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Capstone Experiential Learning in Construction Engineering: Alumni Perspectives on Career Readiness

Brandon M. Fulk P.E., Purdue University at West Lafayette (COE)

Mr. Fulk is the Assistant Head & The Walsh Group Director of Internship for the Division of Construction Engineering and Management (CEM) at Purdue University. His responsibilities not only include the administration of the undergraduate program and the curriculum-based experiential learning (internship) program for the Division but in addition he is the academic advisor and instructor for the Division's year long capstone course.

Dr. Sogand Hasanzadeh, Purdue University at West Lafayette (COE)

Dr. Hasanzadeh is Associate Professor at the Lyles School of Civil and Construction Engineering and the director of the Intelligent-Inclusive-Safe (I2SAFE) lab at Purdue University. Her research focuses on advancing smart safety through the application of cyber-physical-human systems, digital twin, human factors, sesing, extended reality, robotics, and AI. Her interdisciplinary work seeks to create a shared language among civil engineering, computer science, engineerign education, human factors, and cognitive/behavioral psychology that leads to more informed engineering solutions to current and future challenges in complex construction projects.

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Abstract

A persistent challenge in engineering education is the perceived gap between academic preparation and industry expectations for career readiness; construction engineering education is particularly affected by this misalignment. Capstone courses, positioned at the culmination of the undergraduate experience, are recognized as a pedagogical mechanism for addressing this gap by integrating technical knowledge with professional competencies through experiential learning. However, previous literature has documented fragmentation between academic and industry expectations, as well as competing pressures between technical skill development and professional skill advancement. To examine how capstone learning in construction engineering translates into early professional practice, this study interviewed alumni who are practicing construction professionals and reflected on their capstone experiences from the perspective of early career practice. Semi-structured qualitative interviews were conducted to extend the experiential learning cycle beyond the capstone classroom and into the workplace. Findings indicated that while alumni consistently valued communication, teamwork, and critical thinking (CTCt) competencies developed through their capstone experience, they emphasized the need for more structured experiential components that support consequential decision-making and engagement with the human and organizational dimensions of construction engineering education, rather than increased emphasis on additional technical content. The findings also reinforced the construction engineering capstone as a key mechanism for aligning educational outcomes with professional demands, advancing adaptability and ensuring a sustained model for career readiness. This study contributes to the engineering education community by providing alumni-informed insights that help close the feedback loop between industry practice and curriculum design.

Introduction

Career readiness is a growing concern that is gripping the academia-industry interface. Graduates are expected to transition rapidly from academic environments into complex and consequential professional settings. Prior literature consistently highlights a perceived gap between academic preparation and industry expectations [1]. While technical competence remains essential, industry reports and engineering education studies increasingly emphasize that professional success depends on graduates' ability to navigate loosely defined problems, collaborate across disciplines, and make complex decisions within real constraints [2]-[3]. Experiential learning has been widely adopted as a pedagogical response to this challenge, with capstone courses serving as a primary mechanism for integrating theory and practice at the culmination of undergraduate engineering programs [4]. However, evaluations of capstone effectiveness and career readiness are most often conducted at or near graduation, typically through course assessments or senior exit surveys, capturing student perceptions before graduates assume sustained professional responsibility [2]-

[4]. As a result, limited studies have examined how capstone learning outcomes are interpreted, reflected upon, and valued after graduates enter professional practice.

This study addresses this gap by examining career readiness through the lens of alumni who have transitioned into industry and can reflect on capstone learning from a situated professional perspective. Focusing on a two-semester Construction Engineering capstone grounded in experiential learning and curriculum-based experiential learning (CBEL), this paper leverages semi-structured alumni interviews to explore how communication, teamwork, and critical thinking developed during capstone translate into early professional practice and evolve within changing industry contexts. The objective of this paper is: (1) to extend understanding of career readiness beyond graduation by incorporating post-graduation alumni reflection, and (2) to examine how alumni insights can inform continuous improvement of capstone pedagogy. By positioning alumni as reflective practitioners, this study contributes qualitative evidence that strengthens alignment between academic preparation and professional execution offering a practical framework for leveraging experiential learning to reduce fragmentation between academia and industry.

Literature Review

Career Readiness and the Academia-Industry Interface – Career readiness in engineering education lies at the intersection of academic preparation and professional practice. Differences in perspective and priorities at this intersection create tension between academia and industry [1]. Academic programs are tasked with balancing foundational theory, accreditation requirements, and curricular constraints, while industry places greater emphasis on applied judgment, adaptability, and effective execution within dynamic, uncertain, and complicated project environments [1]. These divergent expectations contribute to concerns regarding graduates' preparedness for professional practice, as industry stakeholders reported investing substantial time and resources to mitigate the steep learning curves associated with newly hired graduates [2].

Career readiness is defined in several ways across literature, often articulated as professional preparation, professional practice, or competency fulfillment [2]. While technical knowledge remains essential, an expanding body of engineering education research emphasizes the critical role of communication, teamwork, and critical thinking (CTCt) competencies in enabling effective decision-making, collaboration, and professional judgment [5]-[6]. These capabilities are not merely developed through technical proficiency; rather, they are developed through authentic responsibility, social interaction, and problem-solving, and are closely tied to the formation of their professional identity [7].

Despite the importance of these capabilities, previous efforts in career readiness primarily relied on assessments at or near the point of graduation and did not engage alumni as situated professional observers to extend evaluation beyond graduation. This approach provides very limited insight into how readiness evolves over time once graduates experience professional practice. These limitations suggest considering career readiness as a developmental construct that unfolds as professional responsibility increases, rather than as a static outcome measured at program

completion. Considering that alumni are uniquely positioned to reflect on how experiential learning outcomes—particularly those associated with capstone courses—translate into professional competencies, incorporating alumni perspectives provides valuable insights into which educational experiences contribute significantly to success in practice, especially helping to better understand the role of capstone as a critical pedagogical instrument for aligning academic preparation with the dynamic of construction engineering work.

