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Exploring the Connection Between Academic Preparation and Challenges Encountered During Early-Career Engineering Practice: A Single Case Study Development

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Introduction and Background

Engineering educators and researchers have increasingly argued that stronger connections are needed between engineering education and the realities of professional practice [1-5]. A key challenge, however, is that professional engineering work is not a single, uniform activity; research depicts it as heterogeneous, shaped by organizational structures, distributed expertise, and the social coordination required to realize engineering projects in real settings [4], [5]. A substantial body of research has examined professional engineering work and argues that technical outcomes emerge through socio-technical coordination rather than purely individual technical problem solving alone, positioning professional practice as deeply embedded in organizational life [4-7].

Despite extensive research on engineering work and education, the transition from engineering education into professional practice remains challenging for many early-career engineers [8], [9]. Engineering programs often promote technicist and idealized images of "real" engineering that underemphasize the social, organizational, and boundary-spanning dimensions of practice, leaving many newcomers with inaccurate or overly narrow expectations of professional work [8], [10]. Studies show that early-career engineers often come to recognize the extent to which their work involves coordination, negotiation, and navigating organizational and disciplinary boundaries rather than sustained technical analysis [8-12]. This disconnect can produce significant identity and socialization challenges, requiring newcomers to reinterpret what counts as engineering work and what it means to belong as an engineer, a process that contributes to dissatisfaction and early attrition when it is unsuccessful [13], [14].

Prior studies show that transitions into engineering practice remain difficult and that transfer from classroom to workplace is complex and not automatic, as graduates must reinterpret academic knowledge in organizational and social contexts [10-15]. However, less is known about how early-career engineers themselves interpret and compare the challenges encountered in undergraduate education and professional work, particularly how structured academic performance expectations are retrospectively understood in relation to the ambiguity, information seeking, and organizational negotiation that characterize practice.

To address this gap, this work-in-progress paper examines how an early-career engineer reflects on and compares the challenges encountered during undergraduate engineering education with those experienced in professional engineering work. Employing a qualitative case study approach [16], this paper provides a clear account of how school and work challenges were experienced, contrasted, and interpreted over time, contributing insight into how preparation for professional engineering practice is understood through early-career reflection. The paper specifically addresses the research question:

How does an early-career engineer compare the challenges encountered during undergraduate engineering education with those experienced in professional engineering work?

Theoretical Framework

This study adopts Schlossberg's transition theory [17] as a lens for analyzing the study's data. The theory conceptualizes transitions as inherently complex processes that unfold across multiple dimensions and emphasizes that individuals navigate transitions differently based on their personal characteristics and the contextual conditions surrounding the change [17].

Schlossberg's framework identifies four core components that shape how individuals experience and adjust to transitions: situation, self, support, and strategies. Situation focuses on the circumstances of the transition, including its triggers, timing, duration, perceived control, role changes, concurrent stressors, and prior experiences with similar transitions [17]. Support refers to the interpersonal and institutional resources available to the individual, such as relationships, family networks, communities, and organizations. Self encompasses psychological and personal resources, including identity, values, motivation, abilities, and resilience. Strategies describe the coping responses and actions individuals employ to manage the transition. Schlossberg's transition theory [17] is particularly useful for understanding how these components interact to shape transition experiences. Although Schlossberg's Transition Theory includes four interrelated components, this analysis focuses primarily on the 'situation' dimension to examine how the participant compared the structural conditions of academic and workplace challenges during the transition to professional practice.

Methods

This study employs a qualitative case study [16] design to examine how an early-career engineer reflects on the relationship between undergraduate engineering education and professional work experience. The analysis presented in this paper focuses on a single case drawn from a larger multiple-case study of eight early-career engineers that investigates how academic challenges compare with and influence professional experiences. Guided by Schlossberg's Transition Theory [17], the analysis explored how the participant reflected on the challenges he faced as an engineering student and how those experiences influenced his workplace experience. Focusing on a single case allowed for close analysis of how educational challenges were retrospectively interpreted in relation to workplace demands.

