Designing for success: An examination of microelectronics engineering student internship experiences

JENNIFER S. LINVILL[1]
ERIC HOLLOWAY
EMELINE OJEDA-HECHT
KERRIE A. DOUGLAS
PETER BERMEL
REBECCA N. SEMRAU
Purdue University, West Lafayette, USA

Although internships are widely studied work-integrated learning (WIL) practices, microelectronics and defense-related engineering internships remain underexplored. This qualitative study examines how students' experiences in internships shape their professional and subjective development. Guided by existing scholarship, including the students' reflections of quality (RoQ) framework, the central research question—"What is the nature of students' relationship to their internship experience within WIL programs?"—is examined. The study also explores belonging, job pursuit intentions, developmental value, and satisfaction. Thirty-one participants from thirty-one institutions shared rich descriptions of their internship experiences that were analyzed using thematic analysis. Findings show that internships fostered skill development and, when aligned with students' goals, positively influenced satisfaction and career clarity. Mentorship and organizational support were key to shaping belonging and intention to remain in the field. Results suggest that well-designed internships, co-created by students and employers, can bridge the gap between education and employment while cultivating developmental value.

Keywords: Microelectronics engineering, internships, sense of belonging, developmental value, satisfaction, job pursuit intention

Internships are a cornerstone of higher education, particularly in science, technology, engineering, and mathematics (STEM) disciplines. Internship experiences are one form of work-integrated learning (WIL) experience allowing students to bridge the gap between theoretical knowledge and real-world applications by equipping them with essential technical and professional competencies they would otherwise be unable to obtain in a traditional classroom prior to entering the workforce (Byrne et al., 2025; Jackson & Cook, 2023). Despite the prevalence of internships, relatively little research has explored the developmental impact of internships within niche sectors, such as defense and microelectronics engineering.

Schneider and colleagues (2024) published a systematic review in the International Journal of STEM Education. The authors revealed that most internship studies focus on mentorship within clinical or general technical programs rather than specialized disciplinary contexts, and explicitly noted a "lack of understanding" (p. 3) of mentorship in such discipline-specific internships.

There is currently a critical demand for career-ready graduates in the microelectronics engineering sector, a trend driven by significant public and private investment in the United States (CHIPS and Science Act, 2022). However, a report from the National Academies of Sciences, Engineering, and Medicine (2022) highlighted that there is "limited information available to examine the effectiveness" (p. 71) of the Department of Defense's internship and scholarship programs, especially in terms of tracking students through a career pipeline, starting with internship experiences and moving into STEM careers in the defense sector. While general STEM internships are well-researched, there is a

[1] Corresponding author: Jennifer S. Linvill, jlinvill@purdue.edu

notable lack of focused studies on niche sectors like defense and microelectronics engineering. This study begins to address this important gap by focusing on the voice of students with internship experiences in defense and microelectronics engineering.

WIL programs, including internships, have been shown to prepare students for professional readiness by combining classroom learning with practical experiences (Aprile & Knight, 2020). Prior studies suggest internships enhance career skills and competencies, especially in high-demand fields (Luk & Chan, 2022), and informal learning opportunities emerging through workplace interactions contribute significantly to skill development and adaptability (Marsick & Volpe, 1999). However, the less structured and often unpredictable nature of workplace learning introduces variability in student outcomes (Marsick & Volpe, 1999). As a result, understanding what comprises quality WIL is critical to workforce development efforts. Therefore, the research team sought to explore students' experiences in engineering internships within the defense and microelectronics engineering sectors and engaged in the research to better understand how learning unfolds in dynamic WIL contexts and why students' developmental outcomes may differ.

Current scholarship offers mostly institutional perspectives focused on program elements and employer perspectives on successful experiences (Campbell et al., 2019; Eady et al., 2021; Eady et al., 2025). Given this, the present qualitative research addresses the call for foregrounding student voices in WIL programs (Eady et al., 2025) by focusing on students' rich stories regarding WIL experiences. Specifically, this study examines how student experiences shape their sense of belonging, job pursuit intentions, perceptions of developmental value, and overall internship satisfaction.

The findings provide fruitful insight into students' perceived role in shaping and contributing to quality WIL experiences and the role internships play in preparing students for professional integration in technical industries. This research informs the design of future internship programs and workforce development initiatives within industries requiring highly skilled and adaptable talent. Given this, the following research question was posed:

Main Research Question

What is the nature of students' relationship to their internship experience within WIL programs in defense-related microelectronics engineering, and how does this experience shape their professional and subjective development?

Secondary Research Questions

a. How do students perceive their sense of belonging and connection to the professional field through their internship experience?
b. To what extent does the internship experience influence their job pursuit intentions in the field of microelectronics engineering?
c. What developmental value does students attribute to their internship experience?
d. How do students assess their overall satisfaction with the internship experience?

The results of this paper enhance understanding of how student's internship WIL experiences shape their academic, career, and personal growth, preparing them for successful workforce integration.

LITERATURE REVIEW

Internships play a pivotal role in helping students develop a wide range of skills essential for their professional growth and career-readiness. Research in this area consistently emphasizes that internships expose students to varying professional settings that broaden students' understanding of industry practices and enhance their adaptability and technical competencies Nogueira et al., 2021). These experiential learning opportunities are associated with increased self-confidence (Nogueira et al., 2021), strengthened professional identity (Ahn & Davis, 2020; Ferns et al., 2025; Lee & Branford, 2024; Tsakissiris & Grant-Smith, 2021), and clearer job pursuit intentions (Eady et al., 2021; Nogueira et al., 2021), highlighting the transformative nature of internships on students' developmental trajectories (Nogueira et al., 2021).

Current scholarship examines distinct but complementary themes related to WIL experiences (See Appendix A for summary of literature). These domains collectively shape students' ability to transition successfully from academic to professional settings, enhancing our understanding of students' professional development, identity formation, and learning outcomes.

Campbell et al. (2019) introduced a comprehensive quality assurance framework for WIL that provides a structured lens through which student internship experiences can be understood. This framework encompasses four core domains: (1) student experience, (2) curriculum design, (3) institutional requirements, and (4) stakeholder engagement. These domains combine to support high-impact learning environments that scaffold student development, embed reflective practices, and foster mentorship. The model underscores the importance of student readiness, support structures, alignment between academic goals and industry needs, and structured feedback mechanisms, all of which contribute to enhanced professional identity formation, a sense of belonging, and long-term career engagement (Campbell et al., 2019).

