From Dialogue to Deliberation: Using AI-Mediated Multi-Perspective Dialogue in Engineering Economy Education

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Abstract

This paper presents an instructional approach that integrates artificial intelligence into engineering economy education through structured, multi-perspective dialogue designed to support ethical-economic deliberation. Implemented in a junior-level engineering economy course, the activity engages students in authentic infrastructure decision contexts in which three AI-mediated personas—a licensed professional engineer, an institutional economic steward, and a community advocate—offer distinct and sometimes conflicting perspectives on decisions involving cost, risk, sustainability, and public welfare. Rather than serving as decision authorities, the AI personas function as pedagogical scaffolds that surface competing priorities and prompt critical evaluation.

The intervention design is theoretically grounded in James Rest's Four-Component Model, with emphasis on ethical sensitivity, judgment, and prioritization that precede action. Ethical reasoning is embedded directly within engineering economic analysis rather than treated as a separate or supplemental consideration. Two campus-related infrastructure case studies, in National Society of Professional Engineers (NSPE) case form, were developed to reflect contemporary sustainability and resilience challenges, and limited variation in persona framing was introduced to explore how differences in tone and emphasis influence student reasoning across multiple, sequential interactions.

Analysis of student recommendations and reflections indicates that structured exposure to competing perspectives supports deliberative reasoning characterized by explicit articulation of trade-offs, consideration of lifecycle and opportunity costs, and integration of ethical responsibility with economic justification. The paper describes the instructional design, implementation, and assessment approach, and discusses implications for engineering economy education. The findings suggest that AI-mediated dialogue can support ethically informed economic decision-making while preserving student agency and professional judgment.

1. Introduction

Artificial intelligence (AI) tools are rapidly becoming embedded in engineering education, prompting renewed discussion within the American Society for Engineering Education (ASEE) community about appropriate pedagogical roles, ethical use, and instructional value. Within engineering economy education in particular, AI presents both an opportunity and a challenge. While AI systems can readily support computation, explanation, and content generation, their more consequential potential may lie in shaping how students reason about decisions that involve cost, risk, uncertainty, and ethical responsibility.

Much of the current ASEE literature positions AI as a tutoring aid, content generator, or object of critique, often emphasizing accuracy, academic integrity, or professional skill development. These approaches establish important precedents for responsible AI integration but generally treat ethical considerations as constraints external to economic analysis. In contrast, professional engineering practice frequently requires engineers to justify decisions in which economic efficiency, public welfare, sustainability, and institutional risk are deeply intertwined. Preparing students for such contexts requires instructional strategies that emphasize deliberation, justification, and awareness of trade-offs rather than solution correctness alone.

This paper presents an instructional approach that integrates AI into a junior-level engineering economy course through structured, multi-perspective dialogue. Students engage sequentially with AI-mediated personas representing distinct professional and stakeholder viewpoints, including engineering, economic stewardship, and community advocacy. The personas do not interact with one another; instead, students reconcile competing perspectives through discussion and judgment. Rather than serving as tutors or decision-makers, these personas function as deliberative scaffolds that surface competing priorities and challenge students' assumptions. The instructional goal is not to direct students toward a particular solution, but to support professional-style reasoning in situations where no option dominates across all criteria.

The activity is grounded conceptually in Rest's Four-Component Model of ethical behavior, which emphasizes ethical sensitivity, judgment, prioritization, and character. Consistent with this framework, the intervention focuses on helping students recognize ethical dimensions within economic decisions, reason through competing values, and articulate defensible justifications. The study does not seek to assess moral alignment or character development; rather, it examines patterns of ethical-economic deliberation that emerge when students are exposed to multiple perspectives in a structured setting.

Two campus-related infrastructure case studies were developed to provide contrasting decision contexts while maintaining comparable levels of complexity. Using pre-activity problem formulations and post-activity reflections, this study examines how structured exposure to multiple AI-mediated perspectives influences students' reasoning processes in engineering economic decision-making. The contribution of this work is threefold: (1) it demonstrates a practical, classroom-scalable method for integrating ethical deliberation directly into engineering economy analysis using AI-mediated dialogue; (2) it provides empirical evidence that multi-perspective AI interactions support reasoning shifts, ethical-economic integration, and trade-off awareness without constraining student judgment; and (3) it extends prior ASEE work on AI in engineering education by positioning AI as a deliberative scaffold rather than a tutor or evaluator. By articulating both instructional design and observed learning patterns, this paper offers actionable guidance for engineering economy educators seeking to prepare students for value-laden, professionally realistic decision contexts.