Participant. The participant, referred to by the pseudonym Terra, earned a Bachelor of Science degree in Engineering with a concentration in Electrical Engineering from a small, private, university in the Pacific Northwest. Terra's professional trajectory began with an engineering internship completed during undergraduate study. After graduation, he secured his first full-time engineering role in controls engineering and later transitioned into a firmware engineering role at a technology-oriented company specializing in hardware-software systems. Across these roles,

Terra accumulated approximately eight years of industry experience and at the time of this interview, he was between positions following the conclusion of his most recent engineering role.

This case was selected as an extreme case [18] for multiple reasons. While Terra's recent departure from professional engineering work provided an advantageous temporal position for reflection, the case was also distinguished by the unusually rich and extensive nature of the interview data. Compared to other participants in the larger study, Terra's interview was significantly longer and characterized by detailed, sustained reflection on relationships between undergraduate engineering education and professional engineering practice. Terra consistently articulated connections between academic challenges and workplace demands, making the case analytically "extreme" in terms of both timing and depth of reflective sensemaking.

Data Collection. Data were collected through multiple sources. The primary data source was a semi-structured interview designed to elicit reflection on undergraduate engineering experiences, job experience, and perceived academic and work challenges. The interview lasted for approximately 120 minutes and was conducted over Zoom. Interview questions encouraged comparisons between academic and workplace contexts and invited the participant to reflect on challenges, preparation, expectations, and workplace realities. Additional data sources included the participant's résumé and publicly available contextual information from the websites of the participant's university and employer.

Data Analysis. Data analysis followed an iterative qualitative process. The interview transcript was first reviewed in full to support familiarization with the participant's account. The participant's narrative was then coded to identify segments related to academic challenges and professional work experiences [19], [20]. Initial coding was guided by Schlossberg's Transition Theory [17], with attention to the situation being described, the role of self in that situation, the presence or absence of support, and the strategies used to respond to the situation. The section presented in this paper was analyzed with the 'situation' component of the theory. In addition, segments in which the participant reflected the relationship between undergraduate education and professional work were open coded to capture how these connections were described in the participant's own terms. Coding and interpretation were refined through repeated review of the transcript to ensure alignment with the participant's account.

Findings

The findings below describe how Terra compared the challenges encountered during undergraduate engineering education with those experienced in professional engineering work. Terra's reflections highlight contrasts in how challenges were structured, navigated, and interpreted across contexts.

Experiencing Academic Challenge as Structured and High-Pressure

When reflecting on his undergraduate engineering education, Terra described academic challenge as shaped by heavy workloads, clearly defined problems with right answers, high expectations for performance, and significant emotional strain associated with meeting those expectations. Terra characterized much of his undergraduate coursework as structured around clearly bounded problems, where success depended on identifying the correct solution using information provided through lectures, textbooks, and problem sets. He explained that academic tasks were typically designed with the assumption that the necessary information was contained within a limited set of sources, and that problems had a single correct answer. As Terra summarized, “In school, there is a solution, right?” This structure shaped how he approached learning, emphasizing correctness and completion over exploration or interpretation.

The intensity of academic challenge was compounded by a heavy workload and frequent assessment. Terra recalled semesters characterized by overlapping technical courses and recurring exams, which required continuous preparation and left little room for recovery. He described the effort required to keep up with these demands, noting that “it felt like I had to study six to fifteen hours for each of those tests.” The cumulative nature of this workload contributed to a sense that academic challenge was constant and unavoidable rather than episodic.

Beyond workload, Terra emphasized the pressure associated with navigating clearly defined academic performance expectations. He described experiencing persistent anxiety related to exams and grades, which he initially interpreted as a personal issue rather than as a response to contextual demands. Reflecting on this period, Terra explained, “I just thought I needed to be better. The only way to be better was to put in more effort.” As a result, he approached academic challenge primarily through increased effort and endurance, framing success as meeting the performance thresholds established by the program. Describing this orientation, Terra explained that academic success meant “meeting the bar,” adding that “college is really good at making you meet the bar.” Once that threshold was reached, relief rather than motivation followed, reinforcing an emphasis on endurance rather than sustained engagement beyond required performance.

