Effective Practices and Emerging Opportunities for Integrating Project-Based Learning with Authentic Work Experiences

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Abstract

Continued calls have been made to improve the engineering curriculum by incorporating project-based learning and work-integrated learning experiences [1]. This paper describes and compares the efforts of two undergraduate engineering programs in the United States in integrating project-based learning and authentic work experiences into their respective curricula. Iron Range Engineering (Minnesota) is an established ABET Accredited degree granting program that offers students opportunities to engage in an innovative learning model, allowing them to earn credit while working full-time in engineering internships and co-ops. Students not only gain competencies in technical areas, but also are well equipped with skills in design and professionalism. The Greenway Institute (Vermont) is a brand new engineering college designing a novel program consisting of two years of hands-on project based learning and two years of work integrated learning. In the development of the Institute, Greenway partnered with Elizabethtown College (Pennsylvania) to host a pilot semester where students engaged with engineering coursework through hands-on projects and a paid work-integrated learning experience with local businesses.

1 Introduction

While there is significant literature on project-based learning (PBL) and a growing body of literature on work-integrated learning, there is less work focused on integrating authentic work experiences with a PBL curriculum. The purpose of this practice paper is to describe effective practices and emerging opportunities of two engineering programs that currently integrate project-based learning with authentic work experiences, Iron Range Engineering program and Greenway Institute, both located in the United States.

2 Background of Programs

A. Iron Range Engineering

The Iron Range Engineering (IRE) program is an upper-division engineering program supported by Minnesota State University, Mankato that represents a transformative approach to engineering education. Established in 2009 in Virginia, Minnesota, IRE aimed to bridge the gap between theoretical learning and industry practice [2]. This program integrates project-based learning, work-based experiences, and self-directed learning [2] [3] to prepare engineers who excel both technically and professionally in dynamic global industries. IRE's origins are rooted in the globally acclaimed Aalborg University PBL model [4]. Through an equity lens, IRE also addresses the pressing need for innovative educational models that cater to diverse and geographically isolated student populations, often referred to as "engineering education deserts" [5] [6] [7]. The program actively collaborates with 2-year community colleges across the United States to create seamless transfer pathways, enabling students from diverse backgrounds to pursue engineering degrees without the financial and logistical barriers often associated with traditional four-year programs. Within its first decade, IRE garnered significant recognition for its pioneering efforts, including the ABET Innovation Award in 2017 and its inclusion as an "emerging world leader" in engineering education in MIT's Global State of the Art in

Engineering Education report [8]. Currently, IRE enrolls about 100 students nationwide and achieves a five-semester graduation rate of 80% [9].

B. *Greenway Institute*

The Greenway Institute is a pioneering engineering education initiative located in Montpelier, Vermont. As part of the development of the four-year engineering program, Greenway piloted two key elements of the educational model in partnership with Elizabethtown College. The program and partnership were sponsored through a grant from the U.S. National Science Foundation aimed to broaden participation in engineering. The first pilot semester focused solely on project-based learning and shifted to work-integrated learning during the second pilot semester [10].

In the first year of the program, the Greenway team successfully developed the infrastructure, processes, and academic components necessary to launch a pilot semester of the project-based curriculum in Fall 2023. In the second year of the program, the program underwent a significant transformation by developing a work-integrated learning mode of instruction, furthering the commitment to hands-on learning. The goal of the work-integrated learning pilot was to extend the principles of project-based learning, from the first pilot semester, to promote authentic work experiences. This shift was inspired by feedback from students regarding the significance of authentic opportunities to engage with engineers and local engineering workplaces, as well as discussions with leaders in engineering education, including IRE.

Thus far eight students have participated in the Greenway pilot programs. We have found that project-based learning and authentic work experiences promoted community engagement and fostered engineering identity [10]. The outcomes from the pilot semesters will be used to improve future engineering education at Elizabethtown and the Greenway Institute.

