Higher Education
https://doi.org/10.1007/s10734-025-01442-y

A scaffolding model for designing and implementing work-integrated learning experiences based on the analysis of the university and company's arrangements

Brayan Díaz[1,2] · Cesar Delgado[1] · Kevin Han[3] · Collin Lynch[4]

Accepted: 24 March 2025

Abstract
In response to the lack of field experience perceived by employers and recent STEM graduates, Work-Integrated Learning (WIL) arrangements have become more common. However, not all WIL experiences are valuable. Indeed, having students in companies without establishing protocols to protect their participation, meaningful interaction, and psychological safety could be counterproductive to non-traditional students. Furthermore, WIL experiences must be designed purposefully to ensure equitable learning experiences for all students. This paper applies an inductive thematic analysis of interviews with 19 current and 4 former students, interviews with current and former workers at host worksites, 76 course surveys, and a total of 15 memos collected from class and workplace observations from graduate engineering classes designed under WIL arrangements between 2017 and 2022. Using Communities of Practice (CoP), we conceptualize WIL experiences as a connection between two communities, generating a theory-based understanding of different possible types of connection, how to establish those connections, and how they contribute to student learning. Building from student experiences, vital elements to integrate workplace learning into the curriculum effectively were identified. Leveraging CoP theory concepts, we describe various modes of integrating workplace experiences into the curriculum, supporting students' increased participation in both settings and allowing them to become brokers who can transfer ideas and knowledge and acquire new skills. From this, we propose a scaffolding model to implement WIL, which enables teachers to select from among several effective strategies that adapt to students' unique contexts, prior experiences, and learning objectives. For all strategies, guidance is provided about designing WIL experiences that progressively immerse students as engaged, active participants in companies.

Keywords Work-integrated learning · Communities of practice · Scaffolding learning · University company arrangements

Extended author information available on the last page of the article

Published online: 02 April 2025

Introduction

National policy documents from countries around the world consistently make the argument that we need more STEM graduates who are "ready to work" (Engineering Council UK, 2020; Education Council Australia, 2018; National Science Foundation, 2020), echoing workforce calls to improve the training and retention of STEM professionals to meet the requirements of industry (Engineers Australia, 2022; National Science Foundation, 2020). Consequently, higher education institutions are implementing various strategies to provide students with real-world experiences (Di Meglio et al., 2022; Jackson & Collings, 2018; Small et al., 2018). One such strategy is Work-Integrated Learning (WIL), which serves as a broad concept encompassing different approaches to integrating work into the curriculum (Australian Government Tertiary Education Quality and Standards Agency, TESQA, 2022) including co-working (Jackson et al., 2022), electronic workplace experiences (Gamage, 2022), simulated real environments in classrooms (Fearon et al., 2012; Ponikwer & Patel, 2021), and internships (Di Meglio et al., 2022; Jerez Gomez et al., 2023; Odlin et al., 2022) among others.

Despite the growing adoption of WIL, fundamental issues remain unresolved (Díaz et al., 2022a, 2023). For example, Björck and colleagues argue that basing WIL on a "gap" between academia and work creates an adversarial binary that may lead students to discount their school learning as "merely theoretical" (Björck, 2021; Björck & Johansson, 2019; see also Allan & Evans, 2019; Orr, 2013), implying that universities fail to provide practical skills, and placing the burden on students to bridge this gap themselves (Díaz et al., 2024). Binary/gap discourse misrepresents learning as a transition from theory to practice rather than a dynamic process that integrates both. A more holistic approach to WIL frames learning as contextually situated and participatory, emphasizing the integration of reflective and intentional practices to ensure that students engage meaningfully in both academic and professional settings (Díaz et al., 2024).

Prior studies identified practical challenges associated with the implementation of WIL, such as the lack of evaluation tools (McNamara, 2013), the impracticality of current approaches to assessing student performance (Ajjawi et al., 2020; Ferns & Zegwaard, 2014; Higgs, 2014), and the absence of guidance for the principled design of authentic learning experiences (Ajjawi et al., 2020). Furthermore, Holyoak (2013) highlights an implicit assumption that internships universally provide valuable and positive experiences for all students. However, merely placing students in professional communities does not guarantee the acquisition of relevant and impactful learning experiences that foster active engagement and critical thinking (Sadler, 2009). Workplace activities alone do not ensure a positive effect on students' employability or earnings after graduation (Arsenis & Flores, 2024). Additionally, Alam and Forhad (2022) found that socioeconomic differences significantly determine career advancement in engineering fields, further compounded by the types of programs students pursue. This underscores the need for higher education systems to develop more equitable practices, and internships play a key role in this context. Unfortunately, no model currently exists to clearly guide the design of WIL experiences that can be customized to meet the diverse contexts and requirements of students. Research has also shown that current practices place undue pressure and responsibility on students (Clerke et al., 2021) and can create additional challenges for underrepresented groups (Brooks & Timms, 2023; Hewitt et al., 2018). Indeed, more systematic equity models and evaluation strategies are needed to support the learning experiences of underrepresented groups (Ives et al., 2023).

In search of solutions to the issues previously presented, this paper uses the Community of Practice (CoP; Wenger, 1998, 2002) framework to analyze a graduate engineering course designed to provide a WIL experience.

The theoretical learning framework of CoP emphasizes participation by individuals from diverse backgrounds, learning by doing, and learning as situated in context. It conceptualizes learning as an outcome of participation in a social environment. Additionally, CoP provides key insights into how multiple communities interact and how learning occurs at their intersections. Wenger (1998) explains how two communities can connect: through individuals who participate across both communities (brokers) and through shared artifacts or concepts that hold meaning in both contexts (boundary objects). The university and work setting are "two 'communities' with overlapping practices where connections can be made through boundary objects and brokering…" (Ajjawi et al., 2020, p. 313).

This paper aims to investigate how the articulation of two communities, the university and the workplace, fosters learning outcomes when students navigate the boundaries between them. Using CoP as a theoretical lens, we analyze interviews with students and company workers, class evaluations, instructor notes, and observations from both the classroom and the workplace in the context of the graduate engineering course *Building Information Modeling (BIM)*. This research is guided by the following research questions:

1. How can various arrangements between companies and universities be established to create WIL experiences, and what differences exist in students' learning outcomes and expectations across these arrangements? (RQ1)
2. How can different university-industry arrangements be leveraged by instructors to construct a scaffolding WIL learning experience that facilitates a smoother student transition to the workforce and aligns with class learning outcomes, expectations, and students' needs? (RQ2)

By addressing these research questions, our aim is to offer heuristics and best practices for the effective implementation of WIL experiences, emphasizing a student-centered approach that is flexible and adaptable to the specific needs of students. We identified different models to integrate WIL, and we enhanced the understanding and conceptualization of the purpose and implications of diverse WIL models (RQ1). We also seek to guide stakeholders in utilizing WIL models to provide controlled and scaffolded field experiences, addressing the gaps highlighted by employers and recent graduates without placing undue responsibility solely on students (RQ2).

Background

Work as part of the curriculum: defining WIL

The integration of workplace learning has garnered significant attention and been adopted worldwide (Jackson & Dean, 2023). In the UK, this approach has been steadily growing under the name of Higher Degree Apprenticeship (Hughes & Saieva, 2019; Quew-Jones, 2023), while other European countries have embraced the term Work-Based Learning (Perusso & Wagennar, 2022). In the USA, cooperative education (co-op) programs have been established (Main et al., 2021; Sovilla & Varty, 2011). In Australia, WIL is defined by the government as "structured and purposefully designed learning and assessment

activities that integrate theory with the practice of work" (Australian Government Tertiary Education Quality and Standards Agency, TEQSA, 2022, p.1). WIL is an umbrella term encompassing a range of approaches and strategies intentionally blending theory and work practice within a curriculum (Jackson, 2017; Patrick et al., 2008).