2. Background and Theoretical Framing

2.1 Artificial Intelligence in Engineering Education: Current ASEE Perspectives

Recent ASEE literature reflects rapid growth in the adoption of AI tools across engineering education, with applications spanning tutoring support, assignment assistance, content generation, assessment benchmarking, and professional skills development. Much of this work positions AI as a course resource or instructional aid and emphasizes responsible use, accuracy, and reliability, for example, Ai et al. [1] describe a custom, course-specific chatbot deployed as a non-conversational teaching assistant to support students in a programming-intensive course, while Altuger-Genc and Tatoglu [2] embed AI tools into engineering assignments to promote self-directed learning through structured critique of AI-generated content.

Critical perspectives within ASEE have also cautioned against unreflective adoption of AI tools in engineering education. For example, Tsang [3] questions whether emerging AI applications meaningfully support learning or merely introduce instructional hype, emphasizing the need for intentional design that preserves student agency and higher-order reasoning.

Systematic and narrative reviews confirm these trends. Balart and Shryock [4], Moyaki and Hunsu [5], and Shaw et al. [6] documented widespread ASEE interest in AI-enabled pedagogy, while noting that much of the literature emphasized academic integrity, tool reliability, and general professional skills rather than domain-specific decision-making processes. Collectively, this body of work establishes a strong precedent for intentional AI integration within ASEE. Still, most implementations treat AI as a tutor, content generator, or subject of critique rather than as an active participant in structured reasoning or deliberation.

2.2 Dialogic and Role-Based Uses of AI

A smaller but growing subset of ASEE research explores dialogic or persona-based uses of AI. Littell [7] employs AI role-play agents to support professional communication and stakeholder-awareness skills, while Kim et al. [8] examined ChatGPT's role as a conversational peer within computer-supported collaborative learning environments. These studies suggest that AI-mediated dialogue can support perspective-taking and interaction quality. Still, they also highlight risks when AI engagement is unstructured or replaces peer deliberation rather than scaffolding it.

Related work emphasizes the importance of instructional framing and constraint. Carr and Cornwell [9] and Wyne et al. [10] caution against ad hoc or solution-oriented AI use in core engineering courses, noting potential negative impacts on learning quality and assessment validity. Jamieson et al. [10,11] similarly argue that intentional design is necessary to preserve higher-order cognitive skills and propose a taxonomy to benchmark AI capabilities relative to engineering learning outcomes.

Specific to engineering economy education, Smith and Castles [13] introduced the *Engineering Ethics Coach* as a structured, persona-driven chatbot to support ethical reasoning alongside economic analysis. That work demonstrated the feasibility of using bounded AI dialogue to prompt students' justifications without diminishing their agency. However, much of the dialogic AI literature falls short of operationalizing AI as a structured facilitator of stakeholder-sensitive trade-off-based decision-making inherent to engineering economy.

2.3 AI as a Cognitive Challenger Rather Than an Authority

A complementary perspective in ASEE literature frames AI not as an authority but as a cognitive challenger. Chen and Ratanalert [14] develop a custom "novice" chatbot intentionally designed to exhibit common misconceptions in a Material and Energy Balances course. Rather than providing correct answers, the chatbot serves as a cognitive foil, prompting students to critique, correct, and justify their reasoning. This approach provides conceptual validation for AI systems designed to provoke judgment rather than replace it. Although Chen and Ratanalert [14] focus on technical misconceptions rather than ethical or economic reasoning, their work reinforces a broader ASEE concern. As AI becomes increasingly capable, instructional designs must preserve student agency, critical thinking, and professional judgment [15,16]. This framing motivates AI-enabled designs that surface competing considerations, reveal incomplete reasoning, and require students to synthesize and defend decisions.

2.4 Ethics, Deliberation, and Engineering Economy

ASEE's published work on ethics has traditionally emphasized academic integrity, professional responsibility, and responsible use of technology [3, 9]. While these discussions are essential, they often frame ethics as a constraint on behavior rather than as an integral component of technical and economic decision-making. Recent work in engineering education has similarly argued for moving beyond AI detection and prohibition toward instructional designs that leverage AI to support higher-order reasoning and professional judgment [17]. In engineering economy education, ethical considerations are often treated indirectly or as supplementary reflections rather than as integral elements of economic analysis. Yet real-world economic decisions, particularly those involving infrastructure, sustainability, and resilience, require engineers to reconcile costs, risks, public welfare, and long-term societal impacts under uncertainty and institutional constraints.

