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Cultivating Curiosity, Connections, and Value: A Scaffolded Engineering Economic Analysis Module to Foster Entrepreneurial Mindset

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Abstract

This study examines the design, implementation, and evaluation of a scaffolded, project-based module in an undergraduate Engineering Economic Analysis course intended to cultivate the entrepreneurial mindset (EM) through the KEEN constructs of Curiosity, Connections, and Creating Value. Students engaged in authentic, team-based decision challenges requiring definition of real engineering economic problems, investigation of multiple alternatives, and application of present worth, equivalent uniform annual worth, and internal rate of return to justify value-generating recommendations for stakeholders. A sequential explanatory mixed-methods design combined pre/post EM surveys with rubric-scored project reports and structured reflections to assess changes in EM-related dispositions and practices. Quantitative results showed small positive gains in Curiosity (Δ = +0.17, Cohen's $dz = 0.23$) and Connections (Δ = +0.14, $dz = 0.19$), with Creating Value remaining high from baseline, suggesting a ceiling effect rather than lack of impact. Qualitative analysis of artifacts and reflections indicated that students increasingly framed open-ended economic questions, integrated technical and stakeholder considerations, and articulated multi-dimensional value trade-offs in their recommendations. Collectively, these findings provide evidence that a scaffolded engineering economy project can foster EM-aligned behaviors without sacrificing analytical rigor and offer design principles for embedding entrepreneurial mindset development into core sophomore-level engineering courses.

1. Introduction

Engineering graduates are increasingly expected to operate in environments characterized by uncertainty, competing constraints, and rapidly evolving stakeholder needs. Beyond technical competence, engineers must demonstrate curiosity in problem framing, the ability to connect technical analysis with contextual considerations, and the capacity to create value through informed decision-making. These expectations have motivated growing interest in cultivating an entrepreneurial mindset (EM) within engineering curricula, particularly through instructional approaches that integrate opportunity recognition, systems thinking, and value creation into core technical courses [1][2].

While EM integration has been widely explored in first-year design experiences, capstone projects, and stand-alone entrepreneurship courses, its incorporation into analytically rigorous sophomore-level engineering courses remains underexplored. Engineering economics, in particular, offers a natural yet underutilized venue for EM development. The course sits at the intersection of technical feasibility, economic viability, and decision-making under constraints, conditions that closely mirror authentic engineering practice. However, engineering economics is often taught as a procedural, tool-centric subject, limiting opportunities for students to engage in inquiry, contextual synthesis, and value-driven reasoning.

This study responds to this gap by examining a scaffolded engineering economic analysis module intentionally designed to cultivate the three core EM constructs, Curiosity, Connections, and Creating Value, within a sophomore-level engineering economics course. Guided by constructivist learning principles and value-creation theory, the module sequences inquiry-driven activities, integrative analyses, and reflective assessments to support progressive EM development across the course timeline.

1.1 Problem Statement

Despite the prominence of EM in engineering education discourse, empirical evidence on EM integration within sophomore-level engineering economics courses remains limited. Existing studies primarily focus on early curricular touchpoints or culminating design experiences, leaving a gap in understanding how EM can be systematically developed within core analytical courses that emphasize quantitative rigor. Furthermore, few studies employ mixed-methods designs that triangulate self-reported EM growth with performance-based artifacts and student perceptions.

As a result, instructors lack evidence-based guidance on how to embed EM into engineering economics without sacrificing analytical depth, and researchers lack insight into how students experience and demonstrate EM within this instructional context. Addressing this gap is essential for advancing both EM theory and instructional practice in engineering education.

1.2 Entrepreneurial Mindset and the 3 Cs

Within the KEEN framework, entrepreneurial mindset is conceptualized through three interrelated constructs. Curiosity reflects a disposition toward questioning assumptions, exploring uncertainty, and framing problems beyond given parameters. Connections involve integrating knowledge across technical, economic, societal, and stakeholder domains to inform decision-making. Creating Value emphasizes the ability to generate solutions that deliver economic, social, or professional benefit to defined stakeholders.

Rather than viewing these constructs as isolated outcomes, this study adopts a developmental perspective, wherein curiosity-driven inquiry enables deeper connections, which in turn support defensible value creation. Engineering economic analysis, when embedded within authentic decision contexts, provides a fertile environment for cultivating this progression, as students must navigate trade-offs, justify assumptions, and articulate value propositions grounded in quantitative analysis.