Meyers et al. (2012) sought to examine which students identify as engineers and what factors influence that self-identification with their research suggesting that calling an engineering student an engineer might reduce isolation and enhance sense of belonging to engineering. They called for future research to examine students' sense of belonging and whether a sense of belonging makes students feel like part of the broader engineering community. This research was intended to inform practices that help first-year students feel connected to the engineering community (Meyers et al., 2012). Scholarship by Aprile and Knight (2020) emphasize the theory-to-practice connection as central to the value of WIL placements, where students apply academic knowledge in real-world settings. Their work illustrates how internships serve as bridges between academic knowledge and professional application, helping students internalize workplace norms, culture, and expectations. By engaging in hands-on tasks, students gain insights into industry expectations, workplace culture, and job-specific challenges, shaping their career intentions and satisfaction, thereby clarifying career goals and increasing satisfaction with their chosen paths.

Further building on work in WIL, Luk and Chan (2022) further categorized internship outcomes into four key domains: (1) technical skills, (2) academic-related competencies, (3) non-technical professional skills (e.g., communication and teamwork), and (4) professional attitudes. Similarly, Byrne et al. (2025) provided a multi-dimensional evaluation model for internships, affirming the significance of both technical and professional skills in measuring WIL impact.

Another important domain within the literature is professional identity development, as explored by Tsakissiris and Grant-Smith (2021). Their work highlights how professional identity formation,

encompassing belonging, skill mastery, and career expectations, is a critical outcome of internship participation and significantly influences students' motivation to pursue long-term careers in their field. Similarly, Ferns et al., (2025) advocate for framing WIL through the lens of professional identity development, reflecting the transformative nature of internships (i.e., learning, doing, becoming). These approaches underscore the notion that internships are not only skill-building experiences but also critical identity-shaping opportunities that impact students' subjective and professional trajectories (Ferns et al., 2025; Tsakissiris & Grant-Smith, 2021). This outcome is particularly relevant in specialized industries like microelectronics engineering, given that developing a strong professional identity early on can influence job pursuit intentions and long-term engagement, particularly whether students choose to pursue careers in their field post-graduation (Nogueira et al., 2021).

Internships help students refine career aspirations and align their academic knowledge with industry needs. Research suggests that intentional learning goals play a significant role in this process. Buchanan et al. (2022) emphasized the role of critical reflection and goal setting in maximizing the developmental value of WIL placements. Students who entered internships with well-defined learning objectives and engaged in structured reflection derived greater professional growth and career clarity. This result supports the role of student agency in shaping internship experiences and underscores the need for universities and employers to provide clear, structured frameworks that facilitate career-oriented learning.

Student agency in shaping internship experiences is crucial for internship satisfaction and career preparedness. Lee and Branford (2024) introduce the concept of internship crafting, where students actively engage in shaping their internship roles to align with their strengths, aspirations, and professional goals to actively support student growth. They suggest that when students take initiative in negotiating meaningful tasks, seeking mentorship, and aligning work responsibilities with career aspirations, they are more likely to report higher internship satisfaction, stronger professional identity, and increased motivation to pursue careers in their field.

The developmental benefits of internships are closely linked to the quality of support students receive from mentors and supervisors. Previous research shows that STEM mentor relationships are critical to retaining students in the STEM disciplines (M. Hagler, 2018; M. A. Hagler et al., 2024). Mentoring, in the context of this proposal, is defined as a relationship between a skilled or more experienced person (mentor) and a less skilled or less experienced person (mentee) where the mentor might provide task or career-oriented advice, information, and support (Terrion & Leonard, 2007; Younas & Bari, 2020). McHugh (2017) found that an internship supervisor plays an important role in the internship experience, such as high internship developmental value and satisfaction. Supervisor support and supervisor mentoring are significant predictors of internship efficacy regardless of internship compensation, while work design has much less of an impact on internship efficacy.

In engineering fields, internships provide invaluable insights into industry expectations, as well as networking opportunities that influence students' job pursuit intentions. Internships also play a large role in shaping a student's career aspirations. Powers et al. (2018) found that experiential learning opportunities, such as internships and undergraduate research, are instrumental in clarifying students' career goals. Previous scholarship also underscores the role of intentional learning goals in guiding students through their internship experiences (Buchanan et al., 2022). When students enter internships with clear objectives, they are more likely to perceive their experiences as valuable and relevant to their future careers.

Eady and colleagues (2025) introduced the students' reflections of quality (RoQ) framework, foregrounding student perspectives to enhance educational outcomes and workforce readiness. A key contribution of the RoQ model is emphasis on the student as a co-creator of their WIL experiences. Rather than viewing internships as passive learning opportunities, this perspective acknowledges that students actively interpret and shape their experiences based on personal goals, expectations, and agency. This outcome is particularly relevant to understanding how internship experiences influence students' long-term engagement with the microelectronics engineering field, as the framework underscores the role of structured learning and mentorship in fostering career identity development and job pursuit intentions.

The RoQ framework offers a meaningful way to examine how students experience internships and how these experiences influence a) sense of belonging in the microelectronics engineering industry, b) job pursuit intentions, c) developmental value, and d) overall satisfaction. By applying the RoQ framework to the present study, the researchers were able to effectively capture the student-driven factors that contribute to internship satisfaction and professional belonging, ensuring that WIL programs are not just structured for workforce preparation but are truly aligned with students' evolving academic and career aspirations.

Despite the growing body of work on WIL and internship outcomes, there remains a notable gap in the literature focusing on students' internship experiences within specialized and emerging sectors, such as defense and microelectronics engineering. These fields present unique challenges and professional cultures that differ from more generalized STEM settings. As such, more empirical research is needed to understand how students navigate these niche environments and how their experiences shape both their technical proficiency and their evolving sense of professional self.

METHODS

Building upon the frameworks discussed in the literature review, this study employed qualitative interviews to examine how students experience internships and how these experiences influence their sense of belonging, career aspirations, and developmental value. Specifically, this study sought to answer RQ1: What experiences do students have in their internship? and RQ1a: How does the student's internship experience influence their belonging/sense of connection to working in the microelectronics field, job pursuit intentions, internship developmental value, and internship satisfaction? The study employed a thematic analysis approach informed by the students' reflections of quality (RoQ) framework (Eady et al., 2025) and the institutional quality assurance framework for WIL (Campbell et al., 2019), emphasizing student-centered learning, structured reflection, and assessment to enhance workforce preparedness. The methods described below were utilized.

