From Compliance to Value Creation: Transforming an Engineering Course through the Entrepreneurial Mindset

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Engineering curricula that focus primarily on technical design are necessary but insufficient in a rapidly changing world. Graduates must also develop an entrepreneurial mindset (EM) that enables them to leverage their technical skills to identify opportunities and create value for stakeholders and society. This paper presents a case study of transforming an upper-division Construction Engineering course into an EM-rich learning experience. Supported by a Kern Entrepreneurial Engineering Network (KEEN)Fellowship, the course—retitled *Quality Management and Construction Communication*—was redesigned around the idea that quality is not only defect prevention but a disciplined search for opportunity and value creation, emphasizing the KEEN 3Cs framework (Curiosity, Connections, and Creating Value). Four integrated assignments operationalized this shift: (1) a KEEN Curiosity Library activity linking diverse readings to engineering practice; (2) a structured "future of construction" exploration to practice creative foresight; (3) real-world failure analyses to connect risk assessment and resilience; and (4) peer-teaching presentations on technical standards to build professional communication. Assessment combined pre/post surveys, rubric-based evaluations, and student reflections. Survey results from the Fall 2025 implementation indicate directional shifts in students' self-reported understanding of quality management and increased perceptions of curiosity, connections, and value creation.. Qualitative feedback revealed greater engagement, improved communication, and deeper understanding of how technical excellence contributes to societal impact. The paper discusses design rationale, assessment tools, and lessons learned to help other faculty embed entrepreneurial-mindset outcomes into existing engineering courses without sacrificing technical rigor. The findings demonstrate a scalable model for transforming traditional courses into platforms for creativity, professional growth, and value creation.

Keywords: Entrepreneurial Mindset, Course Transformation, KEEN Fellowship, Curiosity, Connections, Creating Value

1. Introduction

Engineering education has traditionally emphasized technical competence, analytical rigor, and design proficiency. While these elements remain essential, they are increasingly recognized as insufficient on their own in a rapidly changing technological, economic, and societal landscape. Engineers are now expected not only to solve well-defined technical problems, but also to recognize opportunities, integrate diverse forms of knowledge, communicate effectively with stakeholders, and create value for society under conditions of uncertainty and complexity. As a result, calls for reform in engineering education have increasingly emphasized the development of broader professional competencies, adaptive thinking, and mindset-oriented outcomes alongside technical skills.

One prominent response to this need has been the growing emphasis on the **entrepreneurial mindset (EM)** in engineering education. The entrepreneurial mindset, as articulated in engineering contexts, does not primarily refer to venture creation or business formation, but rather to a way of thinking characterized by curiosity, opportunity recognition, systems-level connections, and value creation for stakeholders. Organizations such as KEEN (Kern

Entrepreneurial Engineering Network) have played a central role in advancing this perspective, encouraging faculty to embed entrepreneurial thinking across engineering curricula rather than confining it to standalone entrepreneurship courses. KEEN's framework (Johnson et. al., n.d.) emphasizes three core dimensions—**Curiosity, Connections, and Creating Value**—as foundational habits of mind for engineers operating in real-world contexts.

1.1 Entrepreneurial mindset in engineering education

A growing body of literature supports the integration of entrepreneurial mindset outcomes into engineering programs (Bosman and Phillips, 2022; Huang-Saad, 2009; Ricco, 2020) . Studies have shown that EM-oriented pedagogies can improve students' ability to identify opportunities, think creatively, engage in lifelong learning, and better understand the societal impact of engineering work (Duval-Couetil et al., 2016; Kriewall & Mekemson, 2010). Entrepreneurial mindset development has also been linked to improved student engagement and motivation, particularly when learning activities are framed around authentic, open-ended problems rather than narrowly constrained technical exercises (Byers et al., 2013).

Importantly, prior research has emphasized that entrepreneurial mindset is not discipline-specific and should not be treated as an "add-on" skill set. Instead, it can be cultivated through thoughtfully designed learning experiences embedded within core engineering courses (Duval-Couetil et al., 2012; Shartrand et al., 2012). This approach aligns with broader shifts in engineering education toward outcomes-based learning, professional skills development, and alignment with ABET student outcomes related to communication, ethics, and societal context (ABET, 2023).

