Case Studies for the incorporation of AI in Civil and Construction Engineering Education

Dr. Souhail Elhouar PE, Bradley University

Dr. Elhouar is a Professor of Civil Engineering and Construction at Bradley University. He holds a M.Sc. and a Ph.D. in structural engineering and a BSc in Building Engineering and Construction and he is a registered Professional Engineer. He teaches a variety of courses in civil engineering and construction management programs.

Dr. Phuong Nguyen, South Dakota State University

Artificial Intelligence, Construction Engineering and Management

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Abstract

The use of Artificial Intelligence (AI) tools on college and university campuses is no longer a luxury that is only available to a privileged few. AI bots such as ChatGPT, Perplexity and others are widely available in free and paid versions with many of them being directly integrated into internet search engines. At this juncture, institutions of higher learning have one of three paths to take: either try to control the use of AI tools by either blocking access to them on their campuses or somehow making it against the rules to use them, do nothing, or, as a third option, regulate their use and strategically integrating them into their educational programs. Institutions that choose to adopt the first approach would most likely end up fighting a losing battle, and those that opt to do nothing will be losing out on an opportunity to adequately prepare their students for professional success. The last group of institutions will undoubtedly benefit their students the most as they would be training them on the appropriate and ethical uses of AI tools, thus adequately preparing them to be leaders in an increasingly AI dependent world. In this paper, the authors investigate approaches that can be used to integrate the proper use of AI in civil and construction engineering education. A comprehensive literature review of examples and challenges of AI integration in typical engineering and construction management courses is first presented. Subsequently, a number of case studies are used to demonstrate instructional approaches and methods of assessment. In conclusion, the authors make recommendations with respect to the dos and don’ts and share a number of best practices that can be adapted to various types of engineering and management courses.

Keywords: artificial intelligence, case studies, construction, civil engineering, education

Introduction

Although the use of Artificial Intelligence (AI) for various every day and business tasks has skyrocketed over the last few years, the integration of AI in construction engineering and management education has been progressing at a slow pace. Many reasons for this slow integration have been cited in the literature, including the misalignment between the industry and education in the use of AI and the limited coverage of AI in current construction curricula [1], the lack of formal training to bridge the AI skill gap in faculty [2], and the lack of documented examples to learn from to aid faculty in achieving a broader integration of AI in construction education [3]. This evidence-based practice paper uses a multiple case-study design, combining a targeted literature review with three institutional case studies of AI integration in civil/ construction engineering courses to help address the lack of documented examples issue.

This paper is organized as follows. The next sections outline the purpose of the study and the research methodology used, including literature search and case study selection procedures. Documented AI-related case studies are then summarized from the literature before presenting three course-based case studies from the authors own instructional practice. This is followed by a cross-case discussion of findings, lessons learned, and best practices. The paper is concluded with recommendations for faculty and directions for future work.

Research objectives

The objective of this study is to help bridge the lack of documented examples gap with a special focus on civil engineering and construction-relevant contexts. The objectives are to: (1) synthesize recent examples of AI integration in civil and construction engineering education, (2) document and compare three course-level implementations of AI across two different institutions, and (3) distill cross-cutting lessons and best practices for responsible, strategic AI integration. These objectives are addressed through the following research questions:

- RQ1: How is AI currently being integrated into civil and construction engineering courses, and what outcomes are reported in the literature and in the authors' own implementations?
- RQ2: How do students perceive and use AI when its use is allowed versus explicitly required in courses at different levels?
- RQ3: In an advanced cost estimating course, how does structured generative AI support influence estimate completeness, documentation practices, and risk-reasoning compared to non-AI offerings?

Research methodology

This study employs a two-part methodology consisting of (1) a structured literature review to identify documented cases of AI integration in civil engineering and construction education and (2) three instructional case studies from the authors' own courses, analyzed using descriptive and comparative methods. By briefly reviewing prior efforts, a broader context is established for these course-based implementations, highlighting common opportunities, challenges, and design patterns that further enrich the study.

To fulfill the goals of the first part of the study and identify relevant case studies in the literature, a structured search using Google Scholar was conducted using discipline-specific keywords, including 'case study', 'artificial intelligence', 'civil engineering education', and 'construction education.' The search, limited from the last ten years, yielded approximately 24,000 results, depending on the number and order of search criteria used. Titles and abstracts were screened from this pool and 18 publications that appeared to include case studies relevant to civil and construction engineering were initially selected. These publications were subsequently reviewed, and only those that 1) related to civil engineering and construction education, 2) reported an instructional implementation using AI tools, and 3) provided some form of assessment or reflection were retained for inclusion in this paper.

In addition to case studies that were documented in the literature and briefly reviewed to establish a broader context, the authors are presenting their own experiences with respect to the integration of the use of AI in their courses. These include a course in introductory mechanics where the use of AI was not specifically required but allowed, and a course in structural design and construction and an advanced cost estimating course where the use of AI was required in a number of assignments. The methodology used for the case studies is presented below and their detailed descriptions are presented in later sections of the paper.