Capstone Experiential Learning – Experiential learning offers contextual pedagogy that aligns with how students engage, develop meaning, and apply learning in practical professional fields. Grounded in Kolb's experiential learning cycle, authentic experiences that involve responsibility, consequences, and reflection support deeper learning by enabling students to encode knowledge more clearly through action rather than through abstract, transactional instruction [8]. The Experiential Learning Cycle (Figure 1) and experiential learning activities are the foundation of the Construction Engineering capstone course and of the broader curriculum-based experiential learning (CBEL) framework that supports it [1]. This study examines capstone's impact on career readiness by leveraging alumni reflections to gain a post-graduation, industry-emersed perspective on which elements of the capstone experience translate and evolve once graduates enter professional practice.

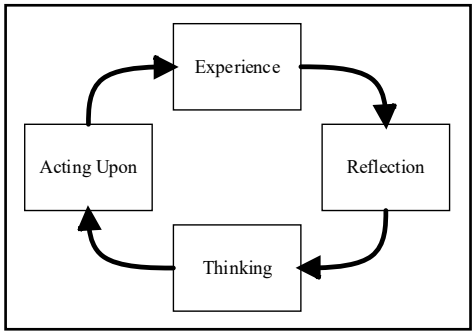

Figure 1 - Experiential Learning Cycle - as applied by the capstone course instructor [3]

In this paper, "career readiness" is broadly defined as professional preparation and early professional practice, specifically aligned with academic preparation and with how work is executed in industry, as interpreted through alumni interviews [2].

The result is that alumni reflections extend the experiential learning cycle beyond the undergraduate classroom, providing an approach to connect capstone pedagogy with evolving industry situations, environments, or trends.

Capstone courses are recognized in the engineering education literature for implementing experiential learning at scale and for bridging theory and professional practice. Positioned as culminating, integrative experiences within undergraduate education, capstone courses aim to synthesize prior technical coursework with professional competencies prior to entering the engineering workforce [4]. In construction engineering, capstone projects should simulate industry contexts. Despite their central role, the effectiveness of capstone courses in career readiness remains challenging to assess. Evaluations of these experiences are typically conducted at or near

graduation, most often through course assessments or senior exit surveys [2]-[4]. While these approaches provide insight into student perceptions of preparedness, they capture perspectives before graduates assume professional responsibility or operate within industry constraints. This limitation highlights a critical need to extend evaluation of capstone experiential learning beyond the academic setting.

Point of Departure

Prior studies have shown that experiential learning in capstone courses is valuable and that communication, teamwork, and critical thinking (CTCt) matter for undergraduate career readiness [1]-[4]. This paper aims to extend these works by examining how these learning outcomes, especially based on capstone courses, are recognized and interpreted after graduates enter professional practice. This study engaged alumni as situated professional observers and extended the experiential learning cycle beyond the capstone classroom and graduation into earlycareer experience. Examining capstone outcomes through the lens of post-graduation professional experience can help better understand how capstone experiential structures can support career-readiness development. Alumni reflections herein suggest a shift of focus away from tool mastery or competency-based learning of technical knowledge toward a more humanistic approach that aligns academic preparation and professional execution. Engaging alumni as reflective practitioners offers a promising approach to addressing the fragmentation between academia and industry by supporting graduates' decision-making and assuming responsibility early in their careers, and by informing the design of more practice-aligned capstone experiences.

Research Methodology

Study Design and Purpose – This study employs an interpretive qualitative inquiry approach, using reflexive thematic analysis, to examine alumni's perceptions of the Construction Engineering capstone experience after entering industry. The study aims to examine how experiential learning outcomes are identified, reframed, and applied once graduates begin to form their professional identity. It must be noted that this paper is part of a broader research program investigating multiple dimensions of experiential learning and career readiness. Within the scope of this paper, thirty alumni were engaged as professionally situated observers and asked to reflect on their undergraduate capstone experience, identify skills that became meaningful only after entering industry, and offer a perspective to inform curricular refinement. The study design emphasizes alumni reflection on capstone learning after entering professional practice, leading to the recognition that certain experiential education learning outcomes may only become visible through sustained professional practice.

Capstone Course Structure – The Construction Engineering capstone course at the center of this study is a two-semester sequence that has evolved incrementally between 2017 and 2023 while maintaining a consistent pedagogical framework. The course is structured around a

progressive design–build model intended to simulate professional project delivery across the project life cycle.

During the fall semester, student teams engage in a pursuit and design phase that includes project scope identification, conceptual and detailed design development, estimating, scheduling, and coordination. This phase culminates in a comprehensive final presentation delivered to a mixed panel of industry professionals and faculty members, who evaluate the proposals and select a preferred project for execution.

The spring semester transitions teams into execution, during which students implement the selected design through the preconstruction and construction phases. Activities include work planning, logistics, procurement considerations, quality assurance, field coordination, and documentation. This allows the students to experience decision-making under evolving constraints. Combined, the two semesters provide a continuous scaffolded experience intended to mirror professional practice while remaining situated within an academic environment.