1.2 Course transformation and pedagogical strategies

Course transformation efforts aimed at developing entrepreneurial or innovation-oriented thinking often leverage active learning, project-based learning, case studies, and reflective practices. Prior studies have documented the effectiveness of integrating real-world case analyses, open-ended design challenges, and interdisciplinary content to support systems thinking and professional judgment (Prince & Felder, 2006; Graham, 2018). In particular, failure case studies have been shown to promote deeper understanding of risk, ethics, and responsibility in engineering practice (Petroski, 2012), while peer-teaching and presentation-based activities can significantly enhance communication skills and conceptual understanding (Felder & Brent, 2016).

More recently, some engineering educators have explored creative and speculative approaches—such as future-oriented scenarios or narrative-based exercises—to encourage imaginative thinking and broaden students' perspectives on technological change (Daly et al., 2014). These approaches align with calls to prepare engineers for ambiguity and complexity rather than exclusively deterministic problem-solving.

1.3 Quality management as an underexplored vehicle for entrepreneurial mindset

Quality management has long been conceptualized in management and organizational scholarship as more than inspection or defect prevention. Foundational thinkers such as Deming (1986) and Juran (1992) emphasized quality as a systemic approach to continuous improvement, customer satisfaction, and long-term organizational value. Subsequent developments in Total Quality Management (TQM) and related frameworks further positioned quality as a strategic mechanism for enhancing competitiveness and stakeholder value (Evans & Lindsay, 2017). Within professional quality organizations such as the American Society for Quality (ASQ), quality is routinely framed as an integrative management philosophy rather than a narrow compliance function.

However, while quality-as-value is well established in management and industry practice, its pedagogical framing within engineering education—particularly in construction engineering curricula—remains less documented at the course level**.** In many engineering programs, quality-related content is introduced through topics such as inspection procedures, standards compliance, safety requirements, and defect reduction. Although these elements are essential, they may inadvertently reinforce a procedural or compliance-oriented view of quality unless intentionally connected to broader systems thinking and value creation.

Recent engineering education scholarship has increasingly explored the integration of entrepreneurial mindset principles into design courses, capstone experiences, and innovation-focused curricula (Duval-Couetil et al., 2016; Shartrand et al., 2010). These efforts often emphasize creativity, opportunity recognition, and value creation in product development or venture contexts. However, comparatively fewer studies have documented the transformation of required, non-design technical courses into entrepreneurial-mindset-centered learning environments, particularly in areas traditionally perceived as compliance-driven.

In construction engineering education specifically, quality management courses are frequently structured around standards, inspection protocols, liability, and documentation practices. While these components are essential to professional competence, there is limited published evidence describing how such courses can be intentionally reframed to position quality as a strategic driver of stakeholder value, resilience, and long-term project performance. Moreover, empirical documentation of how students respond to such reframing, particularly within required upper-division courses, remains sparse.

This study addresses that gap by documenting the intentional redesign of a required Construction Quality Management course into an entrepreneurial-mindset-centered experience. Rather than treating quality solely as conformance to specifications, the redesigned course positions quality as a disciplined approach to identifying opportunities, managing risk, and creating value for clients, organizations, and society. By situating this transformation within both the quality management tradition and the KEEN entrepreneurial mindset framework, this work contributes to emerging scholarship on scalable, discipline-integrated approaches to mindset development in engineering education.

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1.4 Purpose and objectives of this study

To address these gaps, this paper presents a case study of transforming an upper-division Construction Engineering course from a traditionally lecture-based, compliance-oriented structure into an entrepreneurial-mindset-rich learning experience. The transformation was supported by an KEEN Fellowship and intentionally guided by KEEN's entrepreneurial mindset framework. The course was redesigned around the central premise that quality is not only defect prevention, but a disciplined search for opportunity and value creation.

The specific objectives of this study are to:

1. **Describe the design rationale and structure** of a transformed quality management course that embeds entrepreneurial mindset outcomes within required technical content.
2. **Document instructional strategies and assignments** that operationalize Curiosity, Connections, and Creating Value in a non-design engineering course.
3. **Assess student perceptions and learning outcomes** related to entrepreneurial mindset development using surveys, rubrics, and reflective feedback.
4. **Identify lessons learned and transferable insights** to support other faculty seeking to integrate entrepreneurial mindset outcomes into existing engineering courses without sacrificing technical rigor.

By focusing on a required, upper-division course outside the typical entrepreneurship or design context, this study contributes to the growing literature on scalable, discipline-integrated approaches to entrepreneurial mindset development in engineering education.