Models to implement WIL in engineering

Engagement of students in a community is a crucial component for legitimate learning experiences that will lead to construction of new knowledge through WIL (Safran, 2010), but the current models do not provide different levels of engagement that can be developed through different WIL agreements. While models that emphasize student engagement (e.g., Carbone et al., 2020; Xia et al., 2015) have been significant in the study of WIL experiences, there is currently no discussion on how engagement should be supported or how student engagement may change across different stages of their academic careers (e.g., first-year, senior, or graduate students). A model for designing for engagement must also consider individual characteristics. Students' educational level, activity, project, exposure time, and background correlate with their outcomes in WIL experiences (Xia et al., 2015). The lack of theoretically based, systematic processes (Holyoak, 2013) means WIL experiences are implemented without distinguishing the levels of engagement based on students' academic stage, individual characteristics, and needs.

In the field of engineering, the most common implementation involves students being responsible for finding their own workplace (Clerke et al., 2021), which presents challenges for underrepresented students and reinforces a demographic bias in the representation of the labor force (Hewitt et al., 2018). Instructors will thus need guidance on establishing relationships with companies that will provide productive learning experiences for students.

In summary, although different models to implement WIL in Engineering are available, they lack the flexibility to be adapted to the specific needs of students, are not designed for progressive workplace immersion, place the responsibility for finding internships on students, and intrinsically assume that all internships are valuable for students' development. If universities fail to implement systematic processes to ensure student participation and well-being, workplace learning experiences will not be significant for students (Sadler, 2009). The CoP framework (described below) is well suited to conceptualize the WIL experience as an interaction between two communities and to trace trajectories of increasing student participation. Yet, there is currently no empirical investigation or theoretical discussion on how instructors can utilize this framework to *design* scaffolding experiences tailored to students' backgrounds, contexts, and specific learning outcomes. Next, we will describe how CoP concepts can be helpful to describe WIL.

Theoretical framework: community of practice

The Communities of Practice (CoP) theory proposed by Wenger and Lave (1991) emerges from the study of groups of people who negotiate and share meaning and forms of participation, including tools, knowledge, concepts, symbols, and procedures. Wenger's CoP theory is based on four premises: the social nature of humans, the idea that knowledge is competence (doing), that knowing is participating, and learning is meaning (1998). A key concept introduced by Lave and Wenger (1991) is *Legitimate Peripheral Participation* as

a process in which newcomers incorporate into a community and negotiate their participation to become full participants. Significant learning is an outcome of participation in the community, and if a student effectively negotiates their participation, their learning will be more significant and valuable to the community.

Wenger (1998) proposes that the interaction between two communities of practice is generated by "brokers" and "boundary objects." A broker is a participant in two communities who can introduce elements from one community to another, while boundary objects are artifacts, documents, terms, and concepts through which CoPs lay the foundation for their practice and organize their connections. In our context, the two communities are the university course and the host companies at which students intern.

Different encounters may occur when two communities interact, including one-on-one interactions, immersion, and delegation, providing opportunities for communities to connect, exchange knowledge, and negotiate meanings, ultimately fostering collaboration and the development of shared understanding. According to Wenger (1999), connections generated by interacting between two communities can generate three types of connection: (a) boundary practices, (b) overlaps, and (c) peripheries. Boundary practices involve creating a new practice that can be compatible between two communities of practice. Overlap connections occur when two communities have strong connections in their practices, allowing individuals to learn and participate in specific activities from both communities. Despite being engaged in both communities, distinct boundaries still differentiate to which community individuals belong. Peripheries allow the selective entrance of external members into the community.

WIL through the CoP lens

From a CoP perspective, both the university and companies can be seen as separate CoPs. WIL aims to establish practical connections that can be facilitated through the presence of *brokers* and *boundary objects*. Consequently, to implement an effective WIL experience, instructors must identify and leverage the boundary objects involved and define what broker role students must play in the knowledge exchange between the university and the company.

Boundary objects are tools or instruments that are used in both the university and the company, but their meanings and uses may vary in each context. For example, a company may use Excel tools for product pricing and payment management, while students may learn to use Excel for statistical calculations in their academic coursework.

Students need to develop *broker* skills to effectively transfer knowledge, concepts, ideas, and skills between the university or course and the company. Broker tasks are challenging as students must adapt their language, align practices, coordinate two communities, etc. (Baas et al., 2023). Brokers play a crucial role in facilitating the exchange and integration of knowledge and practices across the university and workplace boundaries. For example, students may bring cutting-edge analytical approaches learned in the classroom to the workplace while learning about equipment or new software on the worksite that they can discuss in the classroom.

In previous work, we used a grounded theory analytical approach to build a new conceptualization of WIL through the lens of CoP (Díaz et al., 2024), using course evaluations and retrospective interviews from the years 2017 to 2021. We discovered that WIL can be conceptualized as connections between two CoPs, addressing conceptualization

issues around WIL that previous research had identified (e.g., Allan & Evans, 2019; Björck, 2020, 2021). Additionally, we found that WIL experiences should be designed to allow students to reinterpret boundary objects and develop brokerage capacities by working in a real workplace environment. Building on our prior work, we conducted additional, in-depth research on the Fall 2022 course, collecting class observations and company observations (15 memos), interviews with 19 students, and interviews with workers, which have not been reported previously.

Methods

This research is part of a National Science Foundation grant aimed at improving graduate engineering education using communities of practice. This project consists of the study of three graduate engineering classes taught at a high-intensity research university in the USA. We selected these classes as they are highly diverse in terms of ethnicity, background, etc., and the instructors of these classes are also the Co-PIs of the grant. Additionally, the three classes address representative challenges highly relevant in STEM education for the future: improving interdisciplinarity, supporting the transition of students from university to the workforce, and implementing strategies that ensure more equitable practices in STEM education.

This research uses data collected from one of the courses—Building Information Modeling (BIM) in Construction. In this course, students are divided into small teams (two to three members per team), each assigned to a real project within a local company. Students must apply advanced BIM software, such as Navisworks, to support the companies' construction management projects. BIM software is commonly used to facilitate construction management by creating 3D models of the project and incorporating variables related to time (4D) and cost (5D). Each unique project may involve bridge construction, housing development, or industrial projects.

Participants

This research used BIM course data collected from 2017 to 2022. The historical university report shows that approximately 85% of students are from India or Central Asia, 6% are Hispanic, 6% are from East Asia, and 3% are White US students. Only binary gender descriptions are available, with around 78% identified as male and 22% as female. Class sizes varied from 16 to 30 students, with an average of 20 students per semester. For the years 2017, 2018, and 2019, an open survey was administered to 76 students, which represented the entire class population.

All students in the class were invited to participate in this research. For the 2021 version, five students agreed to be interviewed at the end of the course. Similarly, for the 2022 version, all 14 students participated, and data collection included class observations, multiple interviews, and workplace observations. The North Carolina State University Institutional Review Board approved this study.

Data

Course evaluation

Seventy-six students' anonymous course evaluations collected in Fall 2017, 2018, and 2019 that evaluated students' perceptions at the end of the BIM course were used. The survey has two closed questions and several open questions about the student's experience on-site visits, company interaction, site-course alignment, and reflection on the course (see Appendix for the full questionnaire).

Current and former students' interviews

For the 2021 version, students were interviewed at the end of the course. In the 2022 version, interviews were conducted at the middle ($n = 11$) and end ($n = 8$) of the course. Additionally, four former students who participated in the course between 2017 and 2019 were interviewed in Fall 2021. All the former students had already graduated and were working in engineering companies. The first author conducted all interviews using interview protocols (see Appendix). All student interviews were recorded using Zoom (without video). The automatic transcript generated by Zoom was corrected for accuracy by the research team.