3 Curriculum Structure

A. *Iron Range Engineering*

IRE students spend one semester in the IRE Bell Academy and 24 months in co-op positions while they complete their degrees. As depicted in Figure 1, the Bell Academy is a semester-long bridge program that prepares students for the transition from foundational studies at community colleges to advanced engineering coursework and industry co-op placements [11]. Through six technical courses, industry-sponsored design projects, and professionalism workshops, students are transformed into industry-ready engineers. Learning coaches work with students to create comprehensive "job packages," which include resumes, cover letters, mock interviews, and participation in local career fairs. The majority of students (92%) successfully obtain a co-op position after completing Bell Academy. Afterwards, they spend the subsequent 24 months in full-time paid industry co-op positions, completing their degrees remotely while gaining valuable professional experience. On average, co-op students can earn $21- $23/hour on a 40-hour week, covering their tuition and some living expenses [5]. This model ensures that graduates not only possess the academic qualifications but also have substantial industry exposure, making them highly competitive in the job market.

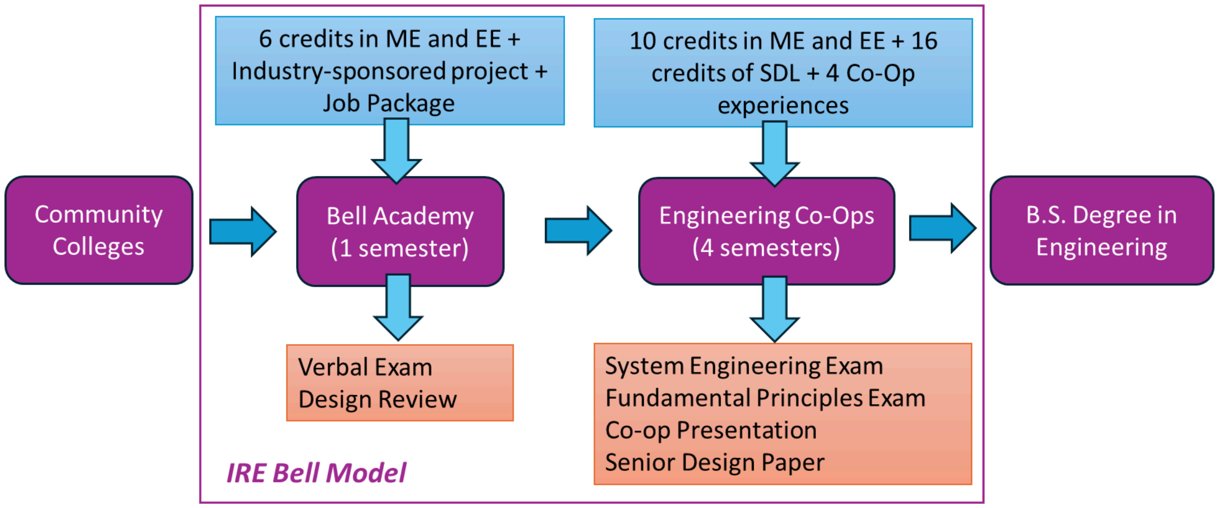

Figure 1 IRE Bell Model structure and major assessment tools [12]

The IRE curriculum is supported through three pillars: technical, design and professionalism, which emphasizes cyclical learning process including problem scoping, competency identification, learning activity design, and oral and written demonstrations of mastery. After completing 16 core competencies in mechanical and electrical engineering, students move on to 16 credits of self-directed learning [3]. In this phase, they create personalized learning plans that incorporate on-the-job training, collaborate with peers and industry mentors, and reflect on their educational growth. Faculty advise students in syllabus design, provide resources, and assess learning through verbal exams. For each credit, students document their learning outcomes through a deep learning activity, which can take various formats ranging from a research paper to a simulation. These components cultivate a deep understanding of engineering principles while reinforcing the practical skills needed to succeed in real-world engineering environments.

B. Greenway Institute

Drawing inspiration from IRE's success with the three pillars of a whole engineer, Greenway designed a mastery-based, work-integrated learning curriculum with outcomes from three categories: technical competencies, professionalism, and engineering design. Furthermore, designing the work-integrated learning pilot required engagement with local industry and just-in-time learning to prepare students for internship placements. The work-integrated learning pilot semester began with a three-week intensive program designed to prepare students for their internships and gain experience with project-based learning in an authentic context through a design project with a real client [13]. In alignment with Greenway's focus on sustainability and community engagement, the design project was co-developed with a local community member and focused on designing a sustainable bike share station near the campus. For the remaining 12 weeks, students engaged in work-integrated learning, spending 30-40 hours per week in their engineering internships while concurrently completing 10-15 hours of coursework.