1.3 Study Purpose and Research Questions

The purpose of this study is to investigate the impact of a scaffolded engineering economic analysis module on students' entrepreneurial mindset development, with particular attention to Curiosity, Connections, and Creating Value. Using a sequential explanatory mixed-methods design, the study examines both measurable changes in EM and qualitative evidence of EM enactment within student work. The study is guided by the following research questions:

- **RQ1:** How does the EM module influence students' self-reported Curiosity, Connections, and Creating Value?
- **RQ2:** How do students demonstrate the three EM constructs within project artifacts?
- **RQ3:** What are students' perceptions of learning gains and challenges associated with the EM module?

1.4 Significance and Contributions

This study makes several contributions to engineering education research and practice. First, it extends the EM literature by providing empirical evidence of EM development within a sophomore-level engineering economics course, an instructional context that has received comparatively little attention. Second, the study demonstrates how intentional scaffolding can support EM growth while preserving analytical rigor, offering a replicable instructional model for engineering educators. Third, by integrating quantitative survey data with artifact analysis and student reflections, the study contributes a methodologically robust mixed-methods approach to EM assessment.

Collectively, these contributions support a broader re-conception of engineering economics as not only a technical decision-analysis course, but also a powerful platform for cultivating entrepreneurial engineers capable of curiosity-driven inquiry, integrative reasoning, and value-centered decision-making.

2. Literature Review

2.1 Entrepreneurial Mindset in Engineering Education

Entrepreneurship education has increasingly emphasized pedagogical approaches that move beyond content transmission toward experiential, context-rich learning environments that cultivate entrepreneurial mindset, opportunity recognition, and value creation. Over the past two decades, engineering education has increasingly emphasized EM as a complement to technical competence, reflecting employer and societal demands for engineers who can navigate ambiguity, integrate diverse forms of knowledge, and create value across economic, social, and environmental contexts. Within the Kern Entrepreneurial Engineering Network (KEEN), EM is commonly conceptualized through the three Cs—Curiosity, Connections, and Creating Value—framing entrepreneurship as a way of thinking rather than solely venture creation [1].

Despite broad agreement on the importance of EM, the literature highlights persistent challenges in definition, alignment, and assessment. Larsen's typology of entrepreneurial mindset conceptualizations identifies multiple dominant interpretations—ranging from opportunity recognition to broader life-orientation perspectives—underscoring the need for instructional coherence between learning objectives and pedagogical strategies [2]. This lack of conceptual clarity has made it difficult for engineering educators to intentionally embed EM into analytically rigorous courses, such as engineering economy, without diluting technical depth.

2.2 Problem-Based Learning in Entrepreneurship Education

Among pedagogical approaches for EM development, problem-based learning (PBL) has emerged as a dominant instructional strategy for integrating entrepreneurship within engineering and STEM curricula, owing to its alignment with real-world problem solving, interdisciplinarity, and learner agency [1][4]. Recent systematic and bibliometric reviews indicate sustained growth in PBL applications across entrepreneurship education contexts. Raimundo and Rosário [4] identified over 140 empirical and conceptual studies published between 2002 and 2024 demonstrating that PBL supports the development of entrepreneurial attitudes, motivation, teamwork, communication skills, and opportunity identification. Their review highlights that PBL is particularly effective when students engage with authentic, ill-structured problems drawn from real or simulated entrepreneurial contexts, reinforcing the connection between theory and practice.

Within engineering education, PBL has been shown to enhance students' ability to navigate uncertainty, frame problems holistically, and integrate technical and non-technical considerations, competencies foundational to entrepreneurial practice. Studies examining challenge-based and project-based variants of PBL report gains in creativity, financial literacy, and multidisciplinary collaboration, with increased entrepreneurial intention among participants exposed to sustained problem-driven learning experiences [4].

2.3 Entrepreneurially Minded Learning and Scaffolded Pedagogy

Entrepreneurially Minded Learning (EML) emphasizes active, contextualized learning experiences that engage students in opportunity discovery, stakeholder awareness, and value creation while reinforcing disciplinary content. Studies of first-year and introductory engineering courses demonstrate that project-based and design-build experiences provide fertile ground for cultivating EM traits, particularly when students work within constraints, interact with users, and justify design decisions economically [3][6].

However, EM development does not occur automatically through projects alone. Jensen and Schlegel [3] demonstrate that while students readily engage with customer interviews and budgeting activities, explicit scaffolding is required to move learners beyond surface-level validation toward deeper opportunity recognition and value analysis. Similarly, Bosman and Phillips [5] emphasize the role of intentional scaffolds, reflection, and alignment between learning outcomes and assessment in ensuring that EM outcomes such as lifelong learning and "seeing value" are realized.