Former and current workers' interviews

Four company workers who supervised students' work between 2017 and 2019 were individually interviewed via Zoom using a semi-structured protocol between March and April 2022 (3–5 years after participating in the course). Additionally, informal interviews were conducted with three company workers during the company observation in the Fall 2022 version of the course. These interviews were in person and not recorded to avoid making the employees uncomfortable. The first author documented the conversation in memos immediately after conducting the interviews.

Class and company observations

We observed lectures, computational laboratories, and company visits from the Fall 2022 offering of the course. A total of 15 memos were generated from these observations. The memos contain information on the date, time, context, student interactions, participation, and contribution. Notes were analyzed regarding the CoP concepts (e.g., students interacting across teams developing broker skills).

Data analysis

We analyzed the data in an iterative process using inductive thematic analysis (Guest et al., 2012) to develop categories that represent the key aspects related to the course arrangement effectiveness. Inductive thematic analysis was chosen to allow themes to emerge directly from the data without being influenced by pre-existing theories or frameworks, which is

particularly suitable when exploring new or under-researched topics such as students' perceptions of course effectiveness in this context. This approach supports a more flexible and data-driven interpretation, enabling us to capture the diverse range of student experiences.

Initially, we conducted open coding, breaking down qualitative data into discrete pieces and comparing them for differences and similarities. We then carried out subsequent axial coding, grouping similar phenomena into categories. For instance, from the survey, we observed that students' perceptions of effectiveness were associated with whether they had previous worksite experience or if this was their first exposure to a real construction company. This was grouped into *adaptability*, consistent with students' previous experience. The data were coded and managed using the Taguette system (Rampin & Rampin, 2021).

Validity and reliability

The survey and interview protocols were piloted previously, finding that they provided accurate and meaningful information (see more details in Díaz et al., 2022b). The first author conducted all the data collection and was carefully guided and supported by the other authors. In the initial analysis, we used two coders for reliability and calculated an inter-code agreement between coders following the procedure of Guest et al. (2012), obtaining an inter-coder reliability above 80% (see Díaz et al., 2024 for details). Considering that the data came from the same course and that the reliability of the first author was already tested and peer-reviewed, we did not repeat the inter-coder reliability analysis, and the first author analyzed the data directly.

Results and discussion

Models to articulate university and industry (RQ1)

The former students identified different models of WIL experiences that they had experienced through their curriculum. For instance, when we asked former student #1 about other WIL experiences (Q3, section F in the interview protocol), he described:

> There is a course that is called Productivity… you are also assign and you have access to a project… we had only two visits, it was not like BIM. Another project was Construction Project Management and that's a course where you learn like different steps or procedures, whatever. That a project manager can implement and we were going to the so, for example, constructability review. We were assigned to a project at [UNIVERSITY], it was the [deleted] gymnasium… we were actually. going to the weekly meetings… we have access to all of the drawings.. all of the report. … those were. But being that the benefits of the BIM course was that you were doing the whole semester, so it wasn't one or two visit it was actually every week… at the end of the day, you feel like part of the company right, and you know the company learned from you, because every day, you learn something.

This former student delineated three distinct WIL experiences encountered during their studies and highlighted the varying challenges associated with each. The initial experience was characterized by control and limited visits/interactions with the company. In the second scenario, students engaged in a project within the university but led by an external company, which included a limited number of visits. Lastly, in the BIM course, students

had a comprehensive immersion into the company, with the expectation of becoming central members. Table 1 summarizes the three types of WIL arrangements identified. Building upon the foundational work of Wenger and Lave (1991), we propose interpreting those three mechanisms of connection between companies and universities in the context of WIL experiences: overlaps, boundary practices, and peripheries models (refer to Fig. 1). Table 1 also provides links to additional examples in the literature.

These models offer varying levels of challenges, learning outcomes, and regulatory involvement from the university, and all other students' descriptions of WIL experience were categorized under those arrangements. Next, we will describe those arrangements further and use an exemplary example from the literature to describe them. Briefly, the productivity WIL experience was overlapped, the gymnasium WIL a boundary practice, and the BIM course WIL a periphery.

Overlapping connections

In overlapping connections, there is integration between university and company built through similar procedures, objects, tools, etc. (boundary objects) but with slightly different interpretations in each community. The connection between companies and universities must be encouraged and supported in order to ease students' participation. For instance, student #20 commented that a disconnection can arise from disparities between the company's practices and the course requirements, which cannot be part of overlaps connections:

> "They were all still old school sticking to construction drawings. The PM uses an iPad, but no model was used."

The instructor is responsible for creating a classroom environment that closely resembles what students may experience in a company. Overlapping connections are meaningful when there is a need to align specific learning outcomes by establishing a connection between the company and the university using various boundary objects. Typical implementations that fall under overlaps connections include guided company visits, company talks, or workshops held at the universities. For instance, former student #3 described that had another WIL experience:

> "We had field visits. We had some of those. Yeah we had an estimating scheduling … Like guest lectures and stuff like that. It was pretty interactive."

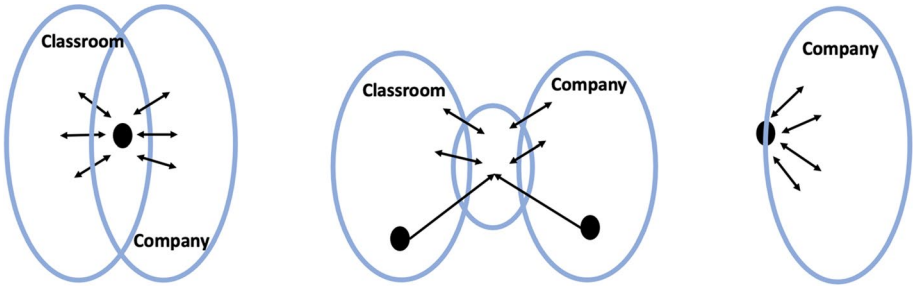
In the program, students are not generally expected to develop brokerage skills. Instead, the instructor and company workers take on the role of experienced brokers and introduce students to the process of connecting both communities. Students are likewise not expected to become fully immersed participants in the companies but become peripheral members. This type of experience was described by student #43 in the course evaluation:

> "In my previous jobsite visit experience. I didn't have chance to interact with different positions in the site. I just supervised by a certain person and only had direct interactions with him."

In overlapping models, it is crucial to ensure that companies involved have in common the use of the relevant learning objects for the class and that the usage of those objects aligns with the meaning that the class provides to those objects. For example, in an introductory general chemistry laboratory where students learn about procedures and safety instructions, a company could be invited to showcase its safety protocols and

Table 1 Types of WIL arrangements and their characteristics

Types of WIL arrangement	Description	Example from literature
On and off-campus company visit—overlaps	Students have the initial approach to industry by receiving companies on campus (e.g., attending a talk or workshop) and/or arrangements where students can visit local companies. These visits are for a short period of time and aim to generate student interest and help them recognize objects (meanings, language, tools, procedures) that are common between their university training and workplace practices	Ponikwer and Patel (2021) developed CoP within the classroom that tried to emulate a professional organization and, for the final class, invited some industry workers to provide feedback on students' products developed in the class
Work on companies within campus—boundary practices	Also known as a third space, these are places where students can spend time in companies located on campus but not administered by universities. Being on campus, the culture of the company is expected to have high alignment with and acknowledgment of the university and its students, offering an intermediate step for students. This type of experience is less common, as not all universities have these partnerships	Villani et al. (2017) reviewed how Italian workplaces and university third spaces accommodated internships for students under the aegis of incubators and technology transfer divisions at the university
Internships—peripheries	Students spend independent time in workplaces. These types of arrangements are the most common internship models. Students are expected to negotiate their participation in the workplace to become more central members with minimal supervision from the class. This full immersion in the workplace is one of the most challenging arrangements for students, as they work more independently. These internships are usually semester-long	In our previous work (Díaz et al., 2022a, 2023), we developed and implemented strategies to facilitate engineering students spending a semester working in small teams (2–4 members) on real construction projects with local construction companies



a) overlaps b) boundary practices c) peripheries

Fig. 1 Models of WIL experiences

their implementation. Overlapping arrangements are not aimed at developing students' brokerage skills; instead, they support learning new objects used in the companies. For instance, former student #2 commented how, in a previous WIL experience, with two visits to the worksite during the semester, they learned specific information:

> "I had one, it was regarding the construction productivity, which was good, … try to understand how the behavior of a worker is… the Wednesday will be the most productive. day of the week.… I just learned about it in the course, but when I went on the industry … I did find out, oh it's it's true that."