2. Study Design and Methodology

This study employs a course transformation case study approach, consistent with principles of design-based educational research, to document and examine the redesign of an upper-division engineering course into an entrepreneurial-mindset-centered learning experience. Design-based educational research emphasizes the study of intentionally designed instructional interventions implemented in authentic educational contexts, with the goal of generating practical and transferable design knowledge rather than establishing causal relationships (Brown, 1992; Design-Based Research Collective, 2003). Accordingly, the purpose of the methodology in this study is not to test hypotheses or infer causality, but to transparently describe the instructional design logic, implementation, and evidence used to assess perceived learning outcomes associated with the course transformation. The Study Design Overview shown is in Figure 1 and is explained in the remainder of this section.

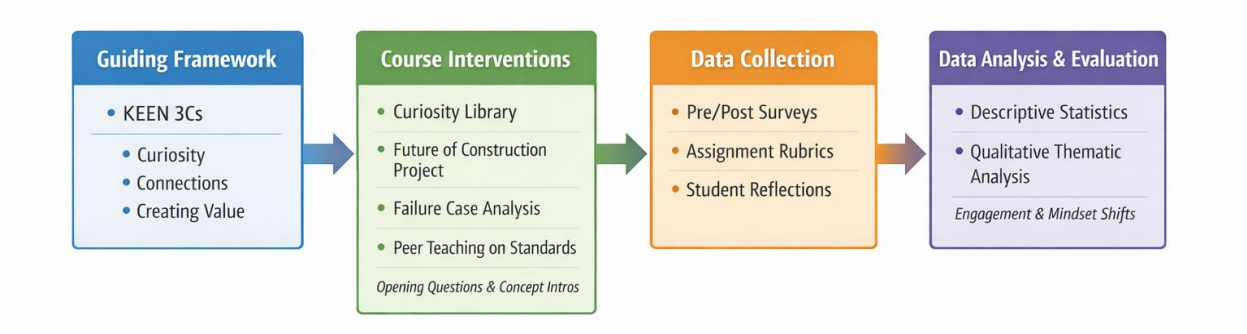

Figure 1: Study Design Overview

2.1 Guiding Framework

The course redesign was guided by the KEEN entrepreneurial mindset framework, which emphasizes three interrelated dimensions: Curiosity, Connections, and Creating Value. These dimensions served as the conceptual foundation for all instructional decisions and assessment strategies in the transformed course.

A central guiding principle of the redesign was the intentional reframing of quality management. Rather than presenting quality primarily as inspection, defect prevention, or compliance with standards, the course was structured around the idea that quality represents a disciplined and systematic search for opportunity and value creation. This reframing aligns naturally with entrepreneurial mindset thinking and positions quality management as a strategic engineering function rather than a procedural obligation.

In addition to informing major assignments, the guiding framework shaped recurring instructional practices throughout the semester. Short opening questions and concept introductions were used at the beginning of class sessions to prime curiosity, surface assumptions, and connect technical topics to broader professional, ethical, and societal contexts. Together, these elements established a consistent mindset-oriented learning environment rather than isolated entrepreneurial activities.

2.2 Course Interventions

The Course Interventions component of Figure 1 represents the primary mechanisms through which the guiding framework was operationalized. The redesigned course integrated four major instructional interventions, intentionally balanced between creative exploration, analytical rigor, and professional communication, along with a recurring instructional practice.

First, curiosity-driven exploration was fostered through the *Exploring the World Through Books* assignment, which leveraged a KEEN Curiosity Library to expose students to diverse perspectives beyond traditional engineering texts. Students selected readings and articulated connections between those ideas, engineering practice, and societal impact. This assignment served as an early entry point for entrepreneurial thinking and lowered resistance to nontraditional forms of learning within a technical course.

Second, creative foresight and systems thinking were developed through a structured *Science Fiction Exploration* focused on the future of construction. Students were asked to imagine plausible future scenarios involving emerging technologies, materials, or practices and to consider their implications for quality, sustainability, and decision-making. This intervention encouraged students to engage productively with uncertainty and long-term consequences.

Third, analytical and integrative thinking was emphasized through a *Quality Failure Analysis* assignment. Students investigated real-world construction failures, examined technical and organizational causes, assessed consequences related to risk and liability, and extracted lessons learned. This assignment connected quality management concepts to professional responsibility, resilience, and societal impact.