This study is part of a larger initiative to support the national effort to develop a microelectronics engineering workforce in the United States. To better understand student internship experiences, qualitative interviews were conducted with student participants from the microelectronics engineering program. This approach allowed participants to provide thick, rich descriptions (Lindlof & Taylor, 2002) of their microelectronics engineering internships, providing a focus on student voice in WIL.

Participants

Human research ethics approval was successfully obtained through the authors' Institutional Review Board (IRB) study number IRB-2024-1035. Participants were recruited from a microelectronics engineering workforce development project that encompassed public–private–academic (PPA)

partners, including industry, private and government contractors, government agencies, and institutions of higher education. Eligible participants were students participating in the program who had participated in an internship within the microelectronics engineering field within the last calendar year. Participation was voluntary and unrelated to the students' program affiliation and verbal consent was received from participants prior to their interview.

This study included 31 students. Appendix B provides a summary of participant demographics. Participants had either recently graduated or were actively pursuing bachelor (n=23), master (n=4), or doctoral degrees (n=4). Participants ranged in age from 19 to 33 years, with an average age of 22. The sample consisted of individuals with diverse academic backgrounds and levels of WIL experience. Most students had prior internship experience, while a smaller portion were engaging in an internship or research experience for the first time, offering insight into new and returning perspectives on workforce preparation. Given the study's focus on the microelectronics field, students' reflections on their industry-specific experiences were examined to understand how they navigated professional roles and career aspirations.

Of the 31 participants, 32% (n = 10) identified as women, while 68% (n = 21) identified as men. Participants reported racial and ethnic identities, which were grouped into broader categories for analysis. Participants were overwhelmingly male when this study reached approximately 20 participants. Given this, the study team sent all students in the participant pool, across thirty-one institutions of higher education, a follow-up recruitment email approved by the IRB. The recruitment email reminded the potential participants of the research opportunity and also included a statement that requested participation of females and individuals who identify as underrepresented or minoritized. A variety of participants responded to the email, including both females and males.

The gender disparities observed in this study reflect broader national trends in STEM education, where women remain underrepresented in many science and engineering disciplines. According to the National Science Foundation (NSF), women earned 42% of all STEM degrees in 2020 but only 22% of engineering degrees and 19% of computer science degrees at the bachelor's level, illustrating persistent gender imbalances across specific STEM fields (NSF, 2023). These disparities are particularly pronounced in engineering programs, which aligns with the demographics observed in our participant pool. While our study included a targeted follow-up recruitment strategy to encourage participation from women and other underrepresented and minoritized groups, the final gender composition remains consistent with the known gender distribution in many STEM majors. Although gender equity in STEM participation is an important issue and a well-documented area of research, it is outside of the spatial and topical scope of the current study, which focuses on student experiences during WIL in microelectronics engineering internships, rather than institutional-level demographic patterns.

Eleven students (35%) identified as White/White, and another 11 students (35%) identified as Asian, a category that included participants who described themselves as South Asian, East Asian, or Asian (unspecified). Those identifying as Chinese were grouped under East Asian. Seven students (23%) identified as mixed or two or more races, one student identified as African, and one did not report. Additionally, six students (19%) identified as Hispanic/Latinx. These categories reflect regional and cultural groupings to enable a meaningful analysis of students' diverse experiences.

Data Collection

This study was approved by the Institutional Review Board (IRB) to ensure ethical research practices and the protection of participant rights. Voluntary participants were recruited by email sent to students participating in a microelectronics engineering workforce development program across 31 universities. The research team sent the email from the lead university from where participants already receive programmatic emails. Students who wished to participate were asked to click the survey link within the email. Participant names and other personally identifying information were not collected to protect participant privacy and confidentiality. Informed consent was obtained from all participants before conducting interviews.

Participants engaged in semi-structured interviews, allowing for open-ended responses while maintaining consistency across key topics. Interviews ranged from 19 to 60 minutes, with an average duration of 36 minutes. Conversations were recorded and transcribed, yielding 639 single-spaced pages of cleaned transcripts. The interview protocol was designed to explore several dimensions of the internship experience, including professional identity formation, workplace belonging, internship satisfaction, and job pursuit intentions. The structured nature of the interviews ensured that personal reflections and broader workforce trends were captured. Given the study's focus on the microelectronics field, particular attention was paid to how students perceived their role within the industry and whether their experiences shaped long-term career aspirations.

Data Analysis

Thematic analysis followed a structured, iterative process informed by the students' reflections of quality (RoQ) framework (Eady et al., 2025) and the institutional quality assurance framework (Campbell et al., 2019) described above. These frameworks emphasize student experiences, curriculum alignment, institutional expectations, and stakeholder engagement as key elements of high-quality WIL experiences. The analysis was conducted in several phases to ensure rigor and depth in identifying themes.

First, researchers familiarized themselves with the data by reviewing transcripts multiple times, developing an initial understanding of recurring patterns. Next, transcripts were systematically coded to categorize responses based on themes such as mentorship, skill development, professional identity formation, and industry alignment. Following this, codes were grouped into higher-order themes, capturing overarching aspects of the internship experience Themes were selected based on frequency, depth of discussion, and relevance to the research questions.

To ensure analytical rigor, multiple researchers reviewed and coded the transcripts, and discrepancies were discussed to refine theme definitions. Reflexivity was maintained throughout to reduce bias in interpretation. Once initial themes were identified, they were refined through an iterative review process, ensuring alignment with the research objectives and theoretical frameworks. Any ambiguous or overlapping themes were re-examined to maintain conceptual clarity. Each theme was then clearly defined and supported with exemplar quotes from participants, allowing for a nuanced understanding of students' reflections on internship experiences.

By employing a structured thematic analysis approach, this study ensures that findings are grounded in participant experiences while contributing to a broader understanding of internship effectiveness and career readiness. The findings highlight the role of structured learning, mentorship, and reflective practices in shaping students' professional trajectories, reinforcing the importance of student-centered

approaches in WIL program design. The next section details these themes, providing insight into how they connect to broader industry and academic frameworks.