Ponikwer and Patel (2021) offer an example of creating a professional CoP atmosphere within a classroom setting. Their approach involves a game-based learning activity where students are divided into groups to evaluate, create marketing strategies, and deliver a promotional speech to sell chemistry equipment. The classroom is transformed into a professional environment by bringing cameras and formal dress and assessing presentations, speeches, and reports in formats commonly used in the industry. Students engage in small projects or use tools (boundary objects) commonly used in the industry. In this experience, students do not have a primary role in brokerage skill development. As former student #1 comments, in an overlapping experience, he learned some tools for tracking construction productivity by visiting an industry as part of the productivity course.

Boundary practices connections

In boundary arrangements, companies and universities expand their boundaries to create a new community centered around specific practices. These models of integration have also been referred to as "third spaces" in the literature and are centered on facilitating fruitful collaborations among faculty, students, and industry professionals. Boundary practices spaces are shared and highly collaborative environments that are sometimes located on the university campus but are "governed" by and represent the workplace cultures of the companies involved. For instance, a company worker who was involved in a WIL experience with a boundary practice approach, where their company was situated within the university as a subcontractor and received students for the BIM class, provided the following comment:

> "We partnered with several groups … because you know we were out there for three years. And I think that it was good to see them like trying to solve challenges that we face in the field."

Effective boundary practices require strong commitment and engagement from both the company and the university, as establishing these involves extending beyond their respective borders. Companies need to see direct benefits from their involvement, and universities must ensure that they offer advantages and create win–win situations (Xia et al., 2015) to incentivize collaboration and secure funding. For instance, worker #2 describes:

> "I would say that that class had started to develop more into something … I think that like seeing them kind of present us like opportunities or rooms for improvements saying like hey we noticed that this is how y'all do it."

In some cases, boundary practice arrangements may be established outside the university campus, but with strong collaboration between the university and the company involved and a strong presence of members with double membership (members of the university and workers), which facilitate the student's membership and participation in the workplace. For instance, former student #4, involved in a boundary practice, described:

> "We started going or then after the meetings were over, the superintendent accompanied us to the job site. And he made us introduced to their like to his subcontractors that these are students at NCSU and they will be working with us for the next couple of months … he made us feel a sense of ownership."

Students are expected to participate and engage fully and actively in the third space. They may work on projects, complete courses, or undertake internships. The advantage of these spaces lies in their design to accommodate and promote the rapid development of new members, fostering *Legitimate Peripheral Participation*.

The work of Villani et al. (2017) provides valuable insights into boundary practices that foster closer collaboration between universities and companies. The study reviews three Italian universities and their Technology Transfer Offices (TTOs), University Incubators (UIs), and Collaborative Research Centers (CRCs). They provide a detailed description of the different types of involvement and expected outcomes in each of these spaces. For instance, UIs promote direct collaboration and physical relationships, facilitating open conversations. On the other hand, CRCs focus on directing collaboration and establishing physical relationships that are more organized and centered around specific research. Thus, TTOs, UIs, and CRCs examined by the authors are all considered boundary practice spaces. These spaces encourage active participation from both companies and universities, offering students the opportunity to transfer and engage in specific activities, particularly through WIL experiences. A boundary practice was also described by former student #1 by working as an intern in a sub-contract company that oversaw remodeling a university building, and his navigation of the legitimate peripheral participation in that company was smoother.

Peripheral connections

Peripheral settings do not focus on established boundary object connections between universities and companies; instead, students are expected to develop brokerage skills. This model is the closest to the experiences that the student will have within the companies upon graduation. We found that our BIM course offers this experience as all former

students recognize a strong connection and similarity to real work. Here are some of the former students' comments in the interview.

> "I come from a very design background … I did not have a lot of exposure to the site… So coming into a construction company when I would have rather felt very lost if I hadn't. taken this course, so it kind of because we were on the site, you know, I was able to see the process myself, I know how they put the form work, I know how they weld the dry sheets, I know how they do a lot of things."

Student #15 also commented:

> "I felt this course is very enriching… I am taking away with me many useful learning experiences which will help me in my professional life."

Even though in the peripheral model, students work more independently and are firmly situated in companies, universities should establish minimum standards for the internship site. Companies use university and students' insight to allocate students' duties and also ensure that students will be properly involved in what they are expected to do and their needs. From a course evaluation, a student provides a concrete example of some misalignment:

> "Our site mainly used the 2D drawing, which was different than the mainly 3D drawings in class."

Similarly, in an interview, another student expressed that their construction company did not use 3D modeling at all, which impacted their experience in the course:

> "I don't like how I feel like our project has significantly more work. We have to like research what we're going to be doing and finding a new program from scratch to do … we didn't have a 3D model. We had to make it complete by ourselves."

The main motivation for the peripheral connections is to generate a win–win situation (Díaz et al., 2022a; Xia et al., 2015), where companies clearly identified benefits from students' ideas that can support company activities, and students learn to fit into the company. The university is responsible for preparing students to make that happen and ensure that student's interests and company assignments are aligned. For instance, a company worker recognizes the value of hosting students:

> "[T]hey were in the BIM course. They went ahead and modeled the project for their coursework, and, at the end, they showed us 3D simulations … it really helped us understand where construction was going … Because we were not doing all of that and. After that, we started doing some 3D modeling ourselves as well, so I think them doing their initial effort was a good contribution to our company."

This bidirectional benefit was also commented on by a former student:

> "[T]he company is open to more students involved in some of the projects, so they can I mean the company learn as, at the same time, the students learn from the company."

Not all peripheral settings will offer students a bi-directional broker role. Indeed, the most common implementation of those arrangements takes place close to graduation when they have very little opportunity to transfer that new knowledge back to the university.

Scaffolding WIL experiences (RQ2)

The successful implementation of WIL experiences must be dynamic and adapted to students' previous experiences. From the course evaluation, we identified nine students (12% of the total responses) with a low value for the BIM course experience. For instance, one student classified with a very low value commented:

> "I did not perceive any value in visiting the site worth doing it."

After carefully reviewing students with low satisfaction or those who did not recognize high value in being in the workplace, we identified that all of them have previous work experience, and the BIM course did not present new challenges to them. For instance, student #38 commented:

> "I had an internship during summer thus there was nothing much different apart from the forms of the topics."

A similar pattern was found with former students. The only one of the five interviewees who perceived a low value in the course mentioned that the WIL experience did not provide new challenges compared to their previous experience. When asked, "What are the new tools, concepts, or techniques that you learned in the course?" she responded:

> "I'm not sure what you were expecting but. Before joining the course I had some work experience, and I was mostly exposed to Revit and Naviswork, so I mean when you are asking about any code word or any. Specific words related to the course don't ring a bell to me because it's inculcated like it's already there in me."

However, other students commented on how they struggled during the course due to a lack of previous experience in the worksite, and they found the course expectations to be challenging. For example, a student described that the challenges of the course were higher, and additional class content could have been beneficial to them.

> "Learning BIM videos and all of its tools was very difficult at first and took a huge amount of time. I wish it would have been more in depth with lectures that teach it."