Fourth, professional communication and peer learning were addressed through *Standards Presentation* assignments. Students researched construction-related standards and taught their peers about the purpose, application, and limitations of those standards. This intervention positioned communication as a core engineering skill and reframed standards as decision-support tools rather than static compliance documents.

Collectively, these interventions were sequenced and integrated to reinforce the entrepreneurial mindset throughout the semester rather than concentrating it in a single activity.

2.3 Data Collection

The Data Collection component of Figure 1 summarizes the sources of evidence used to evaluate the perceived impact of the course transformation. Multiple data sources were employed to capture both quantitative and qualitative perspectives.

The primary data source for this study was an end-of-semester student survey administered at the conclusion of the Fall 2025 course offering. The Fall 2025 course enrollment included 11 students, of whom 10 completed the end-of-semester survey, resulting in a 90.9% response rate. The survey included:

- retrospective pre/post self-assessment items aligned with the KEEN 3Cs,
- assignment-specific questions addressing the four major interventions and opening questions,
- and open-ended prompts inviting reflection on learning experiences and perceptions of quality.

A retrospective pre/post format was intentionally selected to allow students to reassess their prior understanding after completing the course, particularly for constructs such as quality, value creation, and systems thinking that may not be well defined at course entry.

Additional contextual evidence was drawn from rubric-based evaluations of major assignments and open-ended written responses, which provided qualitative insight into student engagement, communication development, and mindset shifts. This paper focuses primarily on the survey data, with other sources used to support interpretation.

Participation in the survey was voluntary and anonymous. Data reported here reflect responses from ten students enrolled in the Fall 2025 offering of the course.

2.4 Data Analysis & Evaluation

The Data Analysis & Evaluation component of Figure 1 represents the final stage of the study design. Given the exploratory nature of the study and the small sample size, analysis was conducted using descriptive and qualitative methods.

Quantitative survey responses were analyzed using descriptive statistics, including response distributions and directional shifts between retrospective pre- and post-course self-assessments. No inferential statistical analyses were conducted, and results are interpreted as indicative rather than generalizable.

Qualitative responses were analyzed using thematic synthesis. Responses were reviewed iteratively to identify recurring patterns related to curiosity, connections, value creation, engagement, and students' conceptualization of quality management. Representative excerpts were selected to illustrate key themes and to contextualize the quantitative findings.

All results are presented as preliminary and context-specific, consistent with the goals of a course transformation case study rather than an experimental evaluation.

3. Results

This section presents descriptive findings from the Fall 2025 implementation of the redesigned CONE 330 course. Results are organized to reflect the study objectives and the structure of the instructional design, with particular attention to students' reported perceptions related to Curiosity, Connections, and Creating Value, as well as their conceptualization of quality management. Findings are based primarily on end-of-semester survey responses (n = 10), supplemented by open-ended student reflections. Given the small sample size, analyses are descriptive and exploratory in nature. No inferential statistical tests were conducted, and findings should not be interpreted as statistically generalizable.

3.1 Shifts in Students' Conceptualization of Quality

One of the central goals of the course transformation was to reframe quality management from a narrow focus on inspection and defect prevention toward a broader understanding of quality as a strategic, value-oriented practice. Survey results indicate a directional shift in how students conceptualized quality over the course of the semester (Figure 2).

Prior to the course, most students reported neutral to statements framing quality primarily as defect detection and defect prevention. After the course, responses shifted away from agreement with this framing, with several students reporting neutral or disagree responses. In contrast, agreement with statements framing quality management as a strategic approach to value creation increased in the retrospective post-course responses.

Open-ended responses reinforce this shift. Students frequently referenced learning from failures, systems-level thinking, and broader organizational or societal implications when asked what most changed how they think about quality. Rather than focusing solely on inspection activities, students described quality as something that influences decision-making, risk, and long-term project outcomes.

These patterns suggest that the redesigned course might have contributed to a broader and more integrative understanding of quality management, consistent with the guiding framework of the transformation.

Figure 2. Students' Perception of Quality before and after the course

3.2 Evidence of Curiosity Development

Survey items related to curiosity examined students' willingness to explore ideas beyond technical content, engage with unfamiliar perspectives, and reflect on course material outside of formal class time.

Students reported strong agreement that activities such as the Exploring the World Through Books assignment, science fiction exploration, and opening questions exposed them to new ways of thinking and encouraged reflection beyond traditional engineering topics. Several students indicated that they continued thinking about opening questions, book ideas, or speculative scenarios outside of class, suggesting sustained cognitive engagement (Figure 3).

