Integrating Generative AI Into Construction Education: A Structured Classroom Activity for Reasoning, Reflection, and Responsible Use

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Abstract

As artificial intelligence (AI) continues to reshape professional practices across industries, higher education must prepare students to engage critically, creatively, and responsibly with these technologies to ensure future workforce readiness. While AI tools are becoming increasingly prevalent in construction practice, there is limited pedagogical research on how generative AI can be purposefully integrated into construction education to benefit both instructors and students. This paper aims to explore how generative AI tools—such as ChatGPT, Copilot, Gemini, and discipline-specific applications—can be integrated into construction education to enhance teaching effectiveness and improve student learning productivity and efficiency. The proposed instructional activity engages undergraduate construction students in both technical problem-solving and creative design tasks. Students first complete a task using only their own knowledge and course materials, then revisit the same task with three AI tools of their choice to generate alternative solutions, explanations, or design concepts. They conclude with a written reflection on how AI outputs influenced their reasoning, addressed misconceptions, improved efficiency, or provided new perspectives, and suggest additional ways AI could support construction-related learning. The activity's novelty lies in its multi-tool AI integration, structured reflection process, and comparative evaluation of human- versus AI-generated work. Although empirical results are not yet available, the paper will present the activity framework, sample prompts, and planned qualitative analysis methods. The expected outcome is a practical, adaptable model for embedding AI into construction education that advances responsible AI adoption and prepares future professionals for an AI-enabled industry.

Keywords: generative AI, construction education, AI literacy, reflective learning, problem-solving, design thinking

Introduction

Recent evidence confirms that student adoption of generative artificial intelligence is both rapid and widespread. A 2025 survey by the Higher Education Policy Institute (2025) reports that more than 90 percent of undergraduate students now use generative AI tools, with the majority employing them for assessed coursework, including concept explanation, technical summarization, and text generation. While students report benefits related to productivity and learning support, many also express concerns regarding academic integrity, over-reliance, and uncertainty about appropriate use. Notably, the survey highlights a persistent gap between AI usage and institutional guidance, as relatively few students receive formal training in responsible or reflective AI use. These findings indicate that generative AI is already embedded in students' academic workflows, underscoring the urgency for structured pedagogical frameworks that support ethical, reflective, and discipline-appropriate integration rather than prohibition or ad hoc adoption.

Parallel to this trend in higher education, generative AI tools, particularly large language models such as ChatGPT, are being rapidly adopted across the construction industry for tasks including documentation drafting, estimating support, scheduling logic exploration, building information modeling rule checking, and technical communication. Construction and engineering students are therefore encountering AI not only as an academic aid but also as an emerging professional tool aligned with contemporary industry practice. However, the pace of adoption has outstripped the development of structured educational approaches that guide pedagogically sound, ethical, and reflective use of these technologies within construction education.

Construction-related disciplines, including surveying, building information modeling, estimating, and construction management, rely heavily on procedural reasoning, error analysis, and professional judgment. These competencies are foundational to safe and effective practice. Uncritical or unrestricted use of generative AI in these contexts risks undermining skill development by obscuring reasoning processes, masking errors, encouraging superficial understanding, and promoting excessive reliance on automated outputs. Conversely, outright prohibition of AI tools is increasingly impractical and misaligned with professional realities, as AI-enabled workflows are becoming common in construction practice.

As a result, instructors frequently face a binary and problematic choice: either banning AI entirely or allowing unrestricted use. Both approaches present clear limitations. Total prohibition is difficult to enforce and may ignore evolving industry expectations, while unrestricted use can erode learning outcomes, compromise academic integrity, and weaken students' capacity for independent reasoning. These challenges highlight the need for instructional approaches that move beyond enforcement or avoidance and instead emphasize intentional and pedagogically grounded integration.

When thoughtfully incorporated into coursework, generative AI has the potential to function as a reasoning aid rather than an answer-generating shortcut. A reflective integration approach can preserve human reasoning as the foundation of learning while leveraging AI as a comparative tool that exposes alternative solution strategies, underlying assumptions, and potential errors. Such an approach also supports the development of students' ability to critically evaluate AI-generated outputs, recognize their limitations, and apply ethical and professional judgment in AI-supported decision-making.