During work-integrated learning, students balanced their time in the workplace with their coursework where they continued to work towards mastery of technical, design, and professionalism outcomes. There is intentional and delicate overlap between the work students are paid to do for their internship and the work they receive credit for. The design and professionalism outcomes were designed to build on and deepen the learning happening in the workplace, while also strengthening the student's ability to be an effective, reflective, and successful employee.

4 Evaluation and Grading

A. Iron Range Engineering

Given the diverse learning formats at IRE, assessment tools are intentionally varied to effectively measure students' understanding of engineering principles and their ability to apply these concepts in design work. Among these, verbal examinations stand out as a unique method for evaluating students' technical competencies and proficiency in articulating engineering concepts. During each verbal exam, students will describe the definition, explain an equation, and finally discuss its application and connection with other principles [14]. Students are given immediate feedback and a score ranging from 1 (deficient work - freshmen in college) to 5 (exemplary work- professional engineer) [15]. The 5-point grading scale connects their performance with industry expectations.

For Bell Academy students, the assessment for design skills is conducted through design reviews [16] which employ an iterative approach to assess student learning and project development. Early in the semester, students present a "Minimal Viable Product" (MVP) that meets basic client requirements. In subsequent design reviews, students and faculty refine the MVP through iterative cycles, integrating feedback to improve technical solutions and communication skills. This process, rooted in Agile principles [17], emphasizes adaptability, customer-focused development, and continuous improvement. Structured rubrics and reflective journals complement the reviews, fostering self-assessment and a growth mindset while preparing students with industry-relevant skills such as project management, teamwork, and technical writing. For students on co-op, design skills are assessed through the senior design paper that consolidates each student's academic and co-op experiences, including robust literature reviews, design methodologies, and modern engineering tools. It addresses stakeholder interests, feasibility analyses, and professional competencies such as communication, teamwork, and conflict resolution, thereby meeting ABET performance indicators and demonstrating readiness for interdisciplinary challenges. By reflecting on breakthroughs and setbacks, students articulate an evolving professional identity and emotional commitment as they become industry-ready engineers.

B. Greenway Institute

Mastery-based assessment is an important component of the Greenway program. There is a growing body of literature and application of mastery-based assessment in undergraduate engineering classrooms [18]. Through the pilot semesters, mastery-based assessment was a useful tool for facilitating project-based learning [19] and work-integrated learning. Rather than assigning a letter grade for each assignment, students have multiple opportunities to demonstrate mastery of each learning objective. Assessments include verbal discussions, projects, quizzes, written reflections, and other creative demonstrations of learning. Proficiency for each learning objective is assessed using the following scale: "Achieved Mastery", "Approaching Mastery", and "Not Yet Mastered." Each outcome consists of a set of actionable skills considered fundamental to the topic and represent the minimum proficiency necessary for success in subsequent courses. Grades higher than a C are achieved through mastery of Essential and Advanced outcomes. Essential outcomes are critical to the discipline and provide a strong foundation for future coursework, while Advanced outcomes serve as optional applications of learning that require higher-order thinking to complete. The flexibility inherent in mastery-based learning assessment models is useful in a work-integrated learning context where instructors have limited ability to dictate exactly what students will be learning and doing in the workplace. In this context, the approach also provides students with the opportunity to pursue mastery of outcomes that are aligned with their particular internship role or personal interests.

During the three-week intensive at the beginning of the work-integrated learning semester, students split the majority of their time between design and professionalism outcomes. To demonstrate mastery in their design outcomes, the students worked with a community partner to complete a 3-week design sprint, gaining hands-on experience with the nuances of a real-world problem. Students engaged in frequent design reviews to practice their technical communication skills and receive feedback and just-in-time instruction. To demonstrate mastery of professionalism outcomes, students engaged in interactive workshops focused on professionalism, participated in weekly "career treks" to local engineering companies, and prepared for their internships practically by communicating with their internship supervisors to develop and articulate an initial sense of their role, responsibilities, and workplace expectations. Students also began to identify their strengths and weaknesses in regards to professional skills, and articulate their long-term professional goals.