Qualitative responses illustrate this pattern. Students referenced specific books, stories, or opening prompts that challenged their assumptions, helped them see engineering from a different perspective, or motivated them to think more deeply before formal instruction began. These

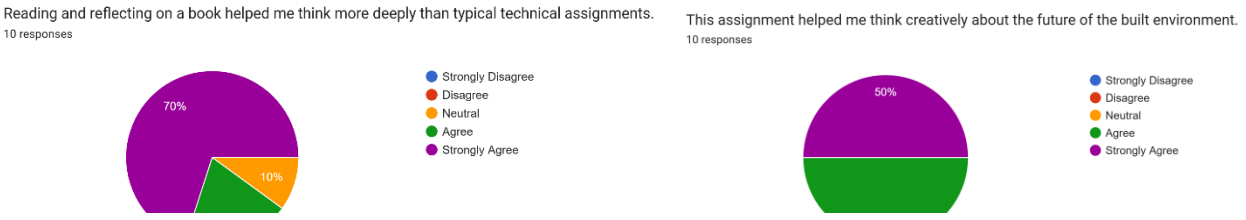

Figure 3. Students' reflections on the creative assignments

reflections indicate that curiosity-driven activities were not perceived as peripheral, but as meaningful components of the learning experience.

3.3 Evidence of Connections Between Technical and Non-Technical Concepts

A second objective of the course redesign was to help students build **connections** between technical engineering content and non-technical ideas, such as ethics, communication, organizational behavior, and societal impact.

Survey results show high levels of agreement with statements indicating that the course helped students see how non-technical ideas relate to engineering practice (Figure 4). Students also reported that assignments and class discussions encouraged them to integrate information from multiple sources, including readings, case studies, peer presentations, and real-world examples.

Open-ended responses provide concrete examples of these connections. Students described linking concepts from books on habits, mindset, leadership, or psychology to construction management practices, teamwork, and professional decision-making. Others highlighted connections between historical failures, standards, and modern project management challenges.

These findings suggest that the combination of creative, analytical, and professional communication–focused assignments supported integrative thinking, aligning with the "Connections" dimension of the entrepreneurial mindset framework.

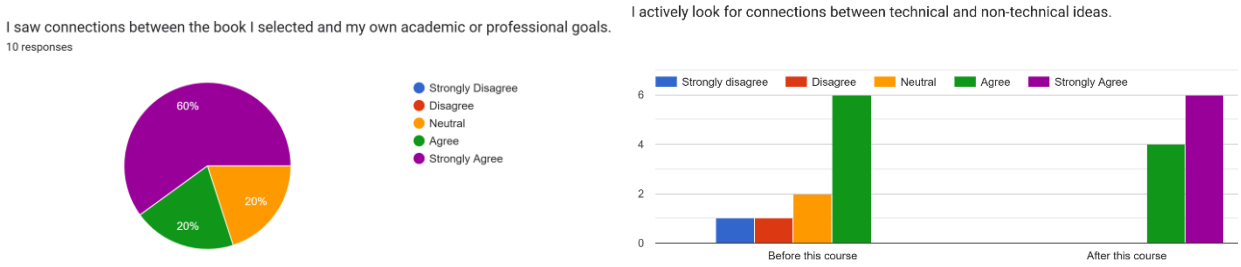

Figure 4. Evidence of Connections Between Technical and Non-Technical Concepts

3.4 Evidence of Creating Value and Professional Awareness

The Creating Value dimension of the entrepreneurial mindset was reflected in students' perceptions of how the course influenced their understanding of professional impact, stakeholder needs, and decision-making.

Students reported that assignments such as the quality failure analysis and standards presentations helped them understand the consequences of engineering decisions and the importance of clear communication. Survey responses indicate that students viewed these activities as relevant to professional practice rather than purely academic exercises (Figure 5).

When asked which assignments should be retained in future offerings, students most frequently identified the book exploration and science fiction assignments, citing their uniqueness,

relevance, and ability to broaden perspectives. At the same time, students recognized the value of analytically demanding assignments, particularly those involving real-world failures and standards.

Together, these responses suggest that students perceived value not only in technical accuracy, but also in communication, foresight, and stakeholder-oriented thinking—key elements of value creation in engineering contexts.