The present study responds to this gap by integrating AI-mediated, multi-perspective dialogue directly into engineering economic decision-making tasks. Rather than treating AI as a tutor, evaluator, or content generator, the instructional design positions multiple AI personas as structured interlocutors that surface competing priorities, challenge assumptions, and require students to justify trade-offs. In doing so, the study extends prior ASEE work on role-based AI dialogue [13] by emphasizing multiple, sequential interactions and examining deliberative reasoning. The focus is on how students frame, reconcile, and defend decisions rather than on ethical alignment alone.

2.5 Ethical Deliberation and Rest's Four-Component Model

Ethical reasoning in professional contexts has frequently been conceptualized using James Rest's Four-Component Model [17,18], which proposes that ethical behavior depends on four distinct but interrelated capacities: moral sensitivity (recognition of ethical issues), moral judgment (reasoning about what ought to be done), moral motivation (prioritizing ethical values relative to competing interests), and moral character (the persistence and skills required to act on one's judgment). Importantly, the model emphasizes that ethical failure may occur even when other components are present if any single component is underdeveloped. Within educational settings, Rest's model is commonly used as a theoretical lens rather than as a direct measurement framework, particularly when the focus is on ethical awareness, reasoning, and prioritization rather than behavioral enactment [20]. In the context of engineering economy education, this distinction is especially relevant, as students are often asked to evaluate alternatives, justify trade-offs, and balance economic efficiency with broader societal obligations.

The instructional intervention examined in this study aligns most directly with the first three components of Rest's model. Pre-activity problem formulation and AI-mediated dialogue support moral sensitivity by surfacing ethical dimensions and affected stakeholders. Structured engagement with competing perspectives supports moral judgment by requiring students to reason through trade-offs and justify decisions under constraint. Explicit consideration of cost, risk, and public welfare reflects moral motivation, as students must weigh ethical considerations alongside economic priorities. The fourth component, moral character, which concerns follow-through and action in real-world contexts, lies outside the scope of this classroom-based study.

3. Methods and Intervention Design

3.1 Course Context and Participants

The intervention was implemented in an engineering economy course, a junior-level undergraduate course with a typical enrollment of 24 students. The course emphasizes economic decision-making under uncertainty, lifecycle cost analysis, and professional judgment, and it serves as a core requirement for engineering majors. The activity was conducted during a regularly scheduled class session and was integrated into the course without altering grading structure or learning objectives. Students participated in the intervention as part of normal coursework. Participation in data collection activities followed standard instructional practices, and all reported results are based on de-identified student artifacts.

3.2 Intervention Overview

The instructional intervention consisted of a structured, in-class decision-making exercise supported by AI-mediated dialogue. Students were assigned to evaluate one of two cases and develop a recommendation under conditions of economic uncertainty, ethical tension, and institutional constraints. The activity was designed to emphasize deliberation and justification rather than the convergence of solutions.

The intervention followed a common structure across both cases. Student teams conducted a series of short interviews with three AI personas representing distinct professional or stakeholder perspectives. Following the interviews, teams synthesized the information into a written recommendation and completed a short reflective component. Figure 1 provides an overview of the instructional workflow and associated data collection stages.

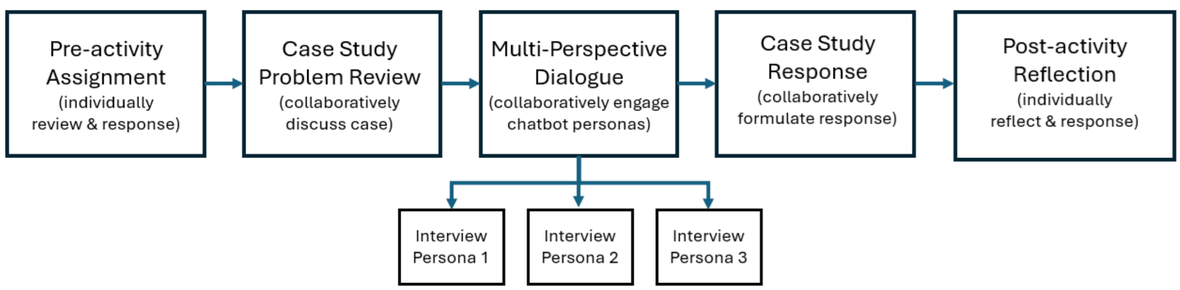

Figure 1. Instructional intervention workflow and staged data collection sequence, progressing from initial individual judgment to multi-perspective dialogue, collaborative recommendation, and individual reflection.

3.3 Case Design and Decision Structure

Two cases were used to provide contrasting decision contexts while maintaining comparable levels of complexity.