These findings suggest that EM is best developed through structured sequences of learning activities that progressively increase cognitive demand—an approach particularly well-suited to engineering economic analysis, where students must integrate technical feasibility, financial viability, and contextual judgment.

2.4 Engineering Education Reform and Contextual Learning

The growing adoption of PBL in entrepreneurship education aligns with broader calls to reshape engineering education in response to complex societal, technological, and economic challenges. Contemporary scholarship argues that traditional engineering curricula overemphasize analytical problem solving at the expense of problem framing, systems thinking, and human-centered design [7]. PBL is positioned not merely as a pedagogical technique but as a structural mechanism for embedding complexity, stakeholder engagement, and value creation into engineering learning environments [4].

Kolmos and colleagues [4] emphasize that PBL supports a shift from disciplinary silos toward integrated, systems-oriented learning, enabling students to grapple with sociotechnical challenges that mirror entrepreneurial ecosystems. This perspective reinforces earlier work in engineering education scholarship that frames engineering practice as inherently contextual, value-laden, and socially embedded rather than purely technical [8].

2.5 Engineering Economics as a Vehicle for Entrepreneurial Mindset

Engineering economy courses traditionally emphasize deterministic tools such as time-value-of-money, cost estimation, and decision criteria. While analytically rigorous, these courses are often perceived by students as abstract or disconnected from real-world decision-making. Recent literature argues that embedding engineering economics within authentic, open-ended decision contexts can enhance both conceptual understanding and entrepreneurial thinking.

Project-based and case-driven approaches in entrepreneurship education demonstrate that economic analysis becomes more meaningful when students must justify decisions under uncertainty, compare alternatives with incomplete information, and articulate value propositions to multiple stakeholders [9][10]. These approaches align closely with the entrepreneurial mindset's emphasis on curiosity-driven inquiry, systems-level connections, and value creation beyond cost minimization.

Moreover, the integration of sustainability, ethics, and social responsibility into technical decision-making further reinforces EM outcomes. Studies incorporating sustainability frameworks and ethical case analysis show that students develop stronger judgment, moral imagination, and appreciation for trade-offs when economic decisions are situated within broader socio-technical systems [11]. Such integrations support the notion that engineering economic analysis can serve as a central integrative hub linking technical, societal, and entrepreneurial considerations.

2.6 Reflection, Metacognition, and Value Recognition

A recurring theme across the EM literature is the importance of reflection and metacognition in consolidating learning. Reflective portfolios and structured reflection prompts have been shown to enhance students' ability to articulate learning gains, recognize value creation opportunities, and regulate their own learning processes [12][5]. Reflection enables students to move beyond procedural competence toward deeper understanding of why economic tools matter and how they inform real engineering decisions.

In multidisciplinary and ethics-integrated contexts, reflection also supports the development of connections across domains, helping students synthesize technical analysis with human, environmental, and organizational factors [12][13]. These findings reinforce the value of incorporating reflective elements into scaffolded EM modules embedded within analytically intensive courses.

2.7 Summary and Positioning of the Present Work

The reviewed literature converges on several key insights: (1) entrepreneurial mindset development requires intentional instructional design; (2) scaffolded, project-based learning enhances curiosity, connections, and value recognition; and (3) engineering economic analysis offers a powerful yet underutilized context for EM integration. While prior studies document EM interventions in first-year design, capstone, and standalone entrepreneurship courses, fewer have examined systematic, scaffolded EM integration within core analytical courses such as engineering economy.

Despite strong evidence supporting PBL in entrepreneurship education, prior studies frequently focus on **single-course interventions**, self-reported outcomes, or short-term implementations. There remains a need for empirically grounded work that examines **scaffolded, course-embedded entrepreneurship modules**, explicitly links pedagogical design to entrepreneurial mindset constructs, and documents learning outcomes using multiple forms of evidence.

Table 1 synthesizes the reviewed literature by mapping representative sources to the KEEN entrepreneurial mindset constructs and aligns each construct with specific activities, assessments, and scaffolding strategies implemented in the present engineering economic analysis module. This alignment clarifies how established EM theory informed the instructional design choices examined in this study.

Table 1: Synthesis of Entrepreneurial Mindset Literature and Alignment to Module Design

EM Construct	**Key Instructional Emphases**	**Representative Sources**	**Alignment to Module Design**
Curiosity	Opportunity recognition; problem framing; inquiry-driven learning; questioning assumptions	Jensen & Schlegel [3]; Larsen [2]	*Activities:* Ill-structured economic decision scenarios with incomplete data; sensitivity exploration. *Assessments:* Opportunity framing memo. *Scaffolds:* Guided prompts; staged data release.