Participants – Thirty alumni from the Construction Engineering program at Purdue University participated in this study (18 male, 12 female; mean age = 25.4 years, SD = 2.08; mean work experience = 3.2 years, SD = 1.77). Alumni represented graduating cohorts spanning Spring 2018 through Spring 2023; as a result, participants had between 1 and 10 years of experience at the time of the interview. In accordance with Institutional Review Board (IRB) approval, all participants were deidentified. Participants were recruited through a targeted email campaign. Interviews were scheduled voluntarily using an online scheduling platform. For evaluation purposes, responses were grouped by the fall semester in which participants completed the capstone course; however, as described previously, we did not scrutinize reflections by cohort. This grouping permitted the initial review, memo creation, and iterative analysis necessary to develop the reflexive thematic analysis.

Data Collection Procedures – Data collected through semi-structured interviews conducted during the summer of 2025. Interviews followed a structured sequence of questions while allowing flexibility for organic dialogue and follow-up. This approach supported deep reflection while maintaining consistency across interviews. Interviews were conducted virtually using Microsoft Teams for video and audio capture. All participants provided informed consent prior to participation, in accordance with IRB requirements, and verbal consent was reconfirmed at the start of each interview.

The interview sequence was designed to create an extended experiential learning cycle (Figure 2), allowing reflections to scaffold from baseline perceptions to professional interpretations and to return to curricular feedback. Question (1) establishes a baseline of alumni perceptions at graduation with time elapsed for reflective evaluation. Question (2) bridges academic preparation to early professional experience by asking what alumni realize now that they gained once they entered industry. Question (3A) shifts the discussion into an immersive professional context by documenting how industry conditions have evolved since graduation. Question (3B) concludes the sequence and completes the experiential learning cycle by returning our focus to academia through alumni recommendations for continuous improvement and curricular refinement.

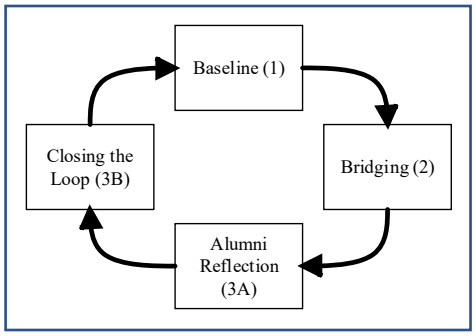

Figure 2 - Extended Experiential Learning Cycle: Alumni with Situated Professional Perspective

The interview protocol included the following questions:

> (1) *Rate your capstone experience regarding advancing the preparation of Bachelor of Science in Construction Engineering students in terms of communication, teamwork, critical thinking, technical skills, and emerging technology competencies. (1-very dissatisfied, 5-very satisfied) Please explain.*
>
> (2) *Were there other skills that you gained in the capstone experience that prepared you for your professional career? Please explain.*
>
> (3) *In an effort to maximize the preparation and career-readiness of the Construction engineering professional (graduating student):*
>
> - *(A) - What has changed in the industry since you graduated?*
> - *(B) - Is there any skills that you have been exposed to professionally in your career that could be incorporated into the capstone experience to enhance the career-readiness of the CNE professional?*

Data Analysis – Data was analyzed using reflexive thematic analysis. Interview transcripts were reviewed iteratively to support immersion and analytic familiarization. Manual open coding was used to identify noticeable patterns grounded in participant language and professional experience. Analytic memos were maintained throughout the analysis to document emerging interpretations, support reflexivity, and synthesize insights across interviews. The analysis focused on understanding how alumni reflected on and interpreted their capstone learning, observed industry trends, and offered suggestions for continuous improvement after gaining professional experience. Themes were refined through an iterative process by two coders and interpreted in light of the experiential learning and career-readiness literature.

Findings

To examine the impact of Construction Engineering capstone experiential learning on career readiness, this study extends evaluation beyond graduation by incorporating alumni professional reflections into the experiential learning cycle, positioning alumni as situated, informed observers of career readiness.

First, alumni reflections are used to establish a baseline evaluation of the capstone experience at graduation. Then, alumni insights are analyzed to study how academic preparation translated into early professional practice, reinforcing the importance of communication, teamwork, and critical thinking, while also uncovering additional elements of professional readiness that were not fully anticipated at the time of graduation. Further, alumni reflections on industry changes provide insight into evolving professional demands and constraints encountered after graduation. Lastly, alumni close the feedback loop by providing recommendations for capstone enhancement with emphasis on dynamic situational experiences rather than expanded technical content.

Baseline Assessment of the Undergraduate Capstone Experience – The interview protocol question, identified as (1), was used to establish a shared reference point for interpreting the reflections that follow in subsequent questions. Alumni generally described the capstone experience as positive, immersive, and well aligned with expectations for undergraduate preparation. They specifically mentioned increased communication, teamwork, and critical thinking competencies in an experiential learning environment that supported their transition into professional practice [1].

Bridging Academic Preparation to Professional Experience – Alumni across cohorts provided insight that reinforced the importance of CTCt, the primary focus of the author's broader research, while reflecting on additional complementary professional skills with less consistency and emphasis aligning this study with nationally recognized expected competencies [2], [6]. Individually, alumni experiences differ across market sectors and years of experience, but their aggregate perceptions provide greater depth to career readiness, with alumni shifting from novice to professional construction engineers.

Communication remained a consistent theme in alumni reflections on the capstone experience and the career-readiness skills they gained. However, it was rarely discussed as an isolated skill. Alumni described communication as foundational to effective teamwork and critical thinking, which reinforces prior findings that these skills are interconnected rather than independent [5]. Alumni observations of the capstone experience emphasize communication as a practical and situational skill developed through authentic efforts rather than formal instruction.