Case A (Microgrid Investment) focused on a campus-scale energy infrastructure decision that involved trade-offs among capital costs, resilience, sustainability, and exposure to institutional risk. Students evaluated alternatives that differed in upfront investment, outage mitigation capability, and long-term financial implications. No option dominated all economic criteria, requiring students to balance avoided losses, lifecycle uncertainty, and budget constraints.

Case B (Stormwater Pavers) examined an infrastructure investment intended to reduce flood risk and improve environmental performance through permeable pavement systems. The case introduced diffuse benefits, maintenance uncertainty, and regulatory foresight considerations. Economic evaluation required students to weigh long-term avoided damages and public welfare considerations against higher initial costs and uncertain maintenance performance.

The cases were intentionally selected to represent distinct types of economic analysis decisions. Case A featured concentrated, high-visibility risk, while Case B emphasized distributed impacts and long-term environmental consequences. This contrast allowed examination of whether deliberative reasoning patterns were case-specific or transferable across contexts.

3.4 AI Persona Design and Pedagogical Role

Three AI personas were instantiated for each case, representing perspectives commonly encountered in professional engineering decisions: a licensed professional engineer, an institutional economic steward (e.g., manager or planner), and a community advocate. Each persona was role-constrained and grounded in the specific case context to promote relevance and consistency. The personas and associated prompts were developed by the instructional team and iteratively refined before classroom deployment to promote consistency with intended stakeholder roles.

The personas were designed to surface competing priorities rather than provide solutions. Responses emphasized perspective-based reasoning, trade-offs, and concerns associated with each alternative. Students were informed that the AI personas were intentionally designed as divergent stakeholders rather than authoritative sources of truth, requiring them to exercise professional judgment when reconciling conflicting viewpoints. This orientation reinforced that the objective was not to identify a predetermined "correct" solution, but to synthesize a defensible recommendation through structured deliberation.

To mitigate known limitations of generative AI, including rhetorical emphasis and overconfidence, interactions were time-limited, prompts were structured, and personas were restricted to case-specific information. The instructional framing emphasized critical evaluation, synthesis, and justification rather than acceptance of AI-generated recommendations.

3.5 Exploratory Variation in Persona Framing

The intervention incorporated limited variation in persona framing to explore whether differences in tone or emphasis influenced student reasoning. In some instances, personas adopted a more critical or opinionated stance, while in others they emphasized caution or feasibility. These variations were intentionally subtle and exploratory and were not designed to test causal effects.

The use of three perspectives was motivated by pedagogical considerations. Three personas provided sufficient diversity to surface ethical, economic, and stakeholder tensions while maintaining cognitive manageability within a single class session. Interview order was also varied across teams to reduce anchoring effects and encourage independent synthesis.

3.6 In-Class Procedure and Deliverables

Students worked in pairs during the activity. Each team conducted three short interviews, one with each AI persona, lasting approximately ten minutes per interaction. The personas did not interact autonomously with one another; instead, students engaged each perspective separately and synthesized viewpoints across the three interviews. Teams were encouraged to ask follow-up questions and probe reasoning rather than seek definitive recommendations. Following the interviews, teams produced a written recommendation identifying a preferred course of action and justifying their decision using engineering-economic and ethical considerations. Students also indicated which perspective they found most influential or challenging. An individually completed post-activity reflection assignment allowed students to articulate shifts in reasoning, awareness of trade-offs, and ethical-economic integration. Consistent with the theoretical framing introduced earlier, Rest's Four-Component Model provides conceptual grounding for the instructional design. However, the study does not directly measure the model's individual components. Instead, it examines patterns of ethical-economic deliberation consistent with moral sensitivity, judgment, and prioritization that precede action, which are most appropriate for assessment in a classroom-based setting.

4. Data Collection and Analysis Approach

This study draws on multiple sources of student-generated data collected before, during, and after the AI-mediated instructional intervention. The analysis emphasizes qualitative patterns in student reasoning rather than causal inference or outcome optimization. Consistent with the exploratory instructional intent, analytic attention is focused on how students framed decisions, integrated ethical and economic considerations, and articulated trade-offs across different stages of the activity.

4.1 Data Sources

Four primary data sources were collected:

1) Pre-activity individual problem formulations, completed before the in-class intervention
2) In-class team-based recommendations, developed following AI-mediated interviews
3) End-of-assignment responses, capturing immediate post-activity judgments
4) Individual post-activity reflections, submitted after the in-class exercise

All data were de-identified prior to analysis. Together, these sources provide insight into both baseline decision framing and post-intervention deliberative reasoning.