EM Construct	Key Instructional Emphases	Representative Sources	Alignment to Module Design
Connections	Systems thinking; integration of technical, economic, ethical, and societal factors; stakeholder awareness	Habbal et al. [7]; Christensen et al. [8]	*Activities:* Comparative analysis incorporating economic, sustainability, and stakeholder criteria. *Assessments:* Decision matrix linking financial metrics to contextual considerations. *Scaffolds:* Structured templates; peer discussion checkpoints.
Creating Value	Economic justification; feasibility analysis; stakeholder value propositions; societal impact	Bosman & Phillips [5]; Raimundo & Rosário [4]	*Activities:* NPV and rate-of-return analyses tied to stakeholder needs. *Assessments:* Final economic recommendation framed as value proposition. *Scaffolds:* Reflection prompts; rubrics emphasizing justification.

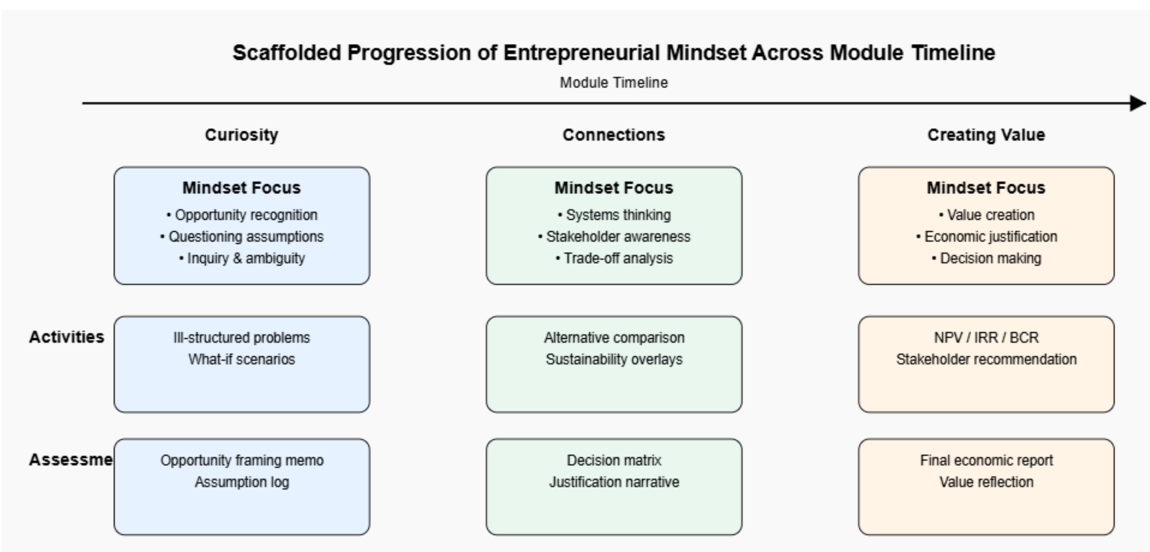

Figure 1. Conceptual model illustrating how scaffolded learning activities in the engineering economic analysis module support student progression from Curiosity, through Connections, to Creating Value across the module timeline.

3. Methodology

3.1 Context and Participants

This study was conducted in *an Engineering Economic Analysis course*, a required sophomore-level course in a general engineering program at a small, private, faith-based university in the western United States. The course serves students pursuing a Bachelor of Science in Engineering with diverse disciplinary interests, including mechanical, civil, and electrical engineering pathways. The course emphasizes foundational engineering economy concepts such as time value of money, cost estimation, alternative comparison, and decision-making under uncertainty.

Participants included students enrolled in the course during the Fall 2025 offering. Participation in the research study was voluntary and did not affect course grades. Institutional Review Board (IRB) approval was obtained prior to data collection. Of the enrolled students, seven completed the baseline survey and six completed the post-implementation survey, with six students providing matched pre/post responses. Demographic data were collected at baseline to characterize the sample, including prior exposure to engineering economics, teamwork experience, and career interests.

3.2 Intervention: Entrepreneurial Mindset Module and Term Project

The instructional intervention consisted of a scaffolded engineering economic analysis module embedded within a semester-long term project. The module was intentionally designed to cultivate the three core EM dimensions, Curiosity, Connections, and Creating Value, by situating engineering economy tools within an authentic, open-ended decision context.

Student teams were tasked with identifying and analyzing a real-world engineering-related investment or design decision involving multiple feasible alternatives. The project required students to define the problem scope, identify stakeholders, gather realistic cost and performance data, and evaluate alternatives using appropriate engineering economy methods. Scaffolded milestones guided students through stages of problem framing, data collection, economic modeling, sensitivity analysis, and final recommendation.