In response to these challenges, this paper presents a structured classroom activity framework for integrating generative AI into construction education. The framework emphasizes independent problem solving, systematic comparison between human and AI reasoning, and structured reflection on ethical and professional implications. Rather than positioning AI as a replacement for student thinking, the proposed approach treats AI as a comparative reasoning partner whose outputs must be scrutinized, validated, and contextualized by students.

The primary purpose of this study is to document and share a scalable and tool-independent instructional framework that supports responsible and reflective use of generative AI in construction education. Specifically, the objectives of this paper are to (1) design a three phase classroom activity that balances independent human problem solving with AI assisted reasoning, (2) apply the framework across multiple construction related courses, (3) develop an assessment strategy that evaluates both technical performance and reflective thinking, and (4) demonstrate how generative AI can enhance rather than replace student learning in surveying, building information modeling, and construction management contexts.

Related Work

The emergence of ChatGPT and other generative AI tools has prompted a growing body of research on their role in engineering and construction education. Studies have focused on student and faculty attitudes, classroom implementation, and overall learning impact.

Sajawal (2024) surveyed 269 engineering students on their beliefs about ChatGPT's future in education. While many anticipated positive advancements, concerns about academic integrity, skill erosion, and equitable access were prevalent. Students were divided on whether ChatGPT supports critical thinking, reflecting a complex blend of enthusiasm and skepticism.

Zhao et al. (2025) expanded this perspective by surveying both students and faculty after prolonged exposure to ChatGPT. Students, initially optimistic, became increasingly concerned about plagiarism and over-reliance. Faculty emphasized preserving critical thinking and writing skills. Both groups agreed on the need for clear policies and AI-literacy training. Zhao et al. recommend integrating process-focused assessments and responsible AI-use guidelines to uphold academic integrity while leveraging AI's benefits.

Buyones-Gonzalez (2025) explored ChatGPT integration in an applied statics course for construction engineering students. Over one semester, students reported that AI helped clarify concepts, improve structural reasoning, and encourage reflection. Ethical awareness also increased, particularly around citation and appropriate use. The study suggests that structured AI use can enhance engagement and critical thinking.

Sahraoui et al. (2025) piloted a generative AI workflow in a graduate-level BIM course. Students used an LLM to check Revit models for code compliance. While learning objectives were met, students faced challenges debugging AI-generated code, often due to limited programming skills. Despite increased cognitive load, learners expressed interest in further GenAI integration, underscoring the importance of scaffolding and technical support.

Wang and Fan (2025) conducted a meta-analysis of 51 studies on ChatGPT's educational impact. They found that AI use significantly improved learning performance (effect size $g \approx 0.87$, which is considered a large effect, with values above 0.8 generally viewed as strong, 0.5 as moderate, and 0.2 as small) and had moderate positive effects on perception and higher-order thinking. These outcomes vary by course type, duration, and AI role. The authors recommend scaffolding ChatGPT use with frameworks like Bloom's taxonomy, integrating it into diverse teaching modes, and promoting sustained use over time. They also call for more research into AI's effects on critical thinking and student engagement.

Collectively, these studies show that generative AI, when thoughtfully integrated, can enhance engineering education through improved reasoning, reflection, and engagement. They also highlight the need for ethical safeguards, clear usage policies, and structured implementation to avoid skill erosion and misuse. These insights support the development of reflective, scaffolded AI-integration frameworks, like the one proposed in this paper, to prepare students for responsible AI use in engineering and construction practice.

Methodology

This section describes the implementation of a generative AI-integrated instructional framework across multiple construction-related courses. It presents the instructional context, the course domains selected for implementation, the structure of the learning activity, and the assessment approach used to evaluate student learning outcomes. The experimental setup was designed to examine how generative AI can be incorporated as a reflective reasoning support while maintaining the central role of human problem-solving and professional judgment.

Course Context and Selection

The instructional framework was implemented across undergraduate and graduate courses within a construction-focused engineering curriculum at two United States institutions. Courses were selected based on their strong emphasis on procedural reasoning, spatial modeling, and project planning. These domains require step-by-step logic, error identification, and judgment-based decision-making, making them well-suited for reflective integration of generative AI tools rather than direct answer generation. The following courses were selected for implementation.

Plane Surveying and GPS

In surveying courses, students engaged in applied tasks including closed traverse adjustment, differential leveling computations, coordinate geometry, and GPS error analysis. These activities require systematic calculation, careful attention to measurement precision, and explicit identification of error sources. Such characteristics make surveying coursework particularly appropriate for examining the role of generative AI in quantitative reasoning and error checking while preserving the importance of human judgment.

