowledgements

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