4.2 Pre-Activity Problem Formulation

Before participating in the AI-mediated dialogue, students completed an individual pre-activity assignment in which they identified a preferred course of action for their assigned case and provided a brief justification. The purpose of this assignment was to capture initial problem framing and decision rationale before exposure to multiple perspectives. Pre-activity responses were collected separately for Case A (Microgrid Power System Investment) and Case B (Stormwater Pavers Investment). Eleven responses were associated with Case A, and ten responses were associated with Case B, yielding an overall pre-activity response rate of approximately 88 percent. These responses establish baseline conditions for interpreting subsequent changes in reasoning and deliberation patterns.

4.3 Post-Activity Artifacts and Reflections

Following the in-class exercise, student teams submitted a written recommendation identifying a preferred alternative and justifying their decision using economic, ethical, and contextual considerations. Teams also indicated which AI persona they found most influential or challenging during deliberation.

In addition, students completed an individual reflection assignment addressing three prompts:

1. How their perspective changed after the AI-mediated interviews,
2. Which engineering economy and ethical concepts guided their final decision, and
3. What they learned about balancing fiscal responsibility with sustainability and resilience.

These artifacts provide complementary views of student reasoning, capturing both collaborative synthesis and individual reflection.

4.4 Analytic Focus and Coding Strategy

Analysis focused on qualitative patterns aligned with the instructional objectives of the intervention. Rather than scoring responses for correctness or depth, student artifacts were examined for evidence of three core constructs:

- Reasoning shift, defined as explicit acknowledgment of changed or expanded thinking
- Ethical-economic integration, defined as the coordinated use of economic analysis and ethical considerations in justification
- Trade-off awareness, defined as explicit recognition of competing objectives, risks, or constraints

Responses were coded for the presence and clarity of these constructs using an iterative review process conducted by the instructor and an additional reviewer. Differences in interpretation were discussed and reconciled through consensus. This approach prioritizes interpretive insight into student deliberation over formal measurement and is consistent with exploratory classroom-based research in engineering education.

4.5 Methodological Scope and Constraints

The analytic approach is intentionally descriptive and context specific. The study does not seek to establish causal effects or generalizable learning outcomes. Instead, it aims to document how students engaged with ethical and economic reasoning when supported by structured, multi-perspective AI dialogue.

This scope aligns with the intervention's purpose and supports the results presented in the following section, which emphasize observed patterns of deliberation, justification, and perspective integration rather than performance metrics or outcome convergence.

5. Results

5.1 Dataset Overview

Before the in-class chatbot-mediated exercise, students completed a brief pre-activity assignment to elicit their initial problem formulation and decision rationale for one of two engineering-economy cases. The assignment asked students to identify a course of action and justify their choice using economic, technical, and ethical considerations. The intent of the pre-activity was not to assess correctness but to document baseline framing before exposure to multiple perspectives.

Pre-activity responses were collected from 21 of 24 enrolled students (approximately 88%). Students were divided across two cases: Case A (Microgrid Investment) and Case B (Stormwater Pavers). Eleven responses were associated with Case A and ten with Case B. Students worked individually during the pre-activity and did not have access to the chatbot personas at this stage.

Tables 1 and 2 illustrate that students entered the activity with heterogeneous but largely cost-anchored problem framings across both cases. While economic feasibility dominated initial reasoning, a meaningful subset of students also articulated risk, sustainability, and public-welfare considerations before any AI-mediated dialogue. Notably, explicit ethical framing was present but secondary in both cases, suggesting that many students initially viewed ethics as contextual rather than central to engineering-economic justification. This variation in baseline framing provided a useful foundation for examining how subsequent exposure to multiple perspectives influenced deliberative reasoning.

A total of 22 students submitted post-activity reflection data. Two students were absent during the in-class activity and were omitted from the analysis. One additional reflection was excluded from the case-level summary table because the participant did not submit a pre-activity problem formulation, yielding 21 reflections included in the post-activity synthesis (Case A: n = 11; Case B: n = 10). The analysis emphasized explicit articulation in student writing rather than inferred intent, leading to a conservative interpretation of observed patterns.