Revit-Based Architectural Design and Building Information Modeling

In Revit-based architectural design and building information modeling courses, instruction emphasized modeling strategy, system selection, and documentation logic rather than executing software commands. Students were required to justify modeling decisions such as wall system selection, family configuration, and system coordination. Generative AI tools were introduced to support exploration of alternative modeling workflows, enhance spatial reasoning, and surface assumptions embedded in design and documentation decisions.

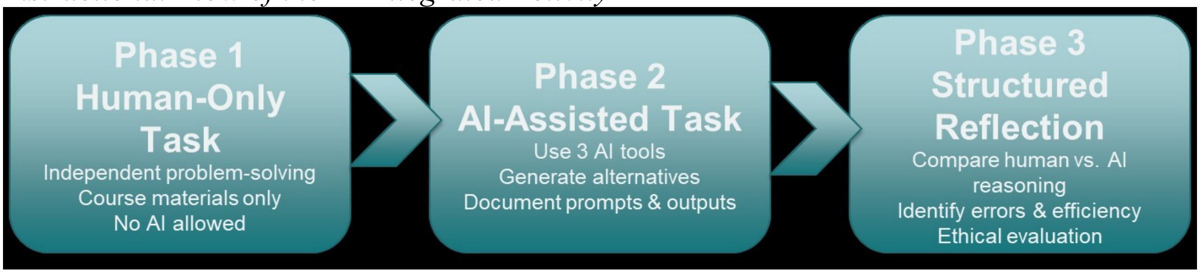
Construction Management

In construction management courses, students focus on estimating, scheduling, sequencing logic, and interpretation of construction documents. Course activities required students to generate and evaluate construction plans and schedules with an emphasis on feasibility, constructability, and consistency with professional standards. AI-generated schedules and cost estimates were compared with student-developed solutions to support evaluation of logic, decision quality, and alignment with industry expectations.

Instructional Framework and Procedure

Figure 1 illustrates the instructional flow of the AI-integrated activity implemented in this study. The activity was organized into three sequential phases that support progressive learning, beginning with independent human reasoning, followed by AI-supported comparison, and concluding with structured reflection.

Figure 1
Instructional Flow of the AI-Integrated Activity



Phase 1: Human-Only Problem Solving

In the first phase, students were required to solve assigned problems independently using standard course materials, lecture content, and their own domain knowledge. Use of generative AI tools was explicitly prohibited during this phase. The purpose was to ensure direct engagement with disciplinary concepts and to establish a baseline solution for subsequent comparison.

Representative tasks included closed traverse adjustment using field notes and computational formulas, selection of wall or roof systems based on project constraints, development of preliminary construction sequencing using Gantt charts, and completion of Revit modeling decisions for specified project scenarios. This phase reinforced technical competency, emphasized accountability, and preserved the central role of human reasoning in problem solving.

Phase 2: AI-Assisted Problem Exploration

After submitting their human-only solutions, students revisited the same problems using up to three generative AI tools such as ChatGPT, Bard, or Copilot. The intent of this phase was not to replace student solutions but to explore alternative reasoning strategies, identify assumptions, and examine how AI systems approach technical decision-making.

Students were required to document the exact prompts used with each AI tool, record the generated responses verbatim, and analyze the reasoning pathways suggested by the AI. They also identified similarities and discrepancies between their own approaches and those produced by AI. Emphasis was placed on evaluating whether AI-generated outputs were logical, efficient, incomplete, or flawed, rather than on adopting them as final answers.

Phase 3: Structured Reflection and Evaluation

In the final phase, students engaged in structured reflection to critically evaluate both their human-generated solutions and AI-assisted outputs. Guided reflection prompts were used to support higher-order thinking and ethical awareness.

Students were asked to examine differences in reasoning and assumptions, assess whether AI identified errors or offered more efficient logic, evaluate risks or inaccuracies present in AI outputs, and consider contexts in which AI use would be appropriate in future professional practice. Through this reflective process, AI was positioned as a comparative reasoning companion rather than a solution provider.

Learning Objectives

The instructional framework was designed to achieve three primary learning objectives aligned with the evolving demands of construction education in an AI-enabled environment.