Each major project activity was explicitly mapped to one or more of the 3 Cs. Curiosity was emphasized through open-ended problem formulation and sensitivity analysis under uncertainty. Connections were fostered by requiring students to integrate technical, economic, and stakeholder considerations, including non-technical constraints such as budget limits and user priorities. Creating Value was addressed by asking students to justify recommendations based on economic viability and broader value considerations, such as risk, sustainability, and stakeholder impact.

3.3 Research Design

A sequential explanatory mixed-methods design was employed, in which quantitative data collection and analysis preceded and informed qualitative inquiry. This design was selected to allow initial measurement of changes in students' self-reported entrepreneurial mindset constructs, followed by deeper exploration of how and why those changes manifested through student artifacts and reflections. The quantitative strand addressed Research Question 1, while the qualitative strand addressed Research Questions 2 and 3, with integration occurring during interpretation.

3.4 Instruments and Data Sources

Multiple data sources were used to support triangulation and strengthen validity. The primary quantitative instrument was a baseline and post-implementation Entrepreneurial Mindset survey consisting of 15 Likert-scale items aligned to the three constructs of Curiosity, Connections, and Creating Value. Survey items were adapted from established EM and KEEN-aligned instruments and reviewed for content validity by engineering education faculty.

Qualitative and performance-based data sources included: (1) a project rubric with subscales aligned to each of the 3 Cs, used to evaluate final team reports; (2) structured mid-project reflection prompts designed to elicit student thinking about uncertainty, stakeholder considerations, and value creation; and (3) post-implementation open-ended survey questions capturing students' perceptions of learning gains and challenges. Together, these instruments provided complementary perspectives on EM development from both self-report and demonstrated practice.

3.5 Procedures and Timeline

At the beginning of the semester, students were introduced to the term project and completed the baseline EM survey. The module activities were integrated throughout the semester alongside core engineering economy instruction. Midway through the project, students completed reflective prompts and received formative feedback on their progress. At the end of the semester, students submitted final project reports, completed the post-implementation EM survey, and responded to open-ended reflection questions.

All research procedures were conducted in accordance with IRB-approved protocols. Survey responses were anonymized prior to analysis, and project artifacts were de-identified before being used for research purposes.

3.6 Data Analysis

Quantitative data were analyzed using descriptive and inferential statistics. For students with matched pre/post responses, paired-samples t-tests were conducted to examine changes in Curiosity, Connections, and Creating Value scores. Effect sizes were calculated using Cohen's d_z to estimate the magnitude of within-subject changes. Internal consistency reliability of each construct was examined using Cronbach's alpha.

Qualitative data from reflections and open-ended responses were analyzed using thematic analysis. An initial coding scheme was developed deductively based on the 3 Cs framework and inductively refined as patterns emerged from the data. Codes were iteratively grouped into higher-level themes, and representative excerpts were identified.

Rubric scores and qualitative themes were compared with survey results to examine convergence and divergence across data sources.

Integration of quantitative and qualitative findings was accomplished through the development of a joint display matrix, which aligned survey trends, rubric performance, and qualitative themes to support meta-inferences addressing the research questions.

3.7 Ethics and Trustworthiness

Several strategies were employed to enhance ethical rigor and trustworthiness. Voluntary participation and confidentiality were emphasized throughout the study. Methodological triangulation across surveys, artifacts, and reflections strengthened credibility. An audit trail documenting coding decisions and analytic memos was maintained to support dependability. Reflexive awareness of the instructor-researcher role informed interpretation and is addressed further in Section 5.

4. Results

4.1 Addressing RQ1: Pre/Post Changes in Entrepreneurial Mindset Constructs

Paired pre/post survey data were available for six students who completed both the baseline and post-implementation surveys. Responses used a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Table 2 summarizes construct means, standard deviations, and within-subject effect sizes (Cohen's d_z).

Table 2: Pre/Post Construct Means and Effect Sizes (n = 6)

Construct	Baseline Mean (SD)	Post Mean (SD)	Δ Mean	Cohen's d_z
Curiosity	3.61 (0.55)	3.79 (0.64)	+0.17	0.23
Connections	3.41 (1.18)	3.55 (0.62)	+0.14	0.19
Creating Value	4.07 (0.35)	4.05 (0.30)	−0.01	−0.04

Small positive gains were observed for Curiosity and Connections, while Creating Value remained high and essentially unchanged from baseline to post-implementation. The Curiosity gain suggests that students became somewhat more likely to investigate open-ended economic problems, ask deeper questions, and engage uncertainty through exploratory analysis. The modest increase in Connections similarly suggests some growth in students' ability to integrate technical, financial, stakeholder, and contextual considerations into engineering economic reasoning. By contrast, Creating Value began at a relatively high baseline mean of 4.07 and remained essentially unchanged at 4.05, suggesting a ceiling effect rather than a lack of instructional impact.