Table 1. Pre-Activity Problem Framing for Case A: Microgrid Power Investment *(n=11 students)*

Pre-Activity Framing Dimension	Description of Framing Observed	Students (n=11, %)
Primary decision criterion	Lowest initial or present-worth cost emphasized	5 (45%)
Risk and resilience consideration	Focus on outage mitigation, reliability, or avoided losses	4 (36%)
Sustainability orientation	Explicit reference to emissions reduction or long-term environmental benefit	3 (27%)
Ethical or public-welfare framing	Reference to responsibility for campus safety or continuity of operations.	2 (18%)
Multi-criteria framing	Explicit consideration of cost alongside risk or sustainability	3 (27%)

Table 2. Pre-Activity Problem Framing for Case B: Stormwater Paver Investment *(n=10 students)*

Pre-Activity Framing Dimension	Description of Framing Observed	Students (n=10, %)
Primary decision criterion	Initial cost or budget feasibility emphasized	4 (40%)
Long-term cost avoidance	Consideration of avoided flood damage or lifecycle savings	3 (30%)
Environmental impact	Emphasis on runoff reduction, water quality, or sustainability	4 (40%)
Regulatory or compliance awareness	Reference to future standards or institutional responsibility	2 (20%)
Public welfare framing	Consideration of pedestrian safety or community impact	3 (30%)
Multi-criteria framing	Explicit integration of cost with environmental or social factors	3 (30%)

5.2 Reasoning Shifts: Reframing, Refinement, and Confirmation

Student reflections described several forms of change in reasoning following engagement with the multi-perspective chatbot panel. Some students reported reframing the decision from an initially narrow cost focus toward broader consideration of long-term risk, resilience, and stakeholder impact. One student captured this reframing by noting that "*what started as a financial problem turned into a lesson on leadership, ethics, and long-term thinking*."

Other students described refinement rather than reversal, indicating that exposure to competing perspectives strengthened or clarified justification for an initially preferred option. As one student stated, "*My overall opinion did not really change, but the interviews made me consider more of the economic and ethical reasoning behind that choice*." A smaller subset reported confirmation through deliberation, describing stable decisions that were reinforced by evaluating alternative viewpoints.

5.3 Integration of Ethical and Engineering-Economic Reasoning

Across post-activity artifacts, ethical and engineering-economic reasoning were frequently integrated rather than treated as separate steps. Students commonly described ethical considerations as shaping how economic feasibility and fiscal responsibility were interpreted, often through established engineering-economy concepts such as lifecycle thinking, risk assessment, opportunity cost, and avoided losses.

For example, one student linked ethical obligation directly to economic justification, explaining that "*even though the system costs more initially, choosing the cheaper but less dependable option would go against our responsibility to protect public safety and welfare*." Across responses, students framed higher upfront costs as either unjustified expenditures or responsible investments depending on anticipated long-term outcomes, including reduced risk, avoided losses, and improved system resilience.

5.4 Tradeoff Awareness and Professional Judgment

Most reflections demonstrated explicit awareness of trade-offs, even when students did not report a major shift in reasoning. Students articulated tensions such as upfront cost versus long-term resilience, fiscal responsibility versus sustainability, and ideal technical performance versus institutional feasibility. Trade-off awareness extended beyond simple cost comparisons to include uncertainty, maintenance burden, funding constraints, and stakeholder impacts.

One student summarized this perspective by noting that "*true engineering decisions are about finding the balance between cost, reliability, and ethics, not just picking the cheapest option*." Taken together, these reflections are consistent with professional-style judgment, in which alternatives are evaluated across multiple criteria and decisions are defended with explicit justification rather than single-metric optimization.

5.5 Exploratory Effects of Persona Framing

Within each case scenario, some student groups interacted with chatbot panels that varied slightly in tone or emphasis (for example, more critical or more assertive personas). While the study was not designed to support causal claims about persona effects, exploratory patterns suggest that framing differences influenced how students articulated justification. More critical or cost-focused personas appeared to prompt more explicit attention to feasibility constraints and stakeholder concerns. These observations are reported to inform future study design rather than as definitive findings.

5.6 Implementation Note

One student team reported technical difficulties that limited meaningful interaction with the chatbot panel. While the reflection did not describe a clear shift in reasoning attributable to the interaction, it nonetheless demonstrated ethical-economic integration and awareness of trade-offs. This instance highlights the importance of reliable technical implementation and suggests that core learning objectives may be reinforced even under partial exposure.

5.7 Summary of Results

Overall, the results indicate that the multi-perspective chatbot panel supported deliberative reasoning rather than outcome convergence. Across reflections, students articulated reasoning shifts (including reframing and refinement), integrated ethical considerations with engineering-economic justification, and explicitly described trade-offs among competing objectives. Table 3 summarizes these post-activity patterns by case using conservative, case-level counts.