First, the activity strengthens independent problem-solving by requiring students to complete technical tasks without generative AI assistance. This reinforces foundational skills, supports mastery of discipline-specific knowledge, and maintains the integrity of core engineering competencies. Second, the framework develops students' ability to critically evaluate AI-generated outputs. By systematically comparing human and AI reasoning, students learn to assess accuracy, logic, and underlying assumptions, fostering analytical thinking and professional skepticism essential to construction practice.

Finally, the activity promotes responsible and ethical use of AI. Through structured reflection, students engage with issues related to academic integrity, AI limitations, and appropriate boundaries for AI assistance. This prepares students to navigate ethical decision-making in both academic settings and real-world construction environments. Collectively, these objectives support workforce readiness and reflect the growing role of AI in contemporary construction practice.

Assessment Strategy

A rubric-based grading scheme was developed to evaluate student performance across the three instructional phases. The rubric was applied consistently across participating courses and was designed to capture both technical proficiency and the depth of students' reflective engagement with generative AI tools. Assessment emphasized not only students' ability to solve engineering problems, but also their capacity to critically analyze and ethically evaluate the role of AI in professional tasks.

The first assessment component, Human Only Task Completion, accounted for 30 percent of the total grade. This component evaluated students' ability to independently solve assigned problems without AI assistance. Criteria included the correctness and completeness of solutions, clarity and coherence of reasoning, and adherence to course standards and accepted disciplinary methods. This component ensured that students demonstrated mastery of core technical concepts and independent reasoning prior to AI engagement.

The second component, AI-Assisted Comparison and Analysis, also accounted for 30 percent of the total grade. This portion assessed students' ability to use generative AI tools to revisit the same problems in a critical and structured manner. Students were evaluated on the clarity and completeness of prompt documentation, accurate presentation of AI-generated outputs, and identification of meaningful differences between human and AI reasoning. Emphasis was placed on students' ability to interrogate AI logic, particularly when identifying efficiency gains, flawed assumptions, or alternative reasoning strategies introduced by the AI.

The third component, Structured Reflection and Critical Evaluation, accounted for the remaining 40 percent and placed the greatest emphasis on higher-order thinking. Reflection was assessed based on the depth of students' analysis, including recognition of AI limitations, reasoning errors, and uncertainty. Evaluation also considered students' ethical awareness, specifically their understanding of academic integrity, professional responsibility, and appropriate boundaries for AI use in engineering and construction contexts.

Together, these three components of the rubric were designed to promote AI literacy while reinforcing student ownership of the learning process. The assessment strategy balanced technical rigor with reflective and ethical considerations, supporting the preparation of future construction professionals for responsible engagement with emerging technologies.

Table 1
Rubric for Assessment of AI-Integrated Learning Activity

Performance Level	**Description**		
	Criterion 1: Human-Only Task Completion (30%)	**Criterion 2: AI-Assisted Comparison and Analysis (30%)**	**Criterion 3: Structured Reflection and Critical Evaluation (40%)**
Excellent (A)	Demonstrates clear, logical reasoning and appropriate application of course concepts. Solution or design decisions are well-justified, even if minor computational or modeling errors are present.	Effectively uses multiple AI tools and clearly documents prompts and outputs. Provides a thoughtful comparison between human and AI-generated solutions, identifying differences in assumptions, logic, and accuracy.	Demonstrates deep reflection on how AI influenced understanding, efficiency, and reasoning. Clearly identify AI limitations, misconceptions, and appropriate professional use cases. Shows strong ethical awareness.
Good (B)	Shows generally correct approach and understanding, with some gaps in explanation or minor conceptual errors. Reasoning is present but not fully articulated.	Use AI tools appropriately and document outputs. Comparison identifies some differences but lacks depth in evaluating reasoning or limitations.	Reflects on AI usefulness and limitations with reasonable insight. Ethical considerations are mentioned but not fully developed.

Satisfactory (C)	Attempts the task with partial understanding. Reasoning is incomplete or unclear, and errors indicate conceptual misunderstandings.	AI use is evident but poorly documented. Comparison is superficial, focusing mainly on results rather than reasoning.	Reflection is descriptive rather than analytical. Limited discussion of AI limitations or professional implications.
Unsatisfactory (D/F)	Minimal effort or incorrect approach. Lacks evidence of independent reasoning or meaningful engagement with course materials.	Inappropriate or undocumented AI use. Little to no meaningful comparison between human and AI work.	Reflection is minimal or missing. Shows little awareness of AI limitations, risks, or ethical considerations.