During the work-integrated learning portion of the semester, design and professionalism outcomes are assessed as students make meaning from their internship work and conduct independent investigations. Building on professionalism work during the three-week intensive, students were supported in taking actions to improve their professionalism skills, as well as asked to reflect on how their professional goals changed following this work experience. Professional activities such as developing workplace mentors, conducting informational interviews, and asking for and reflecting on feedback from internship supervisors were also opportunities for assessment of professional development. Students were also evaluated on their progress towards their project goals and internship activities via regular briefs presented to instructors and members of the cohort. In the realm of design, students were asked to identify where in the design process their internship work was situated, contextualize their work within the larger design process of their internship workplace and beyond, and demonstrate how their abilities and understanding of relevant parts of the design process were strengthened by the internship experience. Furthermore, post-program evaluation found that the students felt that project-based learning "ties in very well with mastery-based assessment" and several students told researchers that they preferred mastery-based assessment of project-based learning over traditional high-stakes engineering exams [19]. Students did note that mastery-based assessment is time intensive and can be particularly stressful towards the end of the semester.

5 Student Support

A. Iron Range Engineering

In addition to faculty advising, students at IRE receive dedicated support from learning coaches, who serve as a vital link between academics and professional growth. These coaches are engineering professionals with industry experience, providing personalized guidance throughout students' time at IRE [20]. To foster trust and strong relationships, each coach works with no more than 15 students. Their support includes three key areas. First, they hold weekly one-on-one meetings to track progress, set goals, and address challenges, helping students balance academics and full-time work while building long-term resilience [21] and well-being [22]. Second, they host professional workshops and student-life events (e.g., virtual gaming, baking contests), to develop essential skills such as time management, emotional regulation, and goal-setting. These activities enhance adaptability in the co-op environment while strengthening the student community [23]. Third, learning coaches assist prospective students during recruitment outside Minnesota. They arrange campus visits, respond to inquiries, and connect applicants with current students and alumni to ease their transition into IRE.

B. Greenway Engineering

Greenway set out to build a strong sense of community in the program and with the local community. Due to intentional informal programming, the relatively small cohort, and high student to staff ratio, Greenway was able to build a sense of community within the program. Students engaged in mentoring and reflection discussions one-on-one with instructors and staff throughout the semester. In addition, a key feature of the program was weekly cohort dinners with faculty and instructors. These dinners were paramount in facilitating peer-to-peer mentorship opportunities, and often discussion topics revolved around mental and physical wellbeing while balancing work, life, and school. To build a sense of community and connections with the local community, Greenway focused their design project on a local community bike share and facilitated local volunteering events. The design project allowed students to apply their engineering knowledge, engage with local community members, and contribute positively in a way that respected and valued local knowledge [13]. Students felt that the informal programming and local volunteering were positive for their "work-life" balance. Furthermore, students in both pilots reported a strong sense of belonging in the program with both their peers and the staff.

6 Shared Practices and Reflections

A. Project-Based Learning (PBL) and Authentic Work Experiences

In both programs, PBL serves the practical purpose of directly preparing students for an engineering co-op or internship. To meet this purpose, PBL is supported by the explicit instruction of professionalism skills, exposing students to authentic work experiences, and guided reflection on how to apply their learnings to future workplaces. The authentic experience and emphasis on building professionalism skills allows students to gain insight about engineering work and helps them build transferable skills for future internships. Leveraging authentic work experiences strengthened learning between class and work contexts.

B. Effective Practices

In reflecting on our curriculum, assessment, and student support, we found three key shared practices.

(1)Integrating current and relevant topics into projects. When students are applying to internships and considering their future careers, it is important to integrate current topics and issues into the curriculum to help them be competitive in the job market. For example, IRE is incorporating AI into their curriculum and GCES is incorporating sustainability.

(2) Work-integrated or work-based learning is in alignment with efforts to decrease barriers and broaden participation in engineering. Allowing students to "earn as they learn" provides students

with valuable learning experiences while also reducing the burden of student debt. As discussed, on average, co-op students can earn $21- $23/hour covering their tuition and some living expenses [5]. In recruitment efforts, both programs have found that this aspect is attractive to students.

(3) Meaningful partnerships are crucial to extending project-based learning to authentic work contexts. Both programs rely on partnerships with other colleges, engineering employers, and community members. Local context is important to both sites as they are located in rural areas of the United States, areas that might otherwise be considered "engineering education deserts." Therefore, building partnerships with organizations who share similar values and support workforce development is crucial to recruiting students, finding clients and designing project-based learning, and supporting students in obtaining internships.