Across cohorts, alumni repeatedly identified the capstone final presentation as a formative communication experience. Participants described presenting to unfamiliar audiences and external evaluators as both realistic and professionally valuable. Excluding the instructor and teaching assistants from the final evaluation enhances this authentic, often organic experience. One alumnus noted that the capstone presentation closely mirrored professional expectations, emphasizing that the level of detail and preparation required was aligned with industry practice (Class of 2023). Earlier cohorts noted that presenting work to a panel of judges representing faculty and industry was impactful and consequential for their experiential learning (Class of 2017).

In addition to formal presentations, alumni described the development of communication through less formal experiences embedded in team-based work. Several alumni highlighted learning to document and explain their work so that others could follow their decisions and processes, emphasizing note-taking, organization, and clarity to facilitate communication (Class of 2020).

The ability to move beyond confrontation and develop the skill of challenging peers constructively was noted as an improved communication skill, a product of the capstone experience (Class of 2021). One alumnus identified the value of silence through their capstone experience. They realized the importance of recognizing when to listen rather than speak, "silence is good" as it relates to the ability to be an effective teammate (Class of 2022).

Teamwork plays a central role in the capstone experience. Alumni indicated that the depth of experiences is much more nuanced and professionally grounded than most undergraduate coursework or activities. Teamwork is not merely task coordination; it is participatory engagement, a dynamic process shaped by communication practices, accountability, role differentiation, and personality awareness.

Several alumni connected the development of teamwork to communication requirements embedded in activities associated with the capstone course. Their preparation of work so others could follow their decisions and reasoning was essential to functioning as a team, and it resonates with alumni growth working in a team as much as it does with communication preparation (Class of 2020). Other alumni emphasized the importance of "developing the courage of conviction and being willing within the team to stand up and say what you think …creating the environment to allow the whole team to do that" (Class of 2019). Several alumni described learning to manage diverse personalities as a critical component of teamwork. They noted that the capstone experience offered early exposure to working with individuals with different levels of knowledge and/or who approached problems in different ways (Class of 2021; 2022).

Several alumni emphasized the relationship between being a team member and being an integrated teammate. One alumnus noted that learning to be present and engaged, recognizing the effective participation sometimes involved listening rather than speaking (Class of 2022). Others discussed learning to differentiate roles within the team but emphasizing collaboration while ensuring that all teammates had opportunities to contribute meaningfully (Class of 2023). Another alumni highlighted the role of the capstone course pedagogy, in the form of shared work and hands-on experiential learning, in strengthening team cohesion. One alumnus noted, "All that hands on work it's fun. It helps you build your team", reinforcing bonds between teammates beyond task coordination (Class of 2022). Other alumni acknowledged situational factors that deepened their understanding of teamwork. One alumnus described how COVID-related constraints required teams to function more intentionally, coordinating schedules, managing limited access to resources, and forming joint ventures (teams combining) to complete the work (Class of 2020). Early cohorts noted the value of observing peer teams throughout the semester, as exposure to other teams' processes and presentations supported learning through comparison and reflection (Class of 2021).

Further, alumni provided fresh perspectives that indicated increased professional maturity, complementing the confirmation that teamwork is a valued outcome of the capstone course. As previously noted, the capstone experience is reinforced by the final presentation activity which strengthens this connection between communication and teamwork. Alumni acknowledged that successful team performance required coordination and collective preparation when presenting

work to external audiences, as the stakes are higher than in a typical presentation to the instructional team (Class of 2017).

Critical thinking insights from the alumni were less robust than those on communication and teamwork; however, a consistent emphasis on the interconnectivity of the CTCt framework and decision-making under uncertain conditions prevailed. Rather than explicitly using the term "critical thinking," alumni described situations that required evaluating priorities, gaining entry-level experience in assessing consequences, and making informed judgments when no answer key was available (outcomes were uncertain).

Several alumni noted that they learned to step back from the project and the immediate task at hand to evaluate the broader project implications in the context of their work. One alumnus shared they recognized the need to question priorities and assess whether limited resources should be invested in specific project elements, framing these decisions as moments that moved beyond procedural completion ("checking the box") and into a phase of informed decision-making (Class of 2018; 2022). Alumni also reflected on decision-making in response to change and uncertainty. Experiences such as simulated owner-driven changes and procurement/sourcing challenges required teams to adapt, communicate clearly, and identify issues proactively, highlighting critical thinking as an adaptive process rather than a static skill (Class of 2019).

Other alumni described critical thinking as abstract and creative. One participant noted that "creativity would be a big one" (experience gained) working on a unique project which fostered creative thinking, requiring their team to navigate unfamiliar boundary conditions and explore non-typical solutions (Class of 2018). Another alumnus described the development of their abstract thinking abilities as a profound outcome of the capstone experience, specifically in budget management and in understanding the cause-and-effect of real financial consequences (Class of 2019). This alumnus emphasized that working with someone else's funds introduced a new level of responsibility, leading to a shift in decision-making from hypothetical, low-stakes calculations to consequential, judgment-based outcomes.

Authentic practice and continuous improvement for the construction engineering professional, whether novice or seasoned, extend beyond communication, teamwork, and critical thinking; alumni highlighted the importance of engaging in authentic professional practice within a controlled academic environment. Alumni described the construction capstone as an environment where real work is undertaken with meaningful consequences, while providing the opportunity to learn, adapt, and grow without the full, personal, and professional risks found in industry.