Discussion

The implementation of the AI-integrated instructional framework yielded several notable educational benefits across a range of construction-related courses. Although the study did not employ quantitative measures to assess learning gains, qualitative observations and instructor feedback collected across multiple semesters revealed consistent patterns that highlight the framework's pedagogical value and broader applicability.

One prominent outcome was improvement in students' AI literacy. Through structured and guided interaction with generative AI tools, students developed a more realistic understanding of both the capabilities and limitations of these technologies. Rather than viewing AI as an authoritative source of correct answers, students learned to recognize its strengths, such as efficiency, clarity of language, and synthesis of information, as well as its weaknesses, including logical gaps, overgeneralization, and limited sensitivity to context. This experiential engagement supported students' ability to distinguish between superficially correct outputs and sound reasoning, a critical competency in AI-mediated professional environments.

The framework also strengthened students' critical thinking and analytical skills. The structured comparison between human-generated and AI-assisted solutions required students to identify errors, evaluate assumptions, and justify preferred approaches. This process moved students beyond procedural execution toward deeper engagement with reasoning and decision making. As a result, the activity promoted reflective habits aligned with engineering judgment, particularly in situations involving uncertainty, incomplete information, or competing solution strategies.

Another important benefit was increased workforce readiness. By engaging with generative AI in the context of authentic construction tasks, including estimating, building information modeling, and surveying logic, students gained exposure to AI-supported workflows that are increasingly present in industry practice. Rather than framing AI as either a prohibited shortcut or an opaque tool, the framework positioned it as a professional resource that must be evaluated, validated, and used responsibly. This approach helped bridge the gap between academic preparation and the evolving expectations of the construction industry.

The instructional framework also demonstrated strong scalability and adaptability. Because the approach was tool-independent and did not rely on a specific software platform, it was successfully implemented across multiple courses and content areas. Instructors were able to tailor the activity to different disciplinary contexts, ranging from spatial modeling to scheduling logic, and to accommodate varying levels of student familiarity with AI tools. This flexibility enhances the potential for broader adoption across construction and engineering education programs where reasoning and decision-making are central learning outcomes.

Collectively, these findings suggest several contributions to construction education. First, the framework provides a structured and ethical model for integrating generative AI into technical coursework, emphasizing reflection, responsibility, and critical evaluation rather than answer generation. Second, it demonstrates how systematic comparison between human and AI reasoning can deepen students' understanding of both disciplinary concepts and technological limitations. Third, the successful application of the framework across surveying, building information modeling, and construction management supports its relevance for cross-disciplinary curriculum development. Finally, the approach aligns construction education more closely with emerging industry practices, supporting students' transition into AI-enabled professional environments.

In summary, this work addresses a pressing challenge in engineering education, namely, how to integrate generative AI in ways that enhance learning without undermining foundational competencies. By centering independent reasoning, structured comparison, and ethical awareness, the proposed framework offers a practical pathway for preparing construction professionals who are capable of critical and responsible engagement with AI in future practice.

Conclusion and Future Work

As generative AI continues to shape the construction industry and engineering professions, higher education must evolve to prepare students for AI-integrated practice. Tools like ChatGPT are increasingly used in documentation, estimation, and planning, making it essential for educators to design frameworks that harness AI's benefits while safeguarding learning outcomes and ethical standards.

This paper introduced a structured, three-phase instructional framework that positions generative AI as a reasoning aid rather than a shortcut to answers. By engaging students in independent problem-solving, AI-assisted analysis, and structured reflection, the framework promotes AI literacy, critical thinking, and responsible use. Its adaptability across construction disciplines—such as surveying, BIM, and project management—demonstrates its scalability and relevance to real-world professional demands.

While the initial implementation revealed clear educational benefits, further research is needed to assess long-term impacts. Future work will include formal evaluation of learning outcomes, studies on skill retention, and broader application across engineering domains. By embedding AI thoughtfully into instruction, educators can better prepare students for ethical, reflective engagement with the technologies shaping their future workplaces.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The author declares that ChatGPT, an AI-assisted writing software, was used in proofreading and refining the language used in the manuscript. The usage was limited to correcting grammatical and spelling errors and rephrasing statements for accuracy and clarity. The author further declares that, apart from Grammarly, no other AI or AI-assisted technologies have been used to generate content in writing the manuscript. The ideas, design, procedures, findings, analyses, and discussion are originally written and derived from appropriate and systematic conduct of the research.

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