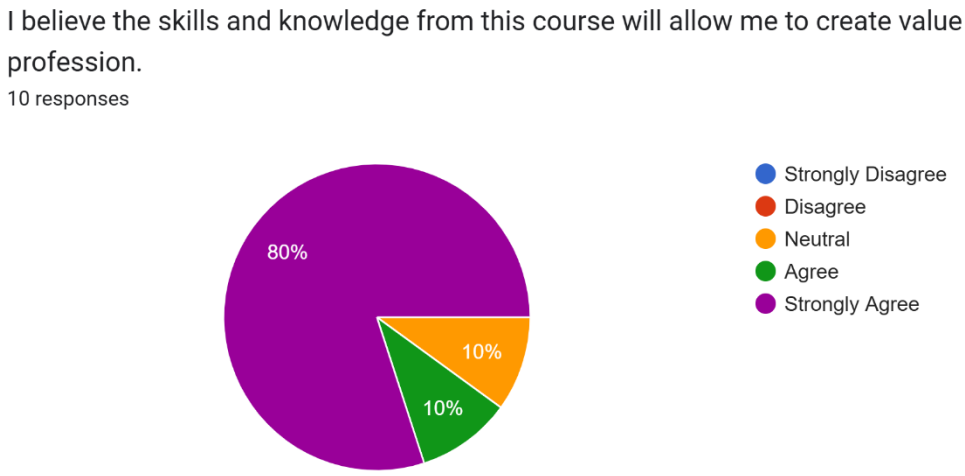

Figure 5. Evidence of Creating Value and Professional Awareness

3.5 Student Engagement and Perceptions of the Learning Environment

Across multiple survey items, students reported that the redesigned course structure contributed to a more engaging learning environment. High levels of agreement were observed for statements indicating that the mix of assignments, opening questions, and peer interaction made the course more interactive and intellectually stimulating than traditional lecture-based formats.

Although some students noted time constraints or suggested refinements to specific assignments, overall feedback emphasized engagement, variety, and relevance. Several students explicitly commented on the uniqueness of the course design compared to other engineering courses, highlighting the balance between creativity and professional rigor.

4. Conclusion

This paper presented a case study of transforming an upper-division engineering course into an entrepreneurial-mindset-centered learning experience through intentional instructional design. Guided by the KEEN entrepreneurial mindset framework, the redesigned course reframed quality management from a compliance-focused activity toward a broader conception of quality as a strategic process for value creation. The transformation integrated creative, analytical, and professional communication–focused interventions while maintaining core technical content.

Results from the Fall 2025 implementation provide **preliminary evidence** that the redesigned course supported meaningful shifts in students' perceptions and learning experiences. Students reported broader conceptualizations of quality, increased curiosity and reflection, stronger connections between technical and non-technical considerations, and heightened awareness of professional value creation. Collectively, these findings suggest that entrepreneurial mindset principles can be embedded effectively within a required, non-design engineering course when instructional activities are intentionally aligned with mindset outcomes.

4.1. Implications for Engineering Education

The findings of this study have several implications for engineering education practice. First, they demonstrate that entrepreneurial mindset development does not require standalone entrepreneurship courses or major curricular restructuring. Instead, mindset-oriented learning can be integrated into existing required courses through targeted design decisions, creative assignments, and reflective instructional practices. Second, the study highlights the potential of reframing traditionally compliance-oriented subjects—such as quality management—as opportunities for value creation, systems thinking, and professional judgment. Finally, the alignment between guiding framework, interventions, and assessment provides a transferable model that other instructors can adapt across engineering disciplines.

4.2. Limitations

This study is subject to several limitations. The findings are based on a single course offering at one institution and rely on a small sample of student responses. Data were collected using self-reported, retrospective pre/post survey items, which capture perceptions rather than direct measures of learning. Additionally, while data from other course offerings were collected, this paper reports only on the Fall 2025 dataset that was digitized and available at the time of analysis. As a result, findings should be interpreted as exploratory and context-specific rather than generalizable.

4.3. Future Work

Future work will focus on expanding data collection across multiple semesters and course modalities to examine the consistency of observed patterns over time. Additional analyses may incorporate direct performance measures, longitudinal tracking, or comparative designs to further explore the relationship between instructional design choices and entrepreneurial mindset development. Future iterations of the course will also refine assignments and assessment instruments based on student feedback and observed outcomes. Together, these efforts aim to contribute to a growing body of evidence on scalable, discipline-integrated approaches to entrepreneurial mindset education in engineering.

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