C. *Areas of Growth*

(1) Extending project-based learning into authentic work contexts comes with a real learning curve. In both programs, the work-integrated learning model presented as a significant transition from prior schooling for students, requiring them to adapt not only to new schedules and expectations but also to greater autonomy and accountability. At IRE, quantitative survey results suggest that this adjustment is supported by a strong community culture and identity formation (Survey details found in [24]). Scoring engineering identity on a Likert scale from 0 to 6, the average respondent score was 5.4, indicating that most participants reported a high level of engineering self-identification. Additionally, the average respondent score for feeling of belonging was 5.5, demonstrating students felt well-supported and accepted as integral members of the IRE community. Students linked this sense of belonging to peer interaction and structured social events that encourage collaboration and camaraderie in the qualitative portion of the study [25]. Together, these findings suggest that community belonging and engineering identity may function as stabilizing supports as students navigate the early challenges of transitioning into work-like learning environments.

At the same time, student feedback collected in 2025 (Table 1 and 2) indicates that the very elements intended to support this transition can also feel demanding.

Table 1 Student feedback from IRE graduating seniors [12]

Most enjoyable experiences	**Most challenging experiences**
Flexibility of learning	Lost on developing self-directed learning plans
Working with learning coaches	Lack of consistency and connection between courses; Hard to manage learning various aspects of engineering
Strong professional skills developed	Overwhelming writing and metacognition
Sense of belonging and social events	Lack of professional development opportunities

Table 2 Student feedback from Greenway Spring 2025 Cohort (collected via qualitative interviews)

Most valuable experiences	Most challenging experiences
Gaining "real-world" experience in the workplace through work-integrated learning	Time management and having school-work-life balance
The people including faculty, staff, internship supervisors, and coworkers	Adapting to a work environment, commuting, office culture, and different work modalities
Developing human-centered design skills	Keeping track of school assignments while working
Small cohort and individualized learning experience	Staying motivated at work

While there are documented benefits to work-integrated learning students in both programs told faculty that it can be challenging to maintain work-school-life balance . To address this, both programs integrated discussions on time management and personal management systems and more data is needed to determine the success of these interventions at decreasing student stress. Additionally, in their feedback many students reported feeling lost or overwhelmed when engaging in self-directed assignments, and others noted inconsistent connections across courses that made it difficult to manage learning across diverse engineering topics. The student feedback and our shared reflection underscores the need for intentional scaffolding to ensure that students are able to successfully manage the learning curve of a work-integrated program and minimise undue stress. Clearer curricular links, more structured mentoring, and explicit guidance for creating and maintaining checkpoints are three approaches that may help ensure that flexibility and reflection in the curriculum function as support for students rather than additional burdens. Consistent with this intent, the Bell Academy (IRE) and the three-week intensive program (Greenway) were designed to serve as an "on-ramp", providing extra support to reduce the learning curve before students enter work-based experiences. Both programs plan to use the student feedback and shared reflection about the unique learning curve of work-integrated learning to improve their respective "on-ramps."

(2) Building strong partnerships takes time and effort. While an important part of extending project-based learning to authentic work contexts, building partnerships takes significant investment. In the early phases of each program, it was challenging to support students in finding internships or co-ops outside of the summer cycle. While Greenway was able to secure placements for all of the students in the pilot semester, all of the internships were facilitated by program staff and were not organic. IRE has reached a high level of success with internship placements, approximately ~92% placement rate for students after Bell Academy [25].

7 Conclusion

Through the work and reflection of our two programs, we have found that extending project-based learning to authentic work contexts is a promising practice for engineering education. Both Iron Range Engineering and Greenway Institute are two programs at different stages in their implementation that have successfully leveraged these practices. Project-based learning allows our work-based learning programs to prepare students for the challenges of industry and teach transferable skills. Furthermore, by tying project-based learning to workplace contexts, students are able to gain a more authentic understanding of how to apply their technical coursework while simultaneously developing a respect for the importance of professionalism and design skills. It is our hope that other engineering educators and researchers reflect on and consider ways to extend project-based learning to support the development of engineering students.

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