FINDINGS

The following set of themes resulted from the research questions and examined what students are doing during internships, or in other words, what experiences they obtain. Pseudonyms are used in place of student names. Participant demographic information indicated are provided as indicated (i.e., self-identified) by each participant. Extraneous words (e.g., "like" and "you know") have been removed from exemplar quotations for clarity and flow.

Technical Skill Development

First, students gained technical skills. These experiences included knowledge of the field, industry-specific tools, and even software used within industry.

For example, Lorenzo expressed that he "gained more knowledge on total ionizing dose single event effects on various devices and using different simulation tools. All of these industry tools I used helped with [making myself] a better resume for employers to see." Karan shared that he "learned a lot more about the entire chip design process" because of his internship experience. He expanded, "I got to really be on the cutting edge of seeing what innovations are going on and understanding how the pipeline of how those innovations go from just an idea to a natural design at these big companies." Logan, a White undergraduate intern, stated that technical skill development was one of his desired outcomes of the internship process "I wanted to be very good with design software, which I did exit with [from my bachelor degree] program. I would consider myself to be a lot more of an expert in it than when I started out." He also shared how technical skills gained on the job differ from those learned in the classroom:

> [My internship] required a lot of electronics knowledge, specifically voltages and resistances. So, I learned a lot more in that regard. You know, it's one thing to learn it in class, and about the theoretics of everything, and how equations are derived and whatnot, but it's another thing entirely to implement that in an industry scenario... Now, that's something they don't always cover in class.

Participants at all degree levels indicated that they gained technical skill development during their internship experiences. Master's and doctoral degree students gained deeper knowledge while undergraduates were often exposed to technologies that they had not been introduced to in their coursework. Participants noted that gaining new technical skills or enhancing their technical knowledge provided for internship developmental value and internship satisfaction.

Professional Skill Development

Students also expressed that professional skills, such as communication, teamwork, and project management, were developed during internships. Drew shared that he gained professional skills that he could use in any job, like project management and "meeting management." He stated:

> But really a lot of those things came down to just general, like confidence and experience at the end of the day, just having those meetings, and not going so well, but just improving on that throughout the whole internship and by the end being seeing like the progress I'd made. I think a lot of that comes down to just confidence and being more comfortable, really.

In a similar vein, Lin shared:

> One of the most important engineering skills I learned on the job, and that I believe is very difficult to teach in class, is project alignment. Establishing a project and having all your stakeholders agree on the direction a project should be headed towards. And then this is more applicable to the workforce, and less so for homework, because homework we have to set a specific rubric for every student to follow. So, it would be a difficult skill, but very crucial to teach in class.

Drew and Lin expressed that project management proved to be an imperative part of internship work. Similarly, Caleb stated:

> So, [professional] communication became really important, because when you're in an office for eight hours a day with the same people every day sometimes it's just like you just talk about random stuff. But then, other times, you communicate like work stuff and technical, really specific things about what you're working on. So, kind of learning how to be a person when you're communicating that kind of stuff. As well as being able to communicate technically what you're thinking. You know, it's really easy to have a lot of ideas, but actually putting them into practice and drawing it out on a whiteboard sometimes isn't enough.

Here, Caleb expressed that professional skills were required for the job, and he gained such skills by going through all of the day-to-day motions within his internship, specifically using examples of talking with coworkers and engaging in teamwork. Owen shared a similar sentiment, but in the context of customers. Owen shared:

> [Another professional skill I learned] was honestly like talking to customers. Since I know emailing to professors, it's always like 'hi, professor, last name,' and it's very formal. But with customers, some of them like they can be very pushy. Like I had a couple of customers that were like demanding I finish this test bench within a day when they said to me at two in the morning. So, I had to be able to like kind of stand up for myself and be like, 'hey, I'll get back to you in a business day…' So, that was also something that I learned, but not what I learned at school.

Caleb and Owen shared that catering communication to coworkers and customers was a professional skill developed throughout their internships. In addition, Lin, Caleb, and Owen would all agree that these professional skills might not have been gained in the classroom or may be difficult to learn within the classroom.

Sebastian strengthened his professional skills during his internship by demonstrating self- and other-awareness and consistently engaging in professional conduct. His experience was shaped by the distinct culture of a defense-related internship, where the field is small and professionals are highly interconnected across organizations.

> And you're [wondering if you'll] be a good fit for the culture. So you're just trying to make sure that you're being nice to everybody, [because] one bad review from an operator [could stay] with you and stay within your [professional] profile. [You] just have to make sure you're always professional….

Similarly, David described his experience as a distinctive aspect of interning within the defense sector:

> It was really weird at first, because [you are] assigned [to work with] … a task leader and my task leader was just really busy. I happened to be on a unique team, [performing in a niche technical area], where there [were] no other interns. Most of the team was remote and [the work was] stuff that no other people in the company did. [I was] reaching out to others, but kind of getting stuck … [and] you can't really do work for other projects because you don't have a charge code for that. Because [they are] a defense contracting company … a lot of the work also requires [security] clearances [that I did not have]. [And] it's really hard to just join another group.

David's account illustrates the professional challenges of navigating limited access and isolation within a defense-related internship. His experience underscores how such constraints—especially the lack of security clearances—can foster adaptability and professional growth within a highly specialized field.

These exemplar quotations illustrate the views expressed by an overwhelming number of participants in this study who shared that they developed their professional skills further through WIL internship experiences. Students at all degree levels and with a wide variety of demographic markers indicated that their internship experienced helped them further develop necessary professional skills.

Adaptability and Problem Solving

Students also expressed that one of their most appreciated and notable experience was the adaptability and problem solving the learned and utilized throughout work experiences. Neela shared that she learned to problem solve by asking thoughtful questions:

> I really needed to learn how to ask the right technical questions … In order to be productive, you had to learn how to go out of your way and read about these technical things without constantly going back to your mentor and asking questions.

Amaan shared that his manager specifically gave him tasks and did not give him the answers for the tasks. He shared:

> A lot of the time I was essentially doing things on my own and figuring out with trial and error. When I would ask questions [my mentor] would say, 'Oh, why don't you try that?' Or 'Why would that work?' Which is good. I actually like that. I like that kind of thinking because that's how engineers should think.

Sebastian noted that he appreciated learning "how [to] use the information that's given to you to really progress the project." Owen framed this as "ambiguous problem solving" and that he was not taught to do so in school.