Several alumni identified new or newly recognized skills that emerged through this experiential learning pedagogical approach. Specifically, in the context of construction engineering, they described gaining exposure to "land development" and "site development" concepts (Class of 2017), developing "adaptability" as a result of being "split between two (different cohort) semesters" (Class of 2019), and building confidence through hands-on problem solving under time constraints (Class of 2021). Cumulatively, these experiences contributed to increased knowledge, adaptability, and confidence as alumni navigated new disciplines, unfamiliar situations, and time-

constrained problem solving. Others shared their experience of leadership development and technology use as by-products of navigating authentic project demands rather than predefined instructional objectives (Class 2021). Alumni also noted that their prior technical training, such as surveying and construction layout, became more meaningful when applied in real project contexts, reinforcing knowledge through organic situations rather than prescribed repetitive practicums (Class of 2022).

Alumni reinforced that the extent to which the capstone provides an authentic experience within defined boundaries. They described executing work and making consequential decisions, while remaining insulated from full external pressures and consequences of professional practice. One alumnus articulated the value of this structure, noting that exposure to real-world activities and project sequencing was essential preparation stating, *"I think just the overarching theme of this is it was exposure to real-world work and activities and seeing how that all sequences together. That I felt as if I wouldn't have had it, I would have been like ill-prepared for joining the workforce"* (Class of 2020). Others emphasized the value of meaningful responsibility for results, even with limited budgets, stakeholder engagement, and evolving project requirements, all within the controlled environment of the capstone course, where personal and professional livelihoods are not at stake (Class of 2018; 2023). At the same time, alumni emphasized that the capstone experience was not immune to external influences. Alumni described constraints related to supply chain conditions and resource availability, as well as time and labor limitations, resulting from broader industry factors such as the COVID-19 pandemic (Class of 2019; 2020).

Alumni shared how these authentic experiences through capstone courses supported a deeper understanding of real-world construction practice. Hands-on engagement with tools, materials, layout, and trade responsibilities helped participants develop a more complete view of how work is performed and coordinated in the field (Class of 2021; 2022). Several alumni emphasized that this exposure reshaped their perception of 1) construction work as a human-centered endeavor, "not just bodies and laborers, they're people" requiring respect, coordination, and relationship-building rather than mere task execution (Class of 2020) and 2) supported increased personal confidence and leadership (Class of 2021). An alumnus noted the early exposure to technology in the capstone experience not only addressed skill development but also growth in confidence because "it's not just, oh, here's a presentation on what we're going to do, It's like here's a presentation on what we're going to go do and here's how we also just went and did it" (Class of 2023). Others described developing an appreciation for the craft/trades and sequencing involved in putting work in place, as well as the importance of documentation and organization so that decisions and work products could be understood by others (Class of 2020; 2021).

Reflection Through Alumni Industry Experience – Following the exploration of skills gained through the capstone experience, many of which alumni did not fully recognize at the time of graduation, the focus now shifts to alumni reflections on how industry conditions or trends have evolved. The alumni moved away from evaluating the capstone experience; therefore, this section reports alumni perspectives on changes in the professional environment since graduation, with themes aggregating in technology, project complexity, and human factors.

Technology emerged as a prominent theme in alumni reflections, with increased reliance on digital tools such as artificial intelligence (AI), virtual design and construction (VDC), light detection and ranging (LiDAR), global positioning systems (GPS), building information modeling (BIM), and data-driven platforms. Alumni noted that these tools are increasingly embedded in everyday practice, supporting construction execution, estimating, coordination, documentation, and, to some extent, decision-making (Class of 2018; 2021; 2022; 2023). Others emphasized shifts toward fully digital workflows, including virtual communication, QR codes, and reduced reliance on printed material (Class of 2021; 2022). Although there was a prevailing sentiment toward technology, alumni consistently framed technological competence as more than just tool use. Several alumni emphasized the importance of judgment in determining when and how technology should be applied. One alumnus cautioned "using the tool because it exists, but learning how to use it, why it's effective, how can we make it the most effective" (Class of 2020). Another alumnus described the need to balance emerging technologies with foundational practices, reflecting that stepping back to understand processes "the old-fashioned way" remains essential for practical applications (Class of 2023). Lastly, alumni raised concerns about ethics, data integrity, and cost awareness in adopting technology. They noted, in reference to AI, "it needs to be harnessed properly…obviously there's a whole bunch of ethical concerns with it" (Class of 2022).

Project complexity is changing the professional landscape by increasing project scale, compressed schedules, and greater coordination demands. Alumni across cohorts noted that projects are larger, project schedules are accelerated, and interconnection with the overall project team is greater than in their undergraduate experiences to the present day (Class of 2022; 2023). Alumni highlighted the growing importance of tracking labor efficiency, responding to a vast amount of RFI's, and coordinating across integrated software platforms as part of managing this complexity (Class of 2022).

External disruptions such as COVID-19 and supply chain volatility were also identified as contributors to project complexity. Alumni noted that these factors heightened sensitivity to budgets, scheduling, and procurement, requiring teams to operate with increased agility and foresight (Class of 2017). In parallel, alumni observed that clients/stakeholders have become more informed and increasingly willing to assume risk, further reshaping project decision-making and coordination requirements (Class of 2021).

The human factor constraints emerged as the final theme. In contrast to technological and procedural advancements, alumni emphasized that many industry challenges are fundamentally human-centered. Workforce shortages were frequently cited by alums, who noted increased pressure on manpower availability and the need to integrate teams effectively (Class of 2019). Alumni observed positive shifts in workforce composition, including increased representation of women in construction roles (Class of 2018).

Work-life balance emerged as a recurring tension with alumni describing generational differences in expectations, communication styles, and definition of professional commitment (Class of 2017; 2020; 2022). Several alums reflected on the importance of mentoring and communication across generations. They noted that younger professionals increasingly seek clarity about "why we're doing things and why we're building things," and more experienced professionals are "more

comfortable just taking the time to step back and explain it a little bit more," providing greater context and rationale for decisions (Class of 2021).