Table 3. Post-Activity Deliberative Reasoning Patterns by Case

Deliberative Reasoning Pattern	Case A (n=11, %)	Case B (n=10, %)
Reported reasoning shift	8 (73%)	7 (70%)
Ethical-economic integration	7 (64%)	7 (70%)
Explicit trade-off articulation	6 (55%)	7 (70%)
Reference to multiple perspectives	9 (82%)	8 (80%)

Across both cases, the most consistent pattern was reference to multiple perspectives, followed by substantial evidence of reasoning shifts and ethical-economic integration, suggesting that the intervention broadened decision framing more than it prescribed specific outcomes. Supplemental survey responses were broadly favorable, with students rating the case scenarios as realistic and indicating that the activity strengthened recognition of links between economic decisions and ethical responsibility. Altogether, post-activity reflections and, where available, aligned end-of-assignment responses suggest that the primary instructional impact was to support structured deliberation, ethical-economic integration, and the explicit articulation of trade-offs in decision-making.

6. Discussion

The findings from this study suggest that structured exposure to competing perspectives can deepen students' engagement with ethical reasoning within engineering economic decision-making. Rather than replacing or diluting traditional economic analysis, the multi-perspective chatbot intervention prompted students to extend that analysis to account for uncertainty, competing values, and institutional constraints. This pattern aligns with professional engineering practice, where defensible decisions often require justification beyond numerical optimization.

A central insight emerging from the results is a shift from a cost-dominant framing to trade-off-oriented deliberation. Students did not abandon economic reasoning. Instead, they expanded it to incorporate avoided losses, lifecycle uncertainty, and public welfare considerations in ways that reflected professional judgment. In both cases examined, students demonstrated an increased willingness to articulate when higher upfront investments might be justified and when institutional realities might constrain them. This form of reasoning reflects how engineering economy tools are often used in practice: not to identify a single, mathematically optimal solution, but to provide a systematic framework for transparent and defensible decision-making under uncertainty.

Figure 2 illustrates the principal reasoning pathways observed after AI-mediated dialogue. Rather than converging on a single preferred outcome, students commonly refined initial views, reconsidered decision criteria, or reinforced prior positions through stronger justification. The figure emphasizes that instructional impact was characterized by diversified reasoning trajectories rather than solution alignment. This finding reinforces the pedagogical value of multi-perspective engagement, particularly in contexts where ethical and economic considerations cannot be cleanly separated.

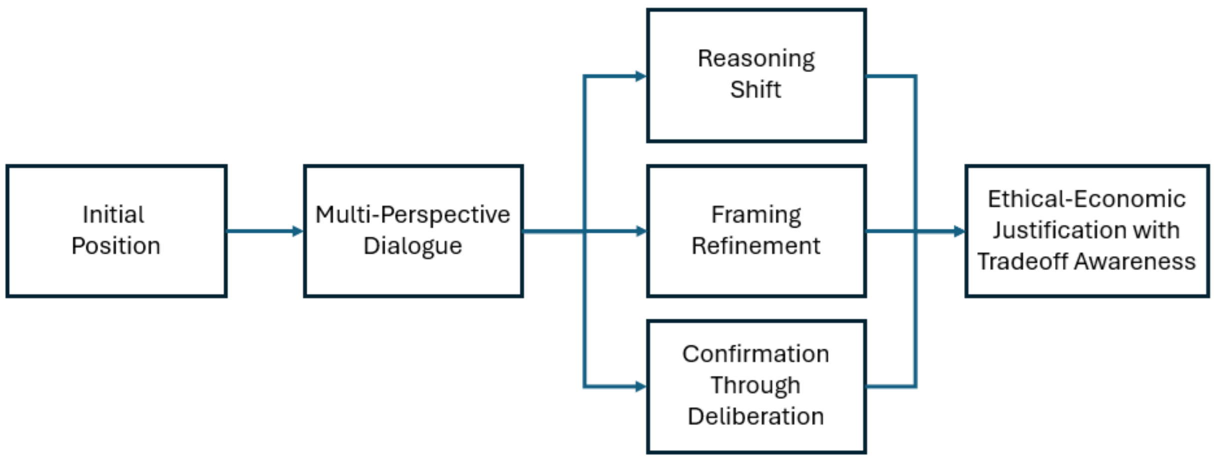

Figure 2. Illustrative deliberative reasoning pathways following AI-mediated dialogue. Common response patterns include refinement of an initial position, reframing of decision criteria, and confirmation through strengthened justification after considering multiple perspectives.

The influence of persona framing raises important instructional considerations. Differences in tone and emphasis across AI personas appeared to shape not only which issues students considered, but how they reasoned about them. While the study does not attempt to establish causal effects of persona variation, the observed patterns suggest that even subtle framing differences can surface latent assumptions and prompt deeper evaluation of trade-offs. This highlights the importance of intentional persona design when using AI-mediated dialogue in engineering education.