Interestingly, each student who discussed the experience of adaptability and problem solving spoke about the experience as a positive one. They expressed that growing in their ability to solve problems and be adaptable was beneficial for their career.

Findings also probed how students' internship experiences influenced their sense of belonging (i.e., their feels of connection to working in the microelectronics field), job pursuit intentions, internship developmental value, and internship satisfaction. The following themes reveal how experiences impact the given outcomes.

Alignment Between Career Goals and Internship Experiences

Students' experiences in internships were often shaped by how closely the work completed aligned with their career aspirations. Internship experiences that align with students' career goals contribute to their sense of belonging to the field and job pursuit intentions. In some instances, like Sam's, the students had the opportunity to cater work to interests. Nineteen students cited that because work closely mirrored their career goals, their experience enhanced satisfaction and/or reinforced intent to pursue a job in the field and/or with that employer.

However, nine students expressed that their career goals and work were misaligned, and as a result they would not return and/or were not satisfied with the general experience. In these cases, students indicated that internships could be difficult to obtain because of a limited number of opportunities related to their specific area of study. In light of this, several students accepted internships that were not related to their area of engineering expertise. Students in this scenario often expressed that they were dissatisfied with the internship experience and many of the associated learning outcomes, including the development of general professional skills. Overall, students wished to get practical, real-world experience for their interests out of the internship. For example, Drew said:

> I was very satisfied, because I really wanted to see how the work I had done in the lab, like what the kind of equivalent job is in industry. I felt like I really got a good understanding of what it looks like on the other side.

Sofia shared that one of her personal goals for the internship was to confirm whether radiation effects was the right technical area for her. She stated, "I wanted to like really solidify whether I wanted to stay in radiation effects, because, unfortunately, I've had some not great experiences with it." In some cases, students expressed having the opportunity to cater their work to career goals and having that opportunity increased their satisfaction. Sofia was given the opportunity to work on projects that directly related to her PhD research. Karan was given the ability to collaborate with his supervisor on goals at the beginning of the internship and adjust them throughout the summer.

However, for three students, positive internship experiences could not make up for the misalignment between career goal and internship field. Emma expressed having an overall positive experience with her mentor and good technical skill development but that she "definitely determined that I don't want to work in electricity or telecom. Not that my internship was bad. It's just not what I want to do forever." She later shared, "I got a lot of good experience, and I enjoyed learning about it but I'm not passionate about it." For Emma, the work of "electricity or telecom" beyond the scope of her microelectronics engineering field of study. Unfortunately, this factor overshadowed the positive experiences that she had with her mentor and gaining technical skill development. Similarly, Caleb shared that he was not given enough work to determine if he belonged to the field. While Sebastian shared that he took the first internship offer he was given even though it was not in his field of interest. He stated that he would have felt more fulfilled if the internship had been more closely aligned with his field of study.

Mentorship and Organizational Support

Interactions with mentors and supervisors significantly shaped students' internship experiences, influencing their developmental value and sense of belonging. For Sofia, a mixed race doctoral student, engaging with her supervisor created a great sense of belonging given that her supervisor shared identities with Sofia, such as being female and Latina. Twenty-two others expressed that their mentor's

and supervisor's support in terms of connecting them with others in the field, providing them glimpses of work life balance, and specifically providing them projects that increased their professional and technical knowledge contributed to their developmental value and sense of belonging. The common factor that these individuals acknowledged during their interview discussion is that they found a sense of belonging due to some form of interpersonal connection with an individual during their internship process. That connection formed based on varying factors, including but not limited to, gender, race, common technical knowledge and/or interests.

Eight students indicated that spending more time with their mentor or with a supervisor would have been the key factor in improving their internship experience. This result was consistently attributed to their supervisors being exceptionally busy, both hindering progression on projects and students' skill development. It is important to note there that these students indicated that the common factor that could have improved their internship experience stemmed from supervisor busyness and was not due to a lack of interpersonal connection. Despite these challenges, students still express overall satisfaction with the internships even if more time with their supervisors would be the one component that would improve their experience.

For others, a negative experience caused the student to question their own belonging to the field or the organization. Two White, female, bachelor degree students endured instances of what could be perceived as gender discrimination from a mentor or supervisor during their internship. One student expressed that despite consistently receiving positive feedback from multiple mentors throughout the duration of her internship, she received one negative performance review by a mentor in the final weeks of the internship. She expressed that this caused her to entirely question her belonging in the field despite the negative review feeling discriminatory and out of the blue. She shared:

> I got kind of flustered and [told myself] 'Oh, maybe it's true. How much do I know? I'm just an intern you know, this manager [has been here] 8 years. If he doesn't think I'm doing a good job, then I'm probably not.' But it was just a kind of at the final moment, where I kind of realized that there might be some sort of issues between me and my mentor. And I was feeling that way from the very first day. I didn't say anything to my manager. I didn't say anything to my parents when they asked me because I felt like it could have been an issue of me being a girl. I just couldn't tell, because I was the only girl on a 20-person team. So, okay it wasn't like there was anyone else there that I could say that it's happening to them too. So, I still don't know.

Another female intern shared that when a fellow intern engaged in discriminatory behavior, her organization acted by reprimanding them. She explained that this response made her feel significantly more comfortable within the company, and if they had not supported her, she would not be planning to pursue a job with the organization as she planned to at the time of her interview.

Themes within the findings section are indicated in Table 1 and will be considered further below in the discussion.

TABLE 1: Summary of key themes from qualitative research on work-integrated learning internships in microelectronics engineering.

Theme	Summary of Findings
Student Voice & Agency	Students' lived experiences enrich understanding of WIL, emphasizing the importance of autonomy, reflection, and role crafting in shaping internship outcomes.
Internship Crafting	Participants actively shaped their roles to align with strengths and career goals, leading to increased technical growth and confidence.
Career Readiness & Technical Development	Internships supported the integration of classroom theory with hands-on learning, developing industry-specific tools, competencies, and professional habits.
Alignment & Satisfaction	Internship satisfaction and job pursuit intentions were influenced by alignment between internship tasks and career aspirations.
Mentorship & Relational Support	Supportive mentors enhanced belonging and development; mentors with shared identities provided validation and guidance.
Contextual & Cultural Barriers	Students, especially women and minoritized groups, faced cultural exclusivity and bias, underscoring the need for inclusive internship design.
Developmental Value	Internships fostered workplace communication, project management, and problem-solving skills, often not achievable in classroom settings.