Alums further highlighted challenges associated with distributed and remote work environments, particularly following the COVID-19 pandemic. They noted changes in interpersonal dynamics, communication norms, and mentoring opportunities, which emphasized the need to integrate teams across locations, cultures, and time zones while maintaining productivity, safety, and quality (Class of 2018; 2020). Alumni reported that capstone experiences primarily focused on colocated teams and synchronous interaction, which did not fully prepare them to coordinate work and sustain professional relationships in hybrid or fully remote project environments.

Alumni also identified safety as an evolving aspect of industry practice, framed as a human-centered challenge rather than purely a technical one. Several alumni observed changes in safety culture, noting increased incident rates and reduced accountability in their isolated observations (Class of 2022). Others described safety as an area of ongoing adaptation and continuous improvement influenced by changing tools, coordination practices, and expectations (Class 2021). One alumnus noted visible changes in personal protective gear and tracking practices, emphasizing the growing role of coordination and communication in supporting safe operations (Class of 2020).

Closing the Feedback Loop Through Curricular Feedback and Continuous Improvement – When the interviewees were asked to reflect on recommendations for improving the capstone course and overall experience, they did not suggest additional technical content or specific software training; instead, they strongly emphasized improving the structure and delivery of the experience. Feedback focused on strengthening professional skills through greater continuity across the project life cycle, the deliberate introduction of consequential challenges, and increased attention to the human dimension of engineering/professional responsibilities. The following findings represent the alumni perspectives across these three areas.

Project Life Cycle Integration – Alumni perspective demonstrated the importance of experiencing projects through a more complete life cycle. Rather than suggesting additional technical material, the alumni emphasized the need for greater intentionality in integrating planning, execution, quality assurance, documentation, and closeout activities. Alumni highlighted work planning, scheduling, logistics, and coordination as foundational elements that gain greater meaning when viewed through a broader lens, where interconnection is a structured process rather than isolated tasks (Class of 2022; 2023). Several alumni specifically noted that field documentation and note-taking are tools for reinforcing accountability, reconstructing decisions, detailing matters, and demonstrating the role of documentation in professional practice (Class of 2021). Site visits with explicit reflection criteria, engagement with trades, and exposure to unions were also cited as valuable opportunities for contextual learning and understanding work beyond the classroom (Class of 2021; 2022). Alumni perspectives underscore the need for project life-cycle integration to enhance meaning and sustained learning by weaving technical activities into the task rather than treating them as isolated activities.

Consequential Decision-Making – Alumni emphasized that enhanced professional practice among construction engineering graduates is related not only to their technical knowledge

but also to their ability to make decisions under uncertainty and to manage the cascading consequences of those decisions. However, they consistently noted that capstone projects often lack authentic consequences. To address this gap, alumni recommended incorporating intentional disruptions, described as "curveballs" (Class of 2019), to simulate the cause-and-effect nature of the professional environment. Their recommendations included last-minute design changes, logistical constraints, stakeholder shifts in priorities, and public-facing coordination challenges. Alumni emphasized that these disruptions should be introduced deliberately but in a controlled manner, allowing the students to experience volatility and uncertainty without creating unnecessary chaos.

One alum suggested that we use a public RFI system for certain inquiries as a mechanism for shared learning and accountability, while introducing additional visibility into questions and responses, which encourages teams to develop strategies "to make sure that everyone's on an even playing field" (X009, Class of 2023). Others recommend scenarios that require rapid adaptation and judgment, such as procurement changes, supply chain issues, adjusting owner needs, or evolving project requirements (Class of 2019).

Some alumni also proposed extending these ideas throughout students' academic careers, suggesting the use of a single case study revisited across multiple semesters or courses to introduce progressively more complex challenges in design, safety, estimating, and execution (Class of 2019). Collectively, alumni perspectives underscore that learning is deepened when students must navigate decisions and adapt in real time to changing conditions.

Human Dimension of Engineering Practice – This theme emphasized the development of confidence, self-awareness, and professional identity. Alumni described the capstone as a formative experience that helped them build confidence prior to graduation through leadership opportunities, hands-on work, and exposure to authentic responsibilities (Class of 2018; 2021; 2022). Several alumni noted that learning to work with diverse personalities, manage difficult interactions, and communicate effectively with trades and stakeholders contributed to their professional growth (Class of 2020; 2021).

Alumni also highlighted the importance of feedback and reflection in shaping their professional identity. Industry-engaged presentations and authentic feedback were described as valuable "knowing that industry was listening and providing feedback" helped students understand expectations and assess their own development because "it adds that realness" (Class of 2019). Some alumni reflected on a desire for greater support in recognizing personal strengths, course correction related to their professional trajectory, and developing a sense of worth prior to entering the workforce (Class of 2017).

Others pointed to instances of discovery such that exposure to specific construction processes or systems influenced their interests and career direction (Class of 2020). Alumni further emphasized the value of continued industry engagement in the classroom, suggesting that the continued commitment to bringing them back to the classroom and the resulting interactions assist in these formative experiences and support professional growth before graduation (Class of 2023). Thus, while these findings suggest that these construction engineering capstone experiences could

effectively help build confidence and initial professional identity, there remain many opportunities to more intentionally scaffold human-centered competencies among graduates.

Discussion

Consistent with prior work [1], the baseline assessment of the undergraduate construction engineering capstone experience indicates extensive alumni agreement regarding satisfaction and perceived preparation. Quantitative findings suggested that the experiential nature of capstone creates a learning environment that alumni reflectively value and generally regard as effective in preparing them for professional practice [1]. The present study builds on that foundation by examining how alumni perceptions evolve once they are immersed in industry and can reflect on their preparation through a professional lens.