Student #7 recognized that BIM tools were boundary objects used in the company and university. However, students were still expected to develop strong brokerage skills as the manner used in the classes differed from how they are used in the industry.

Another student also mentioned that learning the software presented a complex challenge:

> "Although the task to create model was simple, the major challenge was to learn the software that should not have been the case. The course should have utilized more effort to improve model than to create it. The hand as a were mostly on Revit which was barely used as the model was provided by company."

Student #57 also describes that the class should provide better legitimate peripheral participation to facilitate students' participation and mastering the new tools used in the industry.

The type of connection and challenges presented to the students should be novel. Design of WIL experiences should consider students' level of experience.

Additionally, WIL experiences are not necessarily meant to be implemented only at the end of students' training; they should be implemented throughout the students' curriculum, as mentioned by a company worker:

> "I would say it's hard to learn some of these things at school, it's just you gotta get your hands dirty and work before. You can learn a lot of skills on the field, so I think this is what the students, need to be doing, maybe they can start out early during their freshman or sophomore year joining these coursework rather than waiting until their senior year."

Expectations and learning outcomes should vary between students in their initial years and those at the senior or graduate level. WIL must adapt to students' experiences and expectations should acknowledge the diverse challenges that individual students might face. In this regard, we propose that the training of students to participate effectively in the workplace should constitute a scaffolding. This scaffolding exposes students progressively to the industry, developing essential skills that can then be refined as they transition into the professional realm. As they progress, they will need less scaffolding, and WIL experiences can progress from overlaps and boundary object-focused connections to peripheries where students become more central participants and brokers.

Scaffolding in learning entails employing teaching methods that assist learners in grasping concepts beyond their independent capabilities (Wood et al., 1976; see also Vygotsky & Cole, 1978). Students must have a scaffolded learning experience where they can develop the skills needed in the industry. To create meaningful WIL experiences, universities, instructors, and other stakeholders must offer a combination of arrangements that facilitate a smooth transition and positively impact companies. Using the three models of WIL arrangement, overlaps, boundary practices, and peripheries, we propose a scaffolding model that can be implemented in different stages of student training (see Fig. 2). Note that the sequence in which these mechanisms occur differs from Wenger's initial presentation (1998), which places boundary practices first followed by

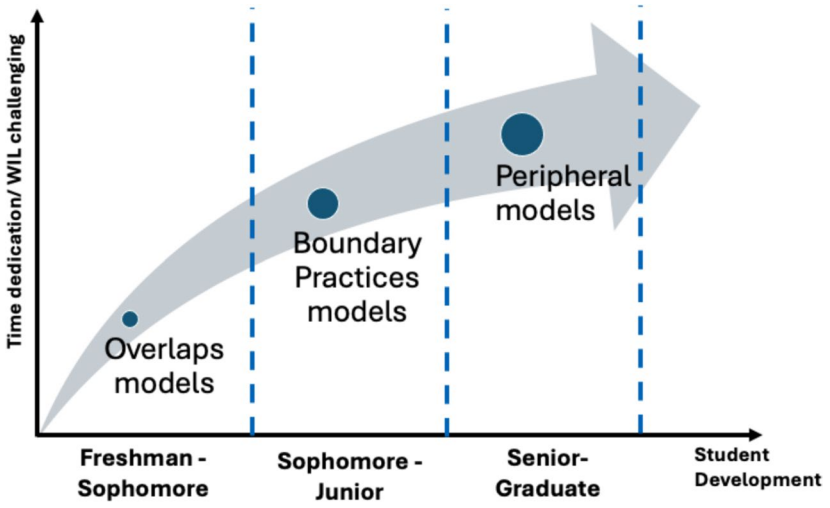


Fig. 2 Integrating WIL models using a scaffolding learning experience

overlaps and finally peripheries. Our proposed sequence aligns the challenges and students' engagement according to their training and academic progress.

We propose implementing overlapping connections for students who have limited or no previous experience in the field. These connections should serve as their initial exposure to a real workplace environment. Small projects can be used to engage companies and involve them in classroom activities.

Next, boundary practices represent an intermediate step suitable for students who are interested in pursuing undergraduate studies in applied fields or graduate studies with a direct transition to the industry. Building boundary practices arrangements requires significant institutional efforts from the companies involved, making it less commonly used compared to other WIL models. Moreover, this arrangement can be utilized for multiple students and across various courses.

As a final stage of the student's development, the peripheral models are recommended for students who have previous job experience or have received a large number of hours of workplace training. This model seeks to help students develop brokerage skills. Students are expected to become full participants in companies and participate in win–win exchanges (Xia et al., 2015; Díaz et al., 2024). Those experiences can be within a course and take place during the whole semester.

Discussion

Universities have failed to provide the skills students need to support a smooth transition to industry (Perez-Encinas & Berbegal-Mirabent, 2023). Facilitating students' transition from classrooms to worksites must go beyond simply letting them spend time in internships (Holyoak, 2013). Teaching and learning practices that aim to facilitate students' transition to the workforce must ensure that students' experience will be value driven, significant, and safe, and activities progress over time (Sadler, 2009). The cooperation and coordination between companies and universities play a critical role in providing a smoother transition to companies (Arranz et al., 2022; Römgens et al., 2020). In response to various policies and documents underscoring the imperative to enhance qualified graduates' quantity and diversity (National Science Foundation, 2020; Engineers Australia, 2022) and recommendations by other researchers (Arranz et al., 2022; Downs et al., 2024), universities have initiated teaching and learning strategies to afford students genuine exposure to real-world work settings. Nonetheless, they have often consisted of exposure to workplace environments without systematic planning for the attendant benefits and learning outcomes. Additionally, the assimilation of work-related elements into the university experience has predominantly centered on producing graduates with enhanced employability (Björck, 2020, 2021) or work-readiness (McManus & Rook, 2021), often at the expense of prioritizing a comprehensive understanding of students' immersion in these strategies.

Grounded in Wenger's (1998) foundational work, three distinctive interaction modes between universities and companies are proposed: overlaps, boundary practices, and peripheries connections. Large-scale WIL implementations are encouraged to employ progressive implementation levels, starting with overlapping arrangements and gradually moving toward peripheral models as students advance in their curriculum. Developing more scaffolded WIL experiences aligns with Onyido et al.'s (2022) proposal for a three-phase placement model: pre-placement, intra-placement, and post-placement. Pre-placement is envisaged as embracing overlapping models, characterized by robust affiliations between

universities and companies. The primary expectation for students during this phase is to develop a familiarity with the distinct practices of companies. Several strategies fall within overlapping models, including company visits, companies' workshops on university premises, informative talks by industry representatives, and immersive classroom settings that emulate workplace environments. These encounters share a common aim of affording students controlled early experiences wherein they can acclimate to the environment, facilitated by close instructor support. After these introductory experiences, students may be exposed to more demanding tasks, such as team-based projects related to companies or developmental class projects integrated with industry themes, consistent with the boundary practices connection. Lastly, students may be prompted to partake in a learning endeavor that situates them as peripheral members within a company. This phase necessitates negotiating participation, progressing toward full integration through *Legitimate Peripheral Participation*. These advanced experiences encompass internships, cooperative education opportunities, or specialized class projects tailored for senior students.

While we classified the different WIL experiences within the three categories, it is also important to recognize that different instructional and contextual approaches can lead to different WIL experiences within each of the three proposed arrangements. For example, in peripheral models, students might be grouped to work within a company in small teams (two to three members) instead of participating individually. Although, in both cases, the development of brokerage skills remains a primary expectation, working in small teams can make it easier for students to negotiate their participation and integrate as insider members within the company.