4.2 Addressing RQ3: Post-Only Portfolio and Implementation Indicators

To capture learning outcomes more directly tied to the project experience, the post-implementation survey included portfolio-aligned indicators related to application, stakeholder engagement, and communication. Descriptive statistics are reported in Table 3.

Table 3: Post-Implementation Portfolio Indicators

Indicator (Post Only)	**Mean**	**SD**
Asked deeper economic questions because of the project	4.00	0.63
Confidence applying engineering economy tools to real data	4.00	0.63
Ability to explain technical trade-offs to non-technical stakeholders	3.67	0.52
Considered multiple forms of value (economic, social, environmental)	3.67	0.52
Stakeholder input influenced final recommendation	3.33	1.21
Time devoted weekly to the project	4.17	0.41
Mid-project feedback improved final deliverable	3.17	0.75
Rubric clarity for understanding high-quality work	2.50	1.05

The highest-rated indicators were time devoted weekly to the project (M = 4.17), deeper economic questioning (M = 4.00), and confidence applying engineering economy tools to real data (M = 4.00), suggesting that students were engaged in the project and perceived it as useful for strengthening authentic analytical practice. Students also reported moderately positive outcomes related to explaining technical trade-offs to non-technical stakeholders and considering multiple forms of value, each with a mean of 3.67, indicating that the project supported broader systems-oriented and stakeholder-aware thinking. Stakeholder influence on final recommendations was more variable (M = 3.33, SD = 1.21), suggesting that some teams experienced stronger stakeholder effects than others. The lowest-rated indicator was rubric clarity (M = 2.50, SD = 1.05), pointing to uneven understanding of expectations for high-quality entrepreneurial-minded work.

4.3 Addressing RQ2 and RQ3: Qualitative Evidence from Student Reflections

Open-ended responses from the post-implementation survey provided preliminary qualitative evidence that students enacted Curiosity, Connections, and Creating Value in the course project. These reflections help explain the quantitative patterns shown in Tables 2 and 3, particularly the modest gains in Curiosity and Connections and the stronger post-only ratings for deeper questioning and real-data application.

A first theme was curiosity through authentic inquiry and economic questioning. Several students described the value of working with real-world information rather than textbook-style data. One student wrote that "*researching the pricing of different equipment as well as looking at the reliability of the equipment were some of the things that I learned most about with this project,*" while another explained that "*using what we have learned in class through the semester and actually applying it to a real world problem made it much* *easier to think about"*. These comments align with the Table 3 finding that students asked deeper economic questions because of the project (M = 4.00) and with the modest Curiosity gain reported in Table 2.

A second theme was connections through stakeholder and contextual integration. Students frequently noted that project decisions were shaped by budget limits, customer priorities, and design constraints. One student reported that "*mainly with stakeholders they cared about money the most which caused us to pick the one with the lowest initial construction cost,"* while another stated that *"stakeholder input changed our analysis because of our cost estimates. Some projects would be over budget, and didn't meet some design requirements they were looking for"*. These responses reinforce the Table 3 indicators showing moderate influence of stakeholder input on final recommendations (M = 3.33) and moderate confidence explaining technical trade-offs to non-technical stakeholders (M = 3.67).

A third theme was creating value through applied reasoning and future transfer. Students often framed the project as useful preparation for future engineering work, internships, or team-based decision-making. One student wrote that they would apply the 3 Cs by "*asking questions on what to improve on, making connections with others in the business… and create value by helping out my team in whatever problem needs solved,"* while another noted that the project helped them learn "*the sources that I can use to find critical information"*. These comments suggest that although Creating Value did not increase quantitatively in Table 2, students were learning to express value creation more concretely in terms of professional action, stakeholder benefit, and evidence-based recommendation.

A final qualitative theme concerned instructional supports and needed improvements. Some students emphasized that feedback helped them improve their work, including one who noted that the instructor identified strengths and weaknesses and the team *"bucked down on our weaknesses and fixed them"*. At the same time, several students requested clearer expectations, asking for *"more explanation of what is expected," "more clear instructions," or "a more in depth example"*. These comments closely match the low rubric clarity rating in Table 3 (M = 2.50), providing qualitative support for that quantitative finding.