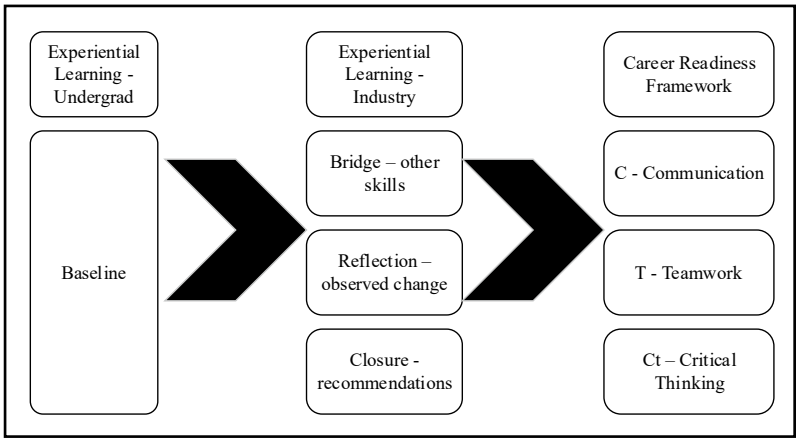

Figure 3- Academia-Industry Interface to Support Career Readiness Framework

Bridging Academic Preparation to Professional Experience – Alumni reflections affirm that communication, teamwork, and critical thinking are not isolated competencies but interconnected professional practices that develop through authentic experiences.

Communication emerged as foundational, supporting teamwork and critical thinking rather than functioning as an unrelated skill, consistent with engineering education literature [5]. Alumni emphasized the importance of communicating to authentic audiences, articulating work clearly so that others can follow, contribute, or replicate decisions, and exercising judgment regarding when to speak and when to listen. These observations were consistent across cohorts, suggesting agreement on how communication is experienced and valued within the capstone experience not by a single activity or even by checking the box as a competency, but through authentic, immersive experiential learning framework.

Alumni reflections also suggest that the structure of the final presentation environment played a meaningful role in shaping communication development. The use of a faculty-industry judging panel, combined with the deliberate removal of the instructional team from evaluative roles positioned students to communicate with authentic professional audiences rather than familiar academic evaluators, removing complacency. This model, simulating professional practice,

appears to have increased accountability, reinforced clarity in explaining their work, and required students to exercise judgment in how they frame and defend it.

Teamwork reflections further reinforced this mutual reliance. Alumni described a shift from participation-based engagement toward accountability, collaboration, and role awareness, an experience shaped by professional immersion and subsequent industry collaboration. The alumni shared new insights, including managing diverse personalities, the value of silence as a form of participation, and coordinating work under real constraints such as scheduling, access, and shared responsibility. These reflections suggest that alumni increasingly interpreted teamwork not merely as compatibility but as the ability to navigate differences, enhanced by structured collaboration and by authentic accountability to external audiences.

Hands-on work was also noted as contributing to team chemistry and identity formation. Alumni reflections aligned with experiential learning principles, where observation, reflection, and shared responsibility supported learning beyond task execution, no longer just checking the box. These findings suggest that the capstone teamwork functioned as a developmental space for learning how to collaborate under authentic conditions.

Critical thinking appeared less frequent and less clearly articulated, reflecting its abstract nature and its embeddedness within practice. Alumni often compared capstone experiences with more transactional academic coursework, in which success was measured by fulfilling requirements and completing tasks, rather than transformational learning focused on honing critical thinking skills. Many of the reflections suggest that critical thinking developed through experiential learning exposed individuals to ambiguity, consequences, and evolving constraints, resulting in late value identification, recognized only after accumulating professional experience. In summary, these reflections indicate that capstone experiences support the development of critical thinking skills, not as a function of a linear system, but as a function of uncertainty, responsibility, and authentic consequences.

Alumni reflections also highlighted the value of learning under authentic project conditions that require agility and adaptation. One alumnus described completing the capstone experience out of sequence, entering a project midstream to assist with the execution phase and later supporting a different cohort during the project pursuit and design phase. This alumnus did not emphasize the course structure but described the experience as requiring fluid adaptation, complex understanding, and adaptability similar to those encountered in professional situations. This reflection reinforces how capstone learning extends beyond planned instruction, preparing students to navigate ambiguity, team dynamics, and responsibility, similar to early-career industry/project environments.

Collectively, alumni observations suggest that the capstone functioned as a form of professional practice (a dress rehearsal), allowing undergraduate construction engineers to practice judgment, adaptability, and integrated understanding through authentic work conducted in a controlled environment. Alumni identified this structure as influential in their preparation, complementing and reinforcing the development of communication, teamwork, and critical thinking competencies.

Reflection Through Alumni Industry Experience – Alumni reflection on how industry has evolved since graduation shifted from evaluating career readiness to framing the professional environment in which that preparation is applied. In general, alumni emphasized three interrelated dynamics: increased technological integration, greater project complexity, and emerging human-centered constraints.

Alumni described technology as increasingly prevalent but noted that industry values engineers who can evaluate tools situationally rather than merely operating them. Several reflections highlighted that technological capability alone does not differentiate professionals; rather, judgment, agility, and critical evaluation remain essential. This observation aligns with concerns about industry-wide being averse to change and reinforces the need for engineers who can serve as change agents rather than passive adopters.

Project complexity was defined by larger scale, compressed schedules, and increased coordination demands. The emergence of the mega project is well-defined, but some of this reflection is influenced by the alumni experience, in which they report that the transition from intern to full-time is particularly abrupt, suggesting that they had not really been exposed to the projects in their entirety, which taints their perception. Alumni observations further suggest that additional experiential learning environments, such as the capstone experience, may help mitigate the steep learning curve typically encountered in industry during the first several years of employment. This remains an area that requires further investigation.