WIL must be tailored to the personal experience students may have to ensure more effective scaffolded learning (Brooks & Timms, 2023; Hockham & Wallis, 2023) to create more authentic learning experiences that will facilitate students' transfer of their knowledge to real work for all (Hagvall Svensson et al., 2022). For instance, if students struggle to negotiate their participation in companies, the instructor could assign a sponsor member for the company to facilitate the student's participation.

Moreover, one of the primary practical challenges in implementing WIL experiences is the evaluation process (Boud et al., 2023; McNamara, 2013). Clearly defining the type of connections being established between universities and workplaces (as outlined in our proposed models) can help clarify the learning outcomes and expectations for student involvement. By articulating clear objectives and outcomes for WIL experiences, communication between instructors and company staff becomes more straightforward, enhancing the overall experience for employers as well (Crawford et al., 2023). A WIL model that takes into account students' backgrounds while addressing the complexities of mastering brokerage skills and engaging with new boundary objects must also incorporate personalized evaluation methods. These methods should acknowledge individual differences and provide equitable mechanisms for assessing student participation. Understanding how boundary objects and brokerage skills shape distinct WIL experiences allows instructors to design and evaluate more authentic and meaningful WIL opportunities (Ajjawi et al., 2021).

For example, when applying an overlapping connections model in WIL, the evaluation could focus on students' engagement and their reinterpretation of specific boundary objects. As illustrated earlier, consider a scenario where students visit a laboratory during a chemistry course to learn about safety procedures. In this case, the evaluation might highlight the key similarities and differences between the safety protocols used by companies and those practiced in the university laboratory while emphasizing the objectives and relevance of these protocols. Conversely, an evaluation framework that assesses students' contributions to workplace safety protocols or their negotiation of roles as more active

participants within a real-world laboratory would be better suited to peripheries or boundary practices models.

Pre-assessment activities could also add value to the WIL experience. For instance, in the overlaps model, where students participate in a 1-day company visit in teams of four to five, the instructor could require each team to prepare a list of questions to ask company representatives. These questions could then be assessed post-visit, accompanied by a brief presentation in which teams share their insights with their peers. This approach not only enhances the students' learning experience but also fosters a collaborative environment where new knowledge is shared with the class.

Limitations

Despite the extensive data collection and in-depth data analysis conducted, our study used several years of data from a single course at the same institution. Additionally, the context where this study was conducted is a highly research-intensive university where students' expectations of translating the research into real work may vary from an institution with a different focus. Finally, our model is strongly related to engineering students and professionals as a representation of a STEM discipline.

Conclusions and future work

In response to the worldwide need for more field experience for STEM students, WIL experiences have become common strategies. While WIL experiences provide a real-world context for students to acquire new tools, vocabulary, procedures, and other skills that can be valuable in their transition to the workforce, merely being in companies does not ensure a meaningful learning experience. For students to have meaningful participation, they must be engaged in the practices, and the workplace must offer legitimate peripheral participation through which students can negotiate their roles and contributions.

Furthermore, while we agree that learning is situated in context, this does not mean that all learning or activities acquired in companies are valuable or contribute to students' development (Sadler, 2009). To address this, we presented a conceptualization of WIL that goes beyond having students merely spend time in companies without proper support, specific aims, and carefully designed structures and procedures to guide their increased participation.

Built from CoP theory, we have conceptualized different arrangements in which WIL experiences can take place. These arrangements offer a vision for how these experiences—from short company visits to semester-long independent internships—can be seamlessly integrated into the curriculum at different stages, rather than waiting until the end of academic training.

To construct a bridge that effectively facilitates students' transition between academic institutions and corporations, thereby equipping them to make a meaningful impact and fulfill the workforce demands, it is imperative to critically evaluate the interface between the two communities (companies and universities). We propose a conceptual framework illustrating how universities and companies can synchronize their practices and, more significantly, elucidate the learning outcomes and student expectations linked with various engagement models in WIL experiences. This conceptual framework directs attention

toward the commonalities between universities and companies, the pivotal brokerage role students must assume, and the integral aspect of *Legitimate Peripheral Participation* that students encounter within workplace environments.

The most critical concept to fully understand is that Legitimate Peripheral Participation is a process of negotiating participation, where individuals transition from being outsiders to becoming more central members. This process is situated within companies, and while the practices, tools, and objects promoted are relative to specific activities, the negotiation of participation is an individual-dependent process. Every student has unique needs and backgrounds, making their negotiation a unique process. As previous research has found, WIL experiences can perpetuate inequitable practices, making them more challenging for students from underrepresented groups. The assumption that all WIL experiences are valuable is erroneous, as it may overlook the need for adaptation to students' differences. For more equitable WIL practices, accommodations must fully align with students' diverse needs.

It is important to highlight the dynamic nature of our proposal. To make WIL meaningful for students, we must consider their diverse backgrounds while implementing these experiences in a way that gradually increases challenges and engagement. As proposed by Wenger's Community of Practice, there are three phases in the negotiation of identity: engagement, imagination, and alignment. Models of WIL implementation should help students negotiate their identity as professionals. Alignment involves visiting companies or hosting companies on campus (overlap connections model), allowing students to find common ground and shared activities/objects of interest. Boundary practices are intermediate phases students participate in some activities within companies but without formal membership. Using boundary objects, students begin imagining themselves as members of the industry community. In this peripheral model, students engage fully in workplace activities (full immersion model), strengthening their participation and identity as workers within the company.

Clearly defining the challenges and expectations in each WIL experience could facilitate practical implementation. For instance, in an overlap model, evaluations should focus on identifying boundary objects. Students visiting companies should be able to recognize how procedures, tools, and other elements taught at the university align with those in the industry. A student report identifying boundary objects could serve as an effective evaluation tool. In boundary practice and peripheral models, the evaluation should center more on brokerage skills and the operationalization of boundary objects (beyond mere identification, as in overlap models). Evaluation should assess how students negotiate their participation in workplace settings.

Finally, while we have operationalized WIL experiences into three major models, the pathway through them may vary based on context. For example, in this research, conducted at a large, highly research-intensive university, we identified a third space—companies located on campus but not administered by the university. However, smaller community-based institutions may have strong connections with local organizations, which are already familiar with the university environment. In such cases, the transition into internships may be less challenging, and third-space WIL experiences may not be necessary. Instead, universities should focus on improving alignment with external organizations.

Our research focuses on physical WIL experiences, and future research is needed to explore how online WIL experiences (particularly boundary and peripheral practices) could be facilitated or made more challenging for students' participation and negotiation processes. We believe that online internships could serve as an intermediary between boundary and peripheral practices because students would still require a strong imaginative

process for negotiation. Physical presence, however, can facilitate engagement and identity formation processes.

Additionally, considering the digital modern era we live in, it is important to explore how digital competencies can be developed in online WIL settings. Particularly after COVID-19, we have observed a forced transition to online or hybrid settings across several industries. In these scenarios, students must be prepared to participate and effectively utilize digital competencies.

While this paper provides a theoretical foundation for understanding different WIL experiences and key aspects of implementing WIL effectively, challenges remain for practical implementation. Establishing clear criteria for company selection, evaluating company workers and instructors, and assessing student reports are crucial steps. Future research will address these challenges and further enhance the understanding and implementation of WIL using the CoP framework.

Acknowledgements The authors thank the support of the National Science Foundation, Grant NSF 210555. Additionally, the first author thanks the support of the National Center for Artificial Intelligence CENIA FB210017, Basal ANID.

Author contribution Brayan Díaz: conceptualization, methodology, formal analysis, writing—original draft. Cesar Delgado: conceptualization, supervision, writing—review and editing. Kevin Han: conceptualization, methodology, writing—original writing, writing—review and editing, project administration. Collin Lynch: conceptualization, supervision, writing—review and editing.

Funding This material is based upon work supported by the National Science Foundation under Grant 1954946.

Declarations

Ethical statement All procedures performed in studies involving human participants were in accordance with the ethical standards of the Human Research Ethics Committee (HREC) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the North Carolina State University Institutional Review Board (IRB) (Protocol ID: 24313).