DISCUSSION

This qualitative research examined how students' experiences within WIL programs shape their academic, professional, and personal development. Specifically, it examined students' sense of belonging, job pursuit intentions, perceptions of developmental value, and overall satisfaction. Building upon the work of Eady et al. (2025), who conducted a systematic literature review to examine how student voice is represented in quality WIL research, this study provides empirical insights into the lived experiences of students in microelectronics and defense-related engineering internships, an area that remains underexplored in WIL literature.

Eady et al. (2025) highlighted the importance of centering student voice in WIL scholarship but acknowledged that their work was limited to secondary sources. Responding to this call, the current study adds a crucial layer of depth by capturing firsthand accounts from students themselves, using their own words. This qualitative study interviewed students participating in a workforce development program effort to provide high-quality WIL programs that combine curricular and programmatic learning activities with internship experiences. The study focused on what students were doing during their internships and the experiences they gained while employing the WIL objective of recognizing and valuing the whole student (Eady et al., 2021; Eady et al., 2025). Focusing on student voice is important because it understanding how students perceive and assess high-quality WIL experiences is crucial for aligning workforce development programs and internship opportunities with students' expectations and career aspirations (Eady et al., 2025). By integrating student voices,

educators and institutions can design WIL experiences that are more relevant and beneficial, thereby enhancing the overall effectiveness of such programs (Eady et al., 2025). Through these narratives, this study enriches the understanding of how WIL programs operate in specialized technical sectors and emphasizes the centrality of student agency, mentorship, and alignment in shaping meaningful outcomes.

A key contribution of this study lies in affirming the role of student agency through the lens of internship crafting. Echoing Lee and Branford (2024), participants described how they actively negotiated roles, shaped learning experiences, and sought mentorship aligned with their strengths and aspirations. Internship crafting reflects an emerging trend in WIL literature that emphasizes students as co-creators of their learning experiences (Eady et al., 2025). Particularly in microelectronics engineering, where tasks can be highly specialized, students who were empowered to tailor their internship roles reported greater technical growth, professional confidence, and intention to pursue a career in the microelectronics engineering sector.

The findings also contribute to the growing demand for career-ready graduates in the microelectronics engineering sector, a trend driven by significant public and private investment (CHIPS and Science Act, 2022). Within this context, the study examined how WIL experiences integrated theoretical knowledge from the classroom with practical applications in a professional work setting, leading to the development of technical skills, industry-specific competencies, and professional habits. These outcomes align with literature that situates internships as key spaces for bridging classroom learning with real-world expectations (Aprile & Knight, 2020; Campbell et al., 2019).

Importantly, the study also reveals that students derive significant value from WIL when their internship responsibilities align closely with their academic interests and career goals. Those who experienced close alignment reported enhanced satisfaction, a stronger sense of belonging, and greater clarity about their future career trajectories in microelectronics engineering. Conversely, students placed in roles misaligned with their aspirations expressed lower satisfaction and weaker job pursuit intentions. These findings extend existing literature on the importance of seeing oneself as an engineer (Meyers et al., 2012) and having goal alignment and structured learning objectives in shaping WIL outcomes (Buchanan et al., 2022; Powers et al., 2018).

Mentorship emerged as a critical determinant of students' developmental outcomes. Participants described how supportive supervisors provided not only technical guidance but also validation of their potential, significantly influencing their sense of professional belonging. When mentors shared social or professional identities with students, these relationships often served as anchors for navigating unfamiliar or what might be perceived as exclusive, niche environments. These findings echo Eady et al.'s (2025) RoQ framework, which emphasizes relational dimensions of student experiences, and support earlier scholarship on the protective and empowering roles of mentorship in STEM (M. A. Hagler et al., 2024; McHugh, 2017; Tsakissiris & Grant-Smith, 2021).

While technical and professional skill acquisition and mentorship are well-documented in the WIL literature, this study expands our theorizing by contextualizing these themes within the niche domain of microelectronics engineering Students in this study reported unique challenges related to obtaining security clearances, high specialization, and exclusive workplace cultures, particularly within defense-related internships. These contextual factors amplified the significance of inclusion and relational support, particularly for students from underrepresented or minoritized backgrounds and for females. As Ferns et al. (2025) and Tsakissiris and Grant-Smith (2021) argue, WIL experiences must be framed

not only as skill-building but also as identity-shaping, a perspective this study's findings strongly support.

The study also reaffirms that student voice is essential for high-quality WIL. Participants offered nuanced reflections on what contributed to their internship satisfaction: alignment with career goals, access to mentorship, opportunities for autonomy, and feeling welcomed in the workplace. Students who experienced these conditions reported enhanced job pursuit intentions, including clarity, confidence, and motivation to remain in the field. These outcomes align with the RoQ framework's assertion that students must be positioned as co-creators of their internship experiences (Eady et al., 2025).

In addressing the core research question, "What is the nature of students' relationship to their internship experience within WIL programs in defense-related microelectronics engineering, and how does this experience shape their professional and subjective development?" the findings highlight the multifaceted nature of student-internship relationships that are shaped by technical engagement, interpersonal dynamics, goal alignment, and organizational inclusion. This confirms prior research suggesting that internships are critical spaces for academic and professional integration and professional identity formation (Aprile & Knight, 2020).

Each of the secondary research questions was also directly addressed by the findings in this study. First, this study found that students perceived a strong sense of belonging (i.e., connection) to others and their work when included in meaningful work and supported by mentors with shared identities or interests. This confirms that belonging is cultivated through inclusive relationships and relevance of tasks (Campbell et al., 2019; Eady et al., 2025). Second, the alignment between internship experiences and career goals was a decisive factor in whether the student's internship experience influenced their job pursuit intentions in the field of microelectronics engineering. Students who engaged in relevant projects reported greater interest in pursuing long-term careers in microelectronics engineering, reinforcing the value of clear, career-connected learning (Buchanan et al., 2022). Third, students widely credited their internships with enhancing their developmental value, both technical and professional competencies, particularly those not easily acquired in the classroom. These included development of workplace communication, project management, and problem-solving skills, all essential outcomes validated in previous literature (Luk & Chan, 2022; Nogueira et al., 2021). Fourth, student internship satisfaction was highest when students perceived that they had agency, supportive mentors, and opportunities to engage in meaningful work. Those lacking these supports reported lower satisfaction, highlighting the interplay between structure, support, and autonomy in WIL success (Lee & Branford, 2024).