The alumni did not characterize the capstone experience as a failure, but their reflections indicate that emerging external constraints in the supply chain and stakeholder involvement prevail in today's market. These forces extend beyond the scenarios typically emphasized in capstone projects [4], which afford the opportunity to more intentionally unfold these complexities within the experiential learning environment.

Human-centered constraints, including labor shortages, generational differences, mentoring gaps, and evolving expectations around the definition of work, were consistently identified in shaping professional practice. Alumni reflections emphasized that technical solutions alone are not adequate. They reinforced the importance of adaptability, interpersonal awareness, and professional agility. Several alumni discussed safety, cementing it as a top priority not only as a technical concern but also as a cultural and behavioral concern closely tied to accountability, coordination, and organizational standards. Collectively, these reflections indicate that career readiness in construction practice depends as much on navigating human-centered constraints as on technical competence which reinforces the need for capstone experiences that introduce the cultural, behavioral, and interpersonal dimensions of professional work.

Collectively, these alumni reflections highlight that construction engineering capstone experiences fall short in preparing students for the complex human-centered constraints that characterize contemporary construction practice, and the need for capstone designs that better align experiential learning with evolving industry realities.

Closing the Feedback Loop Through Curricular Feedback and Continuous Improvement – Alumni recommendations for capstone improvement were enhancements that

increase realism, consequences, and integration. They suggested more deliberate engagement of the project life cycle, intentional introduction of consequential decision-making moments, and greater attention to the human dimension.

Specifically, alumni calls for increased realism and consequential decision-making imply important pedagogical considerations. Planned disruptions and higher-stakes scenarios may better simulate professional practice, but approaches like this introduce tensions related to student stress and emotional response within an academic environment. These dynamics suggest that implementing “curveballs” requires patience from the instructional team and careful scaffolding to balance challenge with support.

These collective reflections reveal that alumni are not asking for more tools but for improved, intentional experiences. Alumni emphasized across themes the mandate to strengthen professional judgment, agility, and self-awareness, often through higher-stakes, controlled exposure to uncertainty rather than expanding technical scope. These recommendations align with the broader experiential learning cycle, supporting the capstone experience framework and pointing toward curricular design as a motivation for sustained impact rather than content expansion.

Limitations and Future Research

This study is limited to alumni of a single Construction Engineering program and reflects the pedagogical structure of a single capstone model within a defined era (2017-2023). The interviews provide insight into how alumni interpret capstone learning in relation to early career development and evolving industry conditions but the analysis does not isolate specific refinements to the course across that same period. Additionally, it does not evaluate earlier instructional formations prior to this evolution. Future research may benefit from segmenting alumni perspectives by defined curricular eras to examine how pedagogical changes influence perceived career readiness outcomes. A comparative analysis across peer institutions with differing capstone models and levels of industry engagement would further clarify the transfer of these findings.

Further, the initial investigation for the author's broader research has yielded a focus on professional skills: communication, teamwork, and critical thinking (CTCt) as foundational to career readiness. This study has reinforced the focus; however, the alumni reflections suggest additional complementary professional skills to consider that would enhance the body of work including but not limited to professional judgment, adaptability, and emerging aspects of professional identity formation. Future investigation may examine how early-career engineers conceptualize and articulate critical thinking once immersed in professional practice and how experiential learning can support the growth of these characteristics in a sustainable manner. Additionally, including non-alumni practitioners could shed light on how alumni-derived feedback differs from external reviews and how these perspectives intersect to inform continuous improvement.

Conclusion

Alumni reflections across the interview sequence 1) baseline assessment of the undergraduate capstone experience, 2) translation of academic preparation into professional practice, 3) reflection through alumni industry experience, and 4) recommendations for continuous improvement collectively reinforce the enduring value of the capstone as an experiential learning environment. Alumni generally reported high satisfaction and perceived career readiness at the point of graduation, many of the most consequential learning outcomes became apparent only after sustained engagement in professional practice.

Across cohorts, alumni consistently described communication, teamwork, and critical thinking as integrated professional practices developed through authentic responsibility, constraint, and consequences rather than as isolated competencies. As alumni have encountered evolving industry conditions, including increased technology integration, project complexity, and human-centered constraints, they have been able to reflect on how capstone experiences have supported professional judgment, agility, and confidence.

Alumni recommendations for continuous improvement did not emphasize the need for additional technical content or exposure to specific software platforms. Their suggestions focused on how the capstone experience is structured and executed, encouraging greater integration across the project life cycle, increased exposure to consequential design-making, and deliberate efforts to focus on the human dimension of engineering practice. These insights suggest that alum value capstone not for the exposure to and competency with tools, but for its role in developing career-ready professionals through experiential learning.

By positioning alumni as reflective practitioners, this study extends the experiential learning cycle beyond the undergraduate classroom and re-engages industry as an active contributor to curricular improvement. As a result, these alumni reflections moved beyond identifying competencies as isolated outcomes toward describing how the capstone shaped professional ways of acting, thinking, and accepting responsibility. These reflections indicated that the impact of capstone extends not only to what students learn to do but also to how they begin to function and see themselves, contextually, as professional engineers.

In sum, the findings highlighted capstone's influence as both a culmination of undergraduate learning and a tool for continuous alignment between academic preparation and professional practice. By anchoring experiential learning in authentic, industry-informed reflection, capstone serves as a dynamic, agile framework that responds to evolving professional demands while preparing graduates for the complexity of the construction industry.

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