Experiencing Workplace Challenge as Ambiguous and Organizational

When reflecting on workplace challenges, Terra described professional engineering challenges as less structured and more organizationally embedded. He explained that workplace tasks were often vague, incomplete, or underspecified, in contrast to the clearly defined problems he encountered through his education. Terra explained that he was frequently relied upon because of his broad skill set even though no one within the organization understood what the work actually entailed. According to him, those who assigned the tasks did not have the expertise to direct or define them. Instead of receiving detailed instructions, he was often given directives such as, “Here’s a thing. You have a skill set. Apply it.”

Terra noted that workplace challenges required navigating multiple, dispersed sources of information. Unlike academic settings, where relevant information was typically assumed to be contained within course materials, workplace problems involved consulting documentation, repositories, unfamiliar tools, and conversations with individuals across the organization. As he explained, “Any problem that you solve requires six different vectors of finding information,” often involving managers, project managers, IT personnel, documentation, and end users. The challenge, according to Terra, was not learning new technical tools, but recognizing that no single source provided a complete understanding of the problem.

Terra also emphasized that workplace challenges were inherently social and required ongoing negotiation to clarify intent and feasibility. He explained that understanding what was being asked often depended on conversations across multiple roles and levels within the organization, as engineers worked to determine why a task mattered, how it fit within existing systems, and what constraints shaped possible solutions. As he noted, “You have to talk to the project manager to try and understand what they actually intend.” In this context, challenges were not defined solely by technical difficulty but by the need to coordinate understanding across roles.

Organizational constraints further shaped Terra’s experience of workplace challenge. He described environments in which deadlines, cost considerations, and profit priorities frequently took precedence over careful planning or long-term system quality. Reflecting on these conditions, he explained that “deadlines and company profit is king,” emphasizing that engineers were often expected to deliver functional outcomes despite limited time, resources, or clarity. When Terra raised concerns about doing work “the right way,” he noted that such requests were often acknowledged but ultimately constrained by schedule and budget pressures: “We’d like to do that, but we can’t afford to.” In these contexts, engineers were expected to deliver functional outcomes despite recognizing that short-term solutions might create future challenges.

Reflecting Back: Reinterpreting Academic Preparation

When reflecting on his undergraduate education from the perspective of professional practice, Terra described a process of reinterpreting academic preparation as both partially enabling and partially misaligned with the realities of engineering work, with value becoming clearer only after entering the workplace. Terra explained that only a small subset of his undergraduate coursework felt directly essential to his professional roles. Looking back, he noted that there were only “a handful of classes” that he needed in order to function effectively at work, while much of the remaining coursework felt less relevant in hindsight. Terra expressed frustration with the breadth of required coursework, describing it as costly and inefficient, and suggested that deeper engagement with fewer technical areas might have been more beneficial. At the same time, he emphasized that he could not have known which knowledge would be most important until he had entered the workforce.

In contrast to more structured coursework, Terra identified open-ended projects as particularly valuable forms of preparation. He described the senior capstone project as more closely aligned with professional engineering work, noting that it required sustained engagement, navigation of uncertainty, and integration of multiple forms of knowledge. Terra explained that these experiences more closely resembled the kinds of challenges he later encountered at work, where problems were not clearly defined and solutions were not predetermined. Terra also reflected on how aspects of undergraduate challenge that he found unpleasant at the time later proved useful in professional contexts. In particular, he noted that managing heavy workloads and meeting deadlines in college helped prepare him for similar pressures in the workplace. Although he expressed ambivalence about this aspect of engineering work, Terra acknowledged that learning to operate under sustained pressure before being "paid to do it" made him better equipped to handle professional expectations.

At the same time, Terra described gaps in his preparation related to support, communication, and motivation. He noted that while he received sufficient support to secure an internship and enter the workforce, he wished there had been more guidance in navigating uncertainty, breaking down large problems, and understanding expectations earlier in the process. Terra also reflected on challenges related to confidence, self-promotion, and sustained motivation, suggesting that undergraduate education emphasized meeting defined performance thresholds rather than fostering learning as an ongoing practice. He explained that while college helped him "meet the bar," it did not cultivate the internal drive he observed in peers who continued to build skills and projects beyond required coursework.