Furthermore, this study addresses gaps in current scholarship. Although many aspects of the study's findings align with existing WIL literature, the study fills several notable gaps. First, it provides rare empirical insight into student experiences in microelectronics and defense engineering, fields largely absent in WIL research. It reveals how students engage with highly specialized tools, navigate structured and often exclusive, niche environments, and interpret their roles within broader industry contexts. Second, the study deepens our understanding of how career alignment affects internship satisfaction and job pursuit intention. Even when internships were well-resourced or mentored, misalignment with students' career goals led to lower satisfaction. This nuance introduces complexity into the literature, emphasizing that high-quality internships must be tailored to individual aspirations to achieve optimal outcomes (Powers et al., 2018). Third, the findings foreground the critical role of mentorship and relational support in shaping student success, particularly in environments where

cultural fit or inclusion is not guaranteed. The relational dimension is often underexplored in literature focused on institutional structures, and this study underscores its significance for fostering belonging (Eady et al., 2025). Finally, the study captures emotional and identity-based dimensions of WIL in ways that few previous studies have, offering qualitative evidence of the barriers faced by women and minoritized students in engineering fields. It affirms that even technically sound internships can falter if students face contexts that lessen their sense of belonging (e.g., the exclusion or microaggressions that some students described), emphasizing the need for culturally responsive internship program design.

Overall, this study contributes to a deeper, more contextualized understanding of how internships shape student development in specialized technical fields. It reinforces the value of student voice, mentorship, and agency in delivering high-impact WIL experiences and provides actionable insights for educators, employers, and policymakers aiming to strengthen the next generation of microelectronics and defense engineers.

LIMITATIONS AND FUTURE RESEARCH

The pool of participants for this study was based on predetermined undergraduate students who were part of a large-scale microelectronics engineering workforce development program that offers curricular, extracurricular, and programmatic experiences. While this provided the opportunity to examine students' internship experiences through the lens of quality WIL and student voice, the findings may not be generalizable to other student internship experiences, particularly internship experiences that do not align with a specific program of study for a specified discipline (i.e., microelectronics engineering).

This project includes the unique perspective of a public-private-academic (PPA) workforce development partnership. Given this, it is possible that the intentional way in which the PPA relationship seeks to develop students may achieve the goal of developing workforce-ready graduates. Therefore, it is important not to over-generalize the findings.

Further research that this program of study aims to accomplish would be to interview recent graduates, after having a year or two in their workplaces, to further examine how their internship experiences may have better prepared them for their careers. This research should examine whether their prior internship experience(s) aligned with their career/degree trajectory and/or how they perceive their internship experience(s) to have influence on their workplace success. Additionally, further research that explores students' perceptions about having a career within their specific discipline (e.g., microelectronics engineering) or sector (e.g., government or national defense) will be important to understanding a more nuanced student perspective of internship experience(s) and how these experiences relate to student perceptions of developmental value, job pursuit intentions, and overall internship satisfaction.

CONCLUSION

Internships and WIL experiences are essential for workforce preparation, especially in specialized sectors like defense and microelectronics engineering. These experiences bridge the gap between academic theory and real-world application, allowing students to apply classroom knowledge in practical settings. This not only sharpens their technical and professional skills but also helps clarify their career aspirations and strengthens their confidence in transitioning to the workforce.

A central finding of this research is the importance of quality WIL experiences in shaping students' technical growth, career navigation, and professional identity. Student-driven learning, reflection, and mentorship emerged as key components that enhanced students' engagement with industry practices and deepened their acquisition of critical career competencies. Moreover, aligning internships with students' academic, career, and personal development goals amplifies their impact, supporting more holistic student growth.

The study also highlights the critical influence of workplace culture, mentorship, and industry exposure on student outcomes. Positive relationships with mentors and supervisors, a supportive organizational environment, and meaningful exposure to professional practices were shown to significantly affect students' sense of belonging, internship satisfaction, and job pursuit intentions. Notably, students' reflections revealed that positive and negative interpersonal dynamics shaped their internship experiences and long-term professional outlooks.

Finally, as industries and technologies rapidly evolve, the intentional design of WIL programs becomes increasingly important. By incorporating student perspectives, strengthening mentorship structures, and promoting reflective learning, educational institutions and employers can co-create internships that serve as a strong bridge between education and employment. Doing so not only supports individual student success but also contributes to building a highly skilled and adaptable future workforce.

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APPENDIX A: Summary of WIL literature.

Author	Themes and Outcomes Explored
Aprile & Knight (2020)	Theory-to-practice integration Workplace/socialization Career intention and satisfaction
Barnett (2011); Crisp (2009); Hagler et al., (2018); M. A. Hagler et al., (2024); Terrion & Leonard (2007); Younas & Bari (2020)	Mentor–mentee relationships Academic/social integration Support frameworks
Buchanan et al. (2022)	Critical reflection and goal setting Student agency
Byrne et al. (2025)	Technical skills Professional/interpersonal skills
Campbell et al. (2019)	Student experience/readiness Curriculum design Institutional requirements Stakeholder engagement Support structures
Eady et al. (2021)	Structured feedback and reflection T-shaped competency development Student agency Sense of belonging Job pursuit intention
Eady et al. (2025)	Enhanced educational outcomes Workforce readiness Student as co-creator RoQ Framework Personal/relational Programmatic Community/contextual
Lee & Branford (2024)	Internship crafting Satisfaction Professional identity
Luk & Chan (2022)	Technical skills Academic-related competencies Non-technical professional skills Professional attitudes
Marsick & Volpe (1999)	Informal workplace learning Skill development and adaptability
Nogueira et al. (2021)	Industry exposure Adaptive competence Professional identity Career/job pursuit intention Support structures
Powers et al. (2018)	Career clarity through experiential learning
Strayhorn (2012); Ahn & Davis (2020)	Sense of belonging Mentorship Professional identity integration
Tsakissiris & Grant-Smith (2021); Ferns et al. (2025)	Professional identity development Transformative learning

APPENDIX B: Participant demographic data summary.