Conflict of interest The authors declare no competing interests.

References

Ajjawi, R., Tai, J., Huu Nghia, T. L., Boud, D., Johnson, L., & Patrick, C.-J. (2020). Aligning assessment with the needs of work-integrated learning: The challenges of authentic assessment in a complex context. *Assessment & Evaluation in Higher Education, 45*(2), 304–316. https://doi.org/10.1080/02602938.2019.1639613

Alam, G. M., & Forhad, M. A. R. (2022). What makes a difference for further advancement of engineers: Socioeconomic background or education programs? *Higher Education, 83*(6), 1259–1278.

Allan, H., spsampsps Evans, K. (2019). Reintegrating theory and practice in nursing. *Routledge International Handbook of Nurse Education*, 130–147.

Arranz, N., Arroyabe, M. F., Sena, V., Arranz, C. F. A., & Fernandez de Arroyabe, J. C. (2022). University-enterprise cooperation for the employability of higher education graduates: A social capital approach. *Studies in Higher Education, 47*(5), 990–999. https://doi.org/10.1080/03075079.2022.2055323

Arsenis, P., & Flores, M. (2024). Do professional year placements matter for job quality? The case of economics graduates. *Studies in Higher Education, 49*(1), 178–191. https://doi.org/10.1080/03075079.2023.2225540

Australian Government Tertiary Education Quality and Standards Agency (TESQA). (2022, May). *Guidance note: Work Integrated Learning*. Edited by Australian Government Tertiary Education Quality and Standards Agency (TESQA). Canberra: Australian Government.

Baas, M., Schuwer, R., van den Berg, E., Huizinga, T., van der Rijst, R., & Admiraal, W. (2023). The role of brokers in cultivating an inter-institutional community around open educational resources in higher education. *Higher Education, 85*(5), 999–1019. https://doi.org/10.1007/s10734-022-00876-y

Björck, V. (2020). The idea of academia and the real world and its ironic role in the discourse on Work-integrated Learning. *Studies in Continuing Education, 42*(1), 1–16. https://doi.org/10.1080/0158037X.2018.1520210

Björck, V. (2021). Taking issue with how the Work-integrated Learning discourse ascribes a dualistic meaning to graduate employability. *Higher Education, 82*(2), 307–322. https://doi.org/10.1007/s10734-020-00650-y

Björck, V., & Johansson, K. (2019). Problematising the theory–practice terminology: A discourse analysis of students' statements on Work-integrated Learning. *Journal of Further and Higher Education, 43*(10), 1363–1375. https://doi.org/10.1080/0309877X.2018.1483016

Boud, D., Costley, C., Cranfield, S., Desai, J., Nikolou-Walker, E., Nottingham, P., & Wilson, D. (2023). The pivotal role of student assessment in work-integrated learning. *Higher Education Research & Development, 42*(6), 1323–1337. https://doi.org/10.1080/07294360.2022.2152981

Brooks, R., & Timms, J. (2023). Widening participation to sandwich courses: Temporal challenges. *Studies in Higher Education*, 1–13. https://doi.org/10.1080/03075079.2023.2295512

Carbone, A., Rayner, G. M., Ye, J., & Durandet, Y. (2020). Connecting curricula content with career context: The value of engineering industry site visits to students, academics and industry. *European Journal of Engineering Education, 45*(6), 971–984. https://doi.org/10.1080/03043797.2020.1806787

Clerke, T., Lloyd, N., Paull, M., & Male, S. (2021). Towards praxis: A practice architecture analysis of the work-integrated learning placement experiences of three Australian engineering students. *Studies in Continuing Education, 43*(3), 343–359. https://doi.org/10.1080/0158037X.2021.1900098

Crawford, V., Brimble, M., & Freudenberg, B. (2023). Can work integrated learning deliver employability? International post-graduate accounting students. *Accounting & Finance*.

Di Meglio, G., Barge-Gil, A., Camiña, E., & Moreno, L. (2022). Knocking on employment's door: Internships and job attainment. *Higher Education, 83*(1), 137–161. https://doi.org/10.1007/s10734-020-00643-x

Díaz, B., Delgado, C., Han, K., Lynch, C. (2022b, June). *Use of Communities of Practice to analyze and improve graduate engineering education*. Papers on Engineering Education Repository, American Society of Engineering Education (ASEE), Minneapolis, Minnesota. https://peer.asee.org/40996https://doi.org/10.18260/1-2--40996>

Díaz, B., Delgado, C., Han, K., Lynch, C. (2023, June). *Improving graduate engineering education through Communities of Practice approach: Analysis of implementation in computer science, robotics, and construction engineering courses*. Papers on Engineering Education Repository, American Society of Engineering Education (ASEE), Baltimore, Maryland. https://peer.asee.org/43581https://doi.org/10.18260/1-2--43581

Díaz, B., Delgado, C., Han, K., & Lynch, C. (2024). Using communities of practice to investigate Work-Integrated Learning in engineering education: A grounded theory approach. *Higher Education*. https://doi.org/10.1007/s10734-024-01225-x

Díaz, B., Delgado, Han, K. (2022a, June). *BIM: A bridge to promote industry-academic partnership in construction engineering*. Papers on Engineering Education Repository, American Society of Engineering Education (ASEE), Minneapolis, Minnesota. https://peer.asee.org/40995https://doi.org/10.18260/1-2--40995

Downs, C., Mughal, F., Shah, U., & Ryder, M. (2024). Are undergraduate internships worth the effort? Time to reconceptualize work-based learning for building protean meta-competencies. *Studies in Higher Education, 49*(1), 84–97. https://doi.org/10.1080/03075079.2023.2222147

Education Council Australia (2018). *Optimising STEM industry-school partnerships: Inspiring Australia's next generation*. Final Report. Education Services Australia.

Engineers Australia. (2022, August 26) *Engineers Australia addresses skills crisis with new engineering recovery roadmap*. Media Release. https://www.engineersaustralia.org.au/news-and-media/2022/08/engineers-australia-addresses-skills-crisis-new-engineering-recovery-roadmap

Engineering Council UK (2020, August). *The UK Standard for Professional Engineering Competence and Commitment (UK-SPEC)*. Fourth Edition implemented by 31 December 2021. https://www.engc.org.uk/media/3877/uk-spec-v12-web.pdf

Fearon, C., McLaughlin, H., & Yoke Eng, T. (2012). Using student group work in higher education to emulate professional communities of practice. *Education + Training*, *54*(2/3), 114–125. https://doi.org/10.1108/00400911211210233

Ferns, S., & Zegwaard, K. E. (2014). Critical assessment issues in work-integrated learning. *Asia-Pacific Journal of Cooperative Education, 15*(3), 179–188.

Gamage, A. (2022). An inclusive multifaceted approach for the development of electronic work-integrated learning (eWIL) curriculum. *Studies in Higher Education, 47*(7), 1357–1371. https://doi.org/10.1080/03075079.2021.1894116

Guest, G., MacQueen, K., spsampsps Namey, E. (2012). *Applied thematic analysis*. SAGE Publications, Inc. https://doi.org/10.4135/9781483384436

Hagvall Svensson, O., Adawi, T., & Johansson, A. (2022). Authenticity work in higher education learning environments: A double-edged sword? *Higher Education, 84*(1), 67–84. https://doi.org/10.1007/s10734-021-00753-0

Hewitt, A., Owens, R. J., & Stewart, A. (2018). The regulation of internships: A comparative study. *U. of Adelaide Law Research Paper*, *2019–12*.

Higgs, J. (2014). *Assessing the immeasurables of practice*.