5. Discussion

5.1 Addressing RQ1: Changes in Self-Reported EM Constructs

The results provide preliminary empirical support for the claim that a scaffolded, project-based engineering economy module can foster elements of the Entrepreneurial Mindset, specifically Curiosity, Connections, and Creating Value. The modest pre/post gains in Curiosity and Connections indicate that students increased their tendency to ask deeper economic questions and integrate multiple sources of information, including stakeholder constraints. Although effect sizes were small, the post-only indicators and qualitative responses suggest that the project prompted students to move beyond procedural calculations toward inquiry-driven economic reasoning and more integrative decision-making.

The absence of measurable growth in Creating Value is best interpreted in light of a ceiling effect. Students entered the course with relatively high baseline scores (4.07 on a 5-point scale), indicating strong initial agreement with value-oriented statements. Post-implementation responses suggest that the project shifted value creation from a general disposition to a more operationalized practice, as evidenced by students' descriptions of stakeholder-aware recommendations, cost-benefit reasoning, and long-term professional application.

5.2 Addressing RQ2 and RQ3: Project Artifacts and Learning Perceptions

The qualitative findings add important depth to the quantitative results by showing how students experienced the project as more than a technical exercise. High ratings on deeper questioning and confidence applying engineering economy tools suggest that students engaged meaningfully with authentic analysis, while their written reflections indicate that this engagement occurred through real-data research, comparison of alternatives, and attention to stakeholder needs. In this sense, the project appears to have supported movement from procedural calculation toward more context-sensitive engineering judgment.

One notable finding is the relatively low rating of rubric clarity ($M = 2.50$), which may have constrained the magnitude of observed gains. This aligns with student suggestions for clearer expectations, exemplars, and stronger alignment between rubric criteria and project deliverables. However, the high ratings on deeper questioning ($M = 4.00$) and tool confidence ($M = 4.00$) suggest that students still recognized the value of the project experience despite ambiguity in the assessment scaffolds. Strengthening instructional supports, particularly rubric clarity and exemplar provision, may enable future implementations to produce more robust measurable gains across EM constructs while maintaining the analytical rigor essential to engineering economics instruction.

6. Conclusions

This study demonstrates that embedding a scaffolded, real-world engineering economy project within an undergraduate course can support the development of entrepreneurial-mindset-aligned behaviors, particularly in Curiosity and Connections, while reinforcing already strong orientations toward Creating Value. Although quantitative pre/post changes were modest, post-implementation indicators and student reflections point to meaningful learning gains in applying economic tools, integrating stakeholder input, and justifying decisions under realistic constraints.

These findings support the feasibility of using engineering economy as a vehicle for EM integration and highlight clear opportunities for instructional refinement—particularly in rubric clarity, exemplar provision, and formative feedback—to strengthen future implementations. The scaffolded module represents a replicable model for engineering educators seeking to integrate EM within analytically rigorous core courses without compromising technical depth.

7. Limitations and Future Work

The findings are limited by a small sample size (paired n = 6), which restricts statistical power and generalizability. In addition, ceiling effects likely influenced the Creating Value construct, masking potential growth. The reliance on self-reported survey data may also underrepresent skill development observable in artifacts or external evaluations.

Future work will expand the sample across multiple course offerings, incorporate rubric-scored portfolio artifacts to address RQ2 more comprehensively, and refine survey items to better distinguish between EM dispositions and demonstrated EM practices. Additionally, comparative analysis across institutions and engineering disciplines would strengthen evidence regarding the transferability of the scaffolded module design.

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Appendices

Appendix I: Pre -Implementation (Baseline) Survey Questions

Instructions:
For each statement, indicate your level of agreement using the following scale:

1 = Strongly Disagree
2 = Disagree
3 = Neutral
4 = Agree
5 = Strongly Agree

Section 1: Curiosity

I enjoy investigating and exploring real-world engineering problems, even when solutions are not immediately obvious.

I am comfortable asking probing and deeper questions to better understand economic decisions and uncertainties.

I actively seek out and use multiple technical, financial, and market data sources when faced with new problems.

When I encounter uncertainty in a project, I am motivated to learn more rather than give up.

I am interested in understanding how economic, technical, and stakeholder factors interact in engineering decisions.

I frequently generate "what if" scenarios to test and deepen my understanding of engineering concepts.

I feel confident framing my own research questions about real-world engineering challenges.

Section 2: Connections

1) I can identify key stakeholders (such as users, customers, or the community) relevant to an engineering project.
2) I consider social, environmental, and ethical factors when analyzing engineering problems.
3) I am able to connect engineering economic theory to real-world decision-making.
4) I can explain how technical and economic trade-offs affect different stakeholder groups.
5) I seek to integrate information from outside sources (such as market reports or interviews) into my engineering economic analysis.
6) Collaborating with peers improves my economic decision making.