Importantly, the use of AI personas did not diminish student agency. Students consistently described the need to reconcile conflicting viewpoints and to take ownership of their final recommendations. The AI system functioned as a structured prompt for deliberation rather than as an authoritative source of answers. This supports a framing of AI as a cognitive scaffold that challenges reasoning and surfaces complexity while preserving student responsibility for judgment.

Collectively, the discussion highlights that the instructional value of AI-mediated dialogue lies in supporting deliberative reasoning rather than directing students toward particular solutions. Through repeated engagement with competing perspectives, the intervention foregrounds justification, ethical-economic integration, and trade-off recognition in ways that align more closely with professional engineering decision-making than traditional case-based instruction.

7. Implications

The instructional approach examined in this study suggests several implications for the design of engineering economy courses. Most notably, it demonstrates a practical method for integrating ethical considerations directly into economic decision-making tasks rather than treating ethics as an external constraint or post hoc reflection. By embedding ethical tension within the same analytic framework used for cost evaluation, the activity reinforces the inseparability of technical, economic, and societal judgment in professional practice. The use of AI-mediated, role-based dialogue also provides a scalable alternative to traditional instructional strategies such as role-play exercises or guest lectures. Structured AI personas allow consistent exposure to multiple perspectives while enabling controlled variation across course offerings. This consistency supports repeatability and instructional alignment while preserving flexibility in case design and implementation.

More broadly, the findings point to the value of deliberative learning experiences in addressing a persistent challenge in engineering economy education: preparing students to justify decisions in ambiguous and constraint-laden contexts. Real-world economic decisions rarely yield unambiguous optima, and instructional designs that foreground synthesis, justification, and trade-off articulation may better prepare students for professional environments where economic analysis informs, rather than dictates, decisions.

Finally, the intervention design is adaptable across a range of engineering economy topics, including sustainability investments, infrastructure planning, capital budgeting, and risk mitigation. While this study focused on two campus-based cases, the underlying structure of multi-perspective engagement and iterative deliberation is transferable to diverse engineering contexts. The activity was intentionally designed for practical classroom deployment, requiring only access to commonly available generative AI tools, structured prompts, and a single class period, making it feasible to adapt across many engineering courses. Instructors can tailor persona roles, case parameters, and interaction sequencing to align with course objectives while maintaining a consistent emphasis on ethical-economic integration.

8. Limitations and Conclusion

8.1 Limitations

This study has several limitations. It was conducted within a single junior-level engineering economy course at a single institution, with the intervention occurring during a single class session and a modest sample size. The analysis emphasizes qualitative patterns in student reasoning rather than causal inference, and the observed differences associated with persona framing are exploratory in nature. The instructor and an additional reviewer coded student artifacts through an interpretive review process. While this approach strengthens analytic trustworthiness, the study did not employ formal inter-rater reliability statistics. In addition, the findings are primarily based on written reflections and recommendations that capture articulated reasoning, rather than on long-term behavioral change or retained learning outcomes.

While AI-mediated dialogue offers consistency and scalability, it also introduces known limitations, including generative bias, rhetorical emphasis, and sensitivity to prompt design. These limitations suggest that the findings should be interpreted as evidence of instructional potential rather than definitive measures of learning impact. Further study is required to examine the durability of effects, sensitivity to case complexity, and generalizability across institutional contexts.

8.2 Conclusion

Despite these limitations, this study contributes a novel and practical instructional approach to engineering economy education. By using AI to facilitate repeated, structured interactions with multiple personas representing distinct professional and stakeholder perspectives, the activity encourages students to move beyond numerical optimization toward ethically informed economic deliberation. Rather than positioning AI as a tutor or decision authority, the design leverages AI as a deliberative scaffold that surfaces competing priorities and challenges student assumptions.

The findings suggest that exposure to multiple, and at times conflicting, perspectives across separate chatbot interactions supported deeper engagement with trade-offs, justification, and professional judgment. Students were prompted to reconcile economic analysis with ethical considerations, mirroring how real-world engineering decisions often emerge through successive rounds of evaluation and critique.

Viewed through the lens of James Rest's Four-Component Model, the observed outcomes are most consistent with gains in ethical sensitivity, judgment, and prioritization rather than alignment with any single ethical position. This framing reinforces the value of deliberative rather than prescriptive instructional designs for preparing students to navigate complex, value-laden economic decisions.

As engineering economy education continues to evolve, instructional strategies that emphasize deliberation alongside analysis may help prepare engineers to make sound, responsible decisions in increasingly complex environments. Future work will expand the analysis of student responses, examine how persona framing and interaction sequencing influence learning outcomes, and explore the application of this approach across institutions, class sizes, and engineering disciplines.

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