Pseudonym	Gender	Age	Race	Degree Level	Internship Position Title	Sector
Amaan	Male	20	Asian American	Bachelor	Product Engineering Intern	Industry
Amber	Female	23	White	Bachelor	Research Intern	Higher Education
Ben	Male	20	White	Bachelor	Assembly Intern	Defense Industrial Base
Blaine	Male		Mixed Race	Doctoral	RFIC Design Verification intern	Defense Industrial Base
Blake	Male	21	White	Bachelor	Mechanical Engineering Intern	Research Laboratory In Higher Education
Caleb	Male		White	Bachelor	Digital Design Intern	Defense Industrial Base
David	Male	21	Asian	Bachelor	RF Signals and Networks Intern	Research Laboratory In Higher Education
Dominic	Male	22	Mixed Race	Bachelor	Mixed Signal Design Intern	Defense Industrial Base
Drew	Male	22	White & Asian	Master's	Packaging Engineer Intern	Defense Industrial Base
Emma	Female	21	White	Bachelor	Fiber Optic Designer	Defense Industrial Base
Jeff	Male	22	Undisclosed	Master's	ASIC Developer Engineer	Research Laboratory in Defense
Karan	Male	21	Indian	Bachelor	Physical Design Intern	Defense Industrial Base
Lin	Male	21	Asian	Bachelor	Supply Chain Reliability Intern	Defense Industrial Base
Logan	Male	21	White	Bachelor	System Industrialization Intern	Defense Industrial Base
Lorenzo	Male	25	Mixed Race	Master's	Radiation Effects Engineer	Defense Industrial Base
Mariana	Female	33	White	Doctoral	Summer Scholar	Research Laboratory In Defense
Matt	Male		White	Bachelor	PCIE (Peripheral Component Interconnect Express) Verification Intern Engineer	Defense Industrial Base
Mei	Female	24	East Asian	Bachelor	Hardware Engineering intern	Defense Industrial Base
Morgan	Female	21	White	Bachelor	Engineering Analyst	Defense Industrial Base
Neela	Female	21	Asian	Bachelor	IC Verification Engineering Intern	Defense Industrial Base
Owen	Male	21	Chinese	Bachelor	Applications Engineer	Defense Industrial Base
Priya	Female	23	South Asian	Master's	Graduate Student Researcher	Higher Education
Ravi	Male	19	Asian	Bachelor	Advanced Packaging Intern	Higher Education
Rohan	Male	21	Indian	Bachelor	[Student trainee] electrical engineer	Defense Industrial Base
Sam	Male	20	Mixed Race	Bachelor	Staff Engineer Intern	Defense Industrial Base
Sebastian	Male	23	Mixed Race	Bachelor	Engineering Intern	Defense Industrial Base

Sid	Male	20	Asian	Bachelor	Hardware Engineering intern	Defense Industrial Base
Sofia	Female	24	Mixed Race	Doctoral	R&D Grad Summer Intern	Research Laboratory In Defense
Sydney	Female	26	White	Bachelor	Summer Intern	Research Laboratory In Defense
Theo	Male	22	White	Doctoral	Systems on Chip Design Intern	Research Laboratory In Higher Education
Zola	Female	21	African	Bachelor	Artificial Intelligence Readiness Consulting Internship	Defense Industrial Base

International Journal of Work-Integrated Learning
ISSN: 2538-1032
www.ijwil.org

About the Journal

The International Journal of Work-Integrated Learning (IJWIL) publishes double-blind peer-reviewed original research and topical issues related to Work-Integrated Learning (WIL). IJWIL first published in 2000 under the name of Asia-Pacific Journal of Cooperative Education (APJCE).

In this Journal, WIL is defined as:

> *An educational approach involving three parties – the student, educational institution, and an external stakeholder – consisting of authentic work-focused experiences as an intentional component of the curriculum. Students learn through active engagement in purposeful work tasks, which enable the integration of theory with meaningful practice that is relevant to the students' discipline of study and/or professional development* (Zegwaard et al., 2023, p. 38*).

Examples of practice include off-campus workplace immersion activities such as work placements, internships, practicum, service learning, and cooperative education (co-op), and on-campus activities such as work-related projects/competitions, entrepreneurships, student-led enterprise, student consultancies, etc. WIL is related to, and overlaps with, the fields of experiential learning, work-based learning, and vocational education and training.

The Journal's aim is to enable specialists working in WIL to disseminate research findings and share knowledge to the benefit of institutions, students, WIL practitioners, curricular designers, and researchers. The Journal encourages quality research and explorative critical discussion that leads to the advancement of quality practices, development of further understanding of WIL, and promote further research.

The Journal is financially supported by the WILNZ, WACE, WIL Australia, and the University of Waikato.

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Types of manuscripts sought by IJWIL are primarily in two forms: 1) *research publications* describing research into aspects of WIL and, 2) *topical discussion and conceptual* articles that review relevant literature and provide critical explorative discussion around a topical issue. The journal will, on occasions, consider good practice submissions.

Research publications should contain; an introduction that describes relevant literature and sets the context of the inquiry. A detailed description and justification for the methodology employed. A description of the research findings - tabulated as appropriate, a discussion of the importance of the findings including their significance to current established literature, implications for practitioners and researchers, whilst remaining mindful of the limitations of the data, and a conclusion including recommendations.

Topical discussion and conceptual articles should contain a clear statement of the topic or issue under discussion, reference to relevant literature, critical and scholarly discussion on the importance of the issues, critical insights into how to advance the issue further, and implications for other researchers and practitioners.

Good practice and program description papers. On occasions, IJWIL seeks manuscripts describing an example of good practice, however, only if it presents a particularly unique or innovative practice or it was situated in an unusual context. There must be a clear contribution of new knowledge to the established literature. Manuscripts describing what is essentially 'typical', 'common' or 'known' practices will be encouraged to rewrite the focus of the manuscript to a significant educational issue or will be encouraged to publish their work via another avenue that seeks such content.

By negotiation with the Editor-in-Chief, the Journal also accepts a small number of *Book Reviews* of relevant and recently published books.

Reference
Zegwaard, K. E., Pretti, T. J., Rowe, A. D., & Ferns, S. J. (2023). Defining work-integrated learning. In K. E. Zegwaard & T. J. Pretti (Eds.), *The Routledge international handbook of work-integrated learning* (3rd ed., pp. 29-48). Routledge. https://doi.org/10.4324/9781003156420-4

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International Journal of Work-Integrated Learning
ISSN: 2538-1032
www.ijwil.org

Publisher: Work-Integrated Learning New Zealand (WILNZ)