Discussion

The findings from this study reinforce and extend prior research documenting differences between academic problem-solving and professional engineering practice [10], [21], [22]. Undergraduate engineering curricula tend to emphasize well-structured problems with pre-determined solutions, while professional engineering work more often involves ill-structured, open-ended problems embedded in social and organizational contexts [1], [23], [24]. The findings from this study align with this body of work, reinforcing that differences between school and work are a persistent feature of engineering preparation and practice.

Importantly, this study adds nuance by shifting attention away from whether challenges are "harder" in school or at work and toward how challenges are organized and experienced. Terra did not describe workplace problems as technically more demanding than academic ones. Instead, difficulty arose from determining what the problem was, why it mattered, and which constraints shaped possible solutions. This shift, from solving problems with known parameters to engaging in ongoing problem framing and sensemaking, highlights a central feature of professional engineering practice that has been documented in prior research but is often underemphasized in discussions of educational preparation.

These differences in the structure of challenge also shaped how Terra retrospectively interpreted academic difficulty. Rather than evaluating difficulty solely within the undergraduate experience, Terra drew on early-career work experience to reassess what those academic challenges had prepared him for. Prior research has shown that engineering curricula often define academic difficulty through heavy workloads, frequent assessment, and high achievement thresholds, implicitly framing performance under pressure as a marker of competence [25], [26], [27]. Terra's undergraduate experience reflected this model, where success was defined by meeting explicit benchmarks and enduring sustained pressure.

Rather than rejecting these experiences, however, Terra identified ways in which academic difficulty became useful in professional contexts, particularly in developing the capacity to manage workload, deadlines, and performance expectations under pressure. Caution is warranted, though. While such difficulty may acclimate students to the pace and intensity of engineering work, it does not necessarily prepare them for other defining features of practice such as articulating professional value, ongoing problem framing, information seeking, and navigating the social and organizational dimensions of engineering work that require different forms of judgment and support [3], [5], [28], [29]. At the same time, Terra's reflections align with research showing that students may come to equate competence with endurance, even when such expectations carry emotional and personal costs [27], [30], [31], [32]. Accordingly, critical attention must be paid to students' mental health and well-being: preparation that normalizes relentless pressure without parallel support for navigating ambiguity and sociotechnical complexity risks reinforcing harmful endurance scripts while leaving graduates underprepared for the interpretive, organizational, and relational demands of professional engineering.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the analysis focuses on a single early-career engineer drawn from a larger multiple-case study. While this case allows for in-depth examination of reflection and transition, the findings are not intended to be representative of all engineering graduates or professional contexts. Instead, the insights presented here highlight how one participant made sense of the relationship between his undergraduate education and professional work. Second, the findings rely on retrospective self-report. Terra's reflections were shaped by his accumulated professional experiences and the specific circumstances surrounding the interview, including being between positions at the time of data collection. As a result, his interpretations of undergraduate experiences may differ from how those experiences were understood at the time they occurred. Third, the study draws primarily on interview data, supplemented by résumé information and publicly available institutional context. Although these sources support contextualization, the analysis does not include direct observation of workplace practices or academic settings, nor does it incorporate perspectives from faculty, work supervisors, or peers. Future research could extend this work by integrating additional data sources and viewpoints.

Conclusion

This study examined how an early-career engineer reflected on the relationship between undergraduate engineering education and professional work experience, with particular attention to how academic challenges were reinterpreted after entering the workforce. Through an in-depth qualitative case study, the findings illustrate that academic preparation was experienced as neither wholly sufficient nor wholly misaligned with professional practice. Instead, Terra's reflections reveal a process of retrospective sensemaking in which the relevance of undergraduate experiences became clearer only through engagement with workplace challenges. Future work will extend this analysis across cases to examine how patterns in the structure of challenge, interpretations of difficulty, and experiences of support and constraint vary across individuals, institutional contexts, and workplaces.

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