Hockham, D., & Wallis, J. (2023). Operationalising the concept of recontextualisation: Leveraging pedagogy and learning strategies in higher education practical courses. *Higher Education*. https://doi.org/10.1007/s10734-023-01136-3

Holyoak, L. (2013). Are all internships beneficial learning experiences? An exploratory study. *Education + Training*, *55*(6), 573–583. https://doi.org/10.1108/ET-02-2012-0024

Hughes, C. J., & Saieva, G. (2019). Degree apprenticeships – An opportunity for all? *Higher Education, Skills and Work-Based Learning, 9*(2), 225–236. https://doi.org/10.1108/HESWBL-10-2018-0113

Ives, J., Falk, J., & Drayton, B. (2023). Broadening participation in STEM through equity-minded high-impact practices: A multimodal systematic review. *Higher Education*. https://doi.org/10.1007/s10734-023-01165-y

Jackson, D. (2017). Developing pre-professional identity in undergraduates through work-integrated learning. *Higher Education, 74*(5), 833–853. https://doi.org/10.1007/s10734-016-0080-2

Jackson, D., & Collings, D. (2018). The influence of Work-Integrated Learning and paid work during studies on graduate employment and underemployment. *Higher Education, 76*(3), 403–425. https://doi.org/10.1007/s10734-017-0216-z

Jackson, D., & Dean, B. A. (2023). Employability-related activities beyond the curriculum: How participation and impact vary across diverse student cohorts. *Higher Education, 86*(5), 1151–1172. https://doi.org/10.1007/s10734-022-00966-x

Jackson, D., Shan, H., & Meek, S. (2022). Enhancing graduates' enterprise capabilities through work-integrated learning in co-working spaces. *Higher Education, 84*(1), 101–120. https://doi.org/10.1007/s10734-021-00756-x

Jerez Gomez, M. P., Bojica, A., Martínez-del-Río, J., & Karaja, R. (2023). Designing successful internships: Exploring the role of duration, formalization and motivational practices. *Education + Training*, *65*(3), 433–453. https://doi.org/10.1108/ET-12-2021-0480

Lave, J., spsampsps Wenger, E. (1991). *Situated learning: Legitimate peripheral participation* (1st ed.). Cambridge University Press. https://doi.org/10.1017/CBO9780511815355

Main, J. B., Johnson, B. N., & Wang, Y. (2021). Gatekeepers of engineering workforce diversity? The academic and employment returns to student participation in voluntary cooperative education programs. *Research in Higher Education, 62*(4), 448–477. https://doi.org/10.1007/s11162-020-09596-7

McManus, L., & Rook, L. (2021). Mixed views in the academy: Academic and student perspectives about the utility of developing work-ready skills through WIL. *Studies in Higher Education, 46*(2), 270–284. https://doi.org/10.1080/03075079.2019.1630809

McNamara, J. (2013). The challenge of assessing professional competence in work integrated learning. *Assessment & Evaluation in Higher Education, 38*(2), 183–197. https://doi.org/10.1080/02602938.2011.618878

National Science Foundation (2020*). STEM education for the future: A visioning report*. National Science Foundation. Retrieved from https://www.nsf.gov/edu/Materials/STEM%20Education%20for%20the%20Future%20-%202020%20Visioning%20Report.pdf

Odlin, D., Benson-Rea, M., & Sullivan-Taylor, B. (2022). Student internships and work placements: Approaches to risk management in higher education. *Higher Education, 83*(6), 1409–1429. https://doi.org/10.1007/s10734-021-00749-w

Onyido, T. B. C., Allman, Z., Hardaker, P., Rughani, D., & Letinov, A. (2022). Embedding sustainability in university work experience placements: A De Montfort University model. *Education + Training*, *64*(8/9), 1037–1059. https://doi.org/10.1108/ET-09-2021-0356

Orr, C. M. (2013). Challenging the "academic/real world" divide. In: *Teaching feminist activism* (pp. 36–53). Routledge.

Patrick, C. J., Peach, D., Pocknee, C., Webb, F., Fletcher, M., & Pretto, G. (2008). *The WIL (Work Integrated Learning) report: A national scoping study.* Queensland University of Technology. https://eprints.qut.edu.au/216185/1/WIL-Report-grants-project-jan09.pdf

Perez-Encinas, A., & Berbegal-Mirabent, J. (2023). Who gets a job sooner? Results from a national survey of master's graduates. *Studies in Higher Education, 48*(1), 174–188. https://doi.org/10.1080/03075079.2022.2124242

Perusso, A., & Wagenaar, R. (2022). The state of work-based learning development in EU higher education: learnings from the WEXHE project. *Studies in Higher Education, 47*(7), 1423–1439.

Ponikwer, F., & Patel, B. A. (2021). Work-Integrated Learning: A game-based learning activity that enhances student employability. *Journal of Chemical Education, 98*(3), 888–895. https://doi.org/10.1021/acs.jchemed.0c00919

Quew-Jones, R. J. (2023). Degree apprenticeships in the UK higher education institutions – Are they viable?: Integrative literature review. *Higher Education, Skills and Work-Based Learning, 13*(6), 1250–1268. https://doi.org/10.1108/HESWBL-02-2023-0026

Rampin, R., & Rampin, V. (2021). Taguette: Open-source qualitative data analysis. *Journal of Open Source Software*, *6*(68), 3522. https://doi.org/10.21105/joss.03522

Römgens, I., Scoupe, R., & Beausaert, S. (2020). Unraveling the concept of employability, bringing together research on employability in higher education and the workplace. *Studies in Higher Education, 45*(12), 2588–2603. https://doi.org/10.1080/03075079.2019.1623770

Sadler, T. D. (2009). Situated learning in science education: Socio-scientific issues as contexts for practice. *Studies in Science Education, 45*(1), 1–42. https://doi.org/10.1080/03057260802681839

Safran, L. (2010). Legitimate peripheral participation and home education. *Anthropological Perspectives on Learning and Teaching: Legitimate Peripheral Participation Revisited, 26*(1), 107–112. https://doi.org/10.1016/j.tate.2009.06.002

Small, L., Shacklock, K., & Marchant, T. (2018). Employability: A contemporary review for higher education stakeholders. *Journal of Vocational Education & Training, 70*(1), 148–166. https://doi.org/10.1080/13636820.2017.1394355

Sovilla, E. S., & Varty, J. W. (2011). Cooperative and work-integrated education in the US, past and present: Some lessons learnt. *International Handbook for Cooperative and Work-Integrated Education: International Perspectives of Theory, Research and Practice*, 3–15.

Villani, E., Rasmussen, E., & Grimaldi, R. (2017). How intermediary organizations facilitate university–industry technology transfer: A proximity approach. *Technological Forecasting and Social Change, 114*, 86–102. https://doi.org/10.1016/j.techfore.2016.06.004

Vygotsky, L. S., & Cole, M. (1978). *Mind in society: Development of higher psychological processes*. Harvard University Press.

Wenger, E. (1999). *Communities of practice: Learning, meaning, and identity*. Cambridge University Press.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17*(2), 89–100.

Xia, J., & (Cecilia), Caulfield, C., & Ferns, S. (2015). Work-integrated learning: Linking research and teaching for a win-win situation. *Studies in Higher Education, 40*(9), 1560–1572. https://doi.org/10.1080/03075079.2014.882302

Authors and Affiliations

Brayan Díaz[1,2] · Cesar Delgado[1] · Kevin Han[3] · Collin Lynch[4]

✉ Brayan Díaz
badiaz@ncsu.edu

[1] D, Epartment of STEM Education, College of Education, North Carolina State University, 208 Poe Hall, 2310 Stinson Drive, Raleigh, NC 27695, USA

[2] National Center of Artificial Intelligence, Santiago, Chile

[3] Department of Civil, Construction, and Environmental Engineering, North Carolina State University, Raleigh, NC, USA

[4] Department of Computer Science, North Carolina State University, Raleigh, NC, USA