7) I seek feedback from stakeholders to refine and improve engineering solutions.

Section 3: Creating Value

1) I feel confident recommending solutions that maximize both economic return and stakeholder benefit.
2) I am able to justify my engineering recommendations with data-driven reasoning and by evaluating multiple alternatives.
3) I consider the long-term impacts (such as sustainability and risk) and prioritize solutions that maximize long-term value rather than just short-term cost savings.
4) I reflect on how my engineering work can create value beyond cost savings, including social or environmental benefits.
5) I am comfortable recommending innovative solutions, even if they involve calculated risks.
6) I am comfortable communicating actionable and quantifiable recommendations to diverse audiences.
7) I believe engineers have a responsibility to create value for both customers and society.

Section 4: Experience & Background

1) I have previously worked on engineering projects that required economic analysis.
2) I have experience interviewing stakeholders or customers as part of a project.
3) I am familiar with payback period, present worth, future worth, equivalent uniform annual worth (EUAW), internal rate of return (IRR) and return on investment (ROI) analysis techniques.
4) I understand the entrepreneurial mindset concept.

Section 5: Open-Ended (Short Answer)

1) What do you hope to learn from this course project?
2) What challenges do you anticipate when integrating stakeholder perspectives into economic analysis?
3) Describe a time when you needed to gather information from multiple sources to make a decision.

Appendix II: Post-Implémentation Survey Questions

Instructions:
For each statement, indicate your level of agreement using the following scale:

1 = Strongly Disagree
2 = Disagree
3 = Neutral
4 = Agree
5 = Strongly Agree

Section 1: Curiosity

1) I enjoy investigating and exploring real-world engineering problems, even when solutions are not immediately obvious.
2) I am comfortable asking probing and deeper questions to better understand economic decisions and uncertainties.
3) I actively seek out and use multiple technical, financial, and market data sources when faced with new problems.
4) When I encounter uncertainty in a project, I am motivated to learn more rather than give up.
5) I am interested in understanding how economic, technical, and stakeholder factors interact in engineering decisions.
6) I frequently generate "what if" scenarios to test and deepen my understanding of engineering concepts.
7) I feel confident framing my own research questions about real-world engineering challenges.

Section 2: Connections

8) I can identify key stakeholders (such as users, customers, or the community) relevant to an engineering project.
9) I consider social, environmental, and ethical factors when analyzing engineering problems.
10) I am able to connect engineering economic theory to real-world decision-making.
11) I can explain how technical and economic trade-offs affect different stakeholder groups.
12) I seek to integrate information from outside sources (such as market reports or interviews) into my engineering economic analysis.
13) Collaborating with peers improves my economic decision making.
14) I seek feedback from stakeholders to refine and improve engineering solutions.

Section 3: Creating Value

8) I feel confident recommending solutions that maximize both economic return and stakeholder benefit.
9) I am able to justify my engineering recommendations with data-driven reasoning and by evaluating multiple alternatives.
10) I consider the long-term impacts (such as sustainability and risk) and prioritize solutions that maximize long-term value rather than just short-term cost savings.
11) I reflect on how my engineering work can create value beyond cost savings, including social or environmental benefits.
12) I am comfortable recommending innovative solutions, even if they involve calculated risks.
13) I am comfortable communicating actionable and quantifiable recommendations to diverse audiences.
14) I believe engineers have a responsibility to create value for both customers and society.

Section 4: EM Growth Oriented

5) Because of this project, I ask deeper economic questions when faced with uncertainty.
6) I am better able to translate technical tradeoffs for non-technical stakeholders.
7) I now consider multiple forms of value (economic, social, environmental) when making recommendations.
8) The EM project increased my confidence in applying analysis techniques such as payback period, present worth, future worth, equivalent uniform annual worth (EUAW), internal rate of return (IRR) and return on investment (ROI) to real data.
9) The stakeholder interviews influenced my final recommendation.

Section 5: Project Specific Effort & Utility

1) I devoted adequate time each week to the EM project.
2) Feedback from the mid-project reflection helped improve my final report.
3) The EM rubrics clarified what high-quality work looked like.

Section 6: Open Ended Reflection

1) Which aspect of the EM project most enhanced your learning, and why?
2) Describe one instance where stakeholder input changed your team's analysis or recommendation.
3) In what ways will you apply Curiosity, Connections, or Creating Value in future courses or internships?
4) What improvements would you recommend for next year's EM project?