In the introductory mechanics and the structural design and construction courses, the use of AI tools in the course was investigated through homework assignments and a student survey that was administered at the end of the semester. The survey consisted of 17 questions grouped into four themes:

1) prior exposure to and purpose of use of AI tools (e.g. which tools, free vs. paid access, use for personal, coursework, or project related tasks),
2) Perceived confidence in AI-generated information and any access barriers.
3) Perceived impact of AI on assignment difficulty, time spent, and understanding of course material.
4) Self-reported familiarity with AI-related concepts (definition and history of AI, machine learning, data quality and bias, ethics, and workforce/societal impacts).
5) Attitudes toward integrating AI in their curriculum and preferences for an introductory AI course (required vs. elective and desired topics).

The complete survey instrument is provided in Appendix A, and survey results (n=39) were analyzed descriptively to identify best practices and make recommendations for the integration of AI use in similar courses. All course-based data used in this study were collected under the institution's educational research policies. The activities were reviewed and determined to be exempt from formal institutional review board (IRB) oversight because they involved normal educational practices and the analysis of de-identified, aggregate student data. Participation in surveys was voluntary, and no identifying information is reported.

The advanced cost estimating course case study used a comparative study across multiple semesters to assess the usefulness of AI integration. The students in the AI-integrated course were asked to complete a semester-long project that had the same scope and deliverables as projects that were assigned in two previous semesters in the same course, but without AI integration. The students were required to document prompts, validate AI output, and justify their revisions. This requirement made it easier to assess the influence of AI on workflow and the decision making process. Students performance was evaluated using a mix of quantitative and qualitative assessment methods. The influence of AI-integration on student learning and decision making skills was investigated by comparing the results of the assessments between the AI-integrated course offering and the non AI-integrated course offerings. A detailed description of this case study is presented in a later section in this paper.

Documented case studies from the literature

Case studies dating back from about ten years ago were considered for this investigation to illustrate how artificial intelligence has been integrated into civil and construction engineering in recent years. The first case study emphasizes research experience over structured coursework, focusing on interdisciplinary teaming rather than curriculum integration and demonstrates how AI can be used to strengthen collaboration between different engineering disciplines and enhance students' experience. Waynyan et al. [4] described an instructional effort in which undergraduate civil and electrical/computer engineering students collaborated to develop a Knowledge-Based Expert System (KBES), called GEO-Expert, to classify soils using three standard systems. This case study was not related to a specific course but was part of an effort to promote an interdisciplinary academic setting in which the latest state-of-the-art AI applications are introduced to undergraduate students, thus encouraging them in early involvement in research. The civil engineering students reported a deeper understanding of soil classifications after being engaged in encoding the rules, and the electrical and computer engineering students acknowledged an increased appreciation for their ability to support practical engineering applications with their programming skills. The students also strongly agreed that the experience raised their self-confidence as researchers and helped improve their communication skills, in addition to raising their motivation to engage in research.

One of the key findings of the case study is that the integration of AI tools into an undergraduate civil engineering curriculum using a KBES platform and problem-based research (PBR) is not only feasible but can also significantly enhance problem-solving, critical thinking, and communication learning outcomes while reinforcing interdisciplinary collaboration. The authors recommend expanding this model by integrating AI tools into other civil engineering courses stating that an expandable KBES can serve as an educational tool as well as research platform.

The second case study is focused on a quantitative assessment of AI learning efficiency among civil engineering students in Taiwan. The study that was reported by Chiang [5] involved surveying 237 students from eight Taiwanese universities offering AI-related courses such as machine learning, deep learning, and AI applications in civil engineering. The survey questionnaires were based on two input categories, student engagement and college engagement, and four output categories: interdisciplinary skills, reflective behavior, recognizing disciplinary perspectives, and incentive outcomes. The author applied a traditional and a novel data envelopment analysis (DEA) to assess students' AI learning efficiency, treating them as decision-making units (DMUs). The study identified three distinct groups in terms of outputs and efficiency that are directly linked to the inputs. This means that the group that achieved higher outputs exhibited distinctly higher inputs, which are related to student and college engagement. The key findings of the study focused more on the low-outputs group, which exhibited significantly lower inputs and efficiency when compared to the other two groups. To improve the AI learning outputs for this group, the author recommended improving student engagement through self-discipline (no phones in the class and arriving to class on time), effective teaching practices, frequent interactions with faculty, attending expert meetings and seminars, and learning with peers.

In a study that emphasized alignment across the education-training-practice continuum rather than individual course implementations, Jelodar [6] synthesized 19 case studies across education, training, and practice, identifying gaps in AI integration that limit job-ready skills, leadership development, and workflow efficiency. While education boosts foundational learning and training improves task skills, both fall short on strategic competencies due to high implementation costs and resistance to change. The author recommends hybrid AI-human models, industry-academia collaboration, phased adoption, and curricular reform to achieve comprehensive AI literacy.

The next case study describes an implementation that emphasizes short-term intensive training with mixed professional/academic audiences rather than semester-long curriculum integration. Khodabakhshian and Re Cecconi [1] aimed at bridging AI advancements with practical construction management activities through hands-on applications. Their hybrid program involved 162 participants from industry and academia through six sessions on AI techniques, including machine learning, computer vision, probabilistic models, and digital twins applied to construction tasks. The sessions addressed real world challenges like scheduling, cost estimation, safety, and resource allocation. Participant satisfaction, learning outcomes, and AI's transformative potential in the field were all evaluated. The authors reported that the sessions received high ratings with sentiment analysis showing two-thirds positive feedback on the relevance of AI to risk management, scheduling, and safety. The authors concluded that, the integration of AI into construction management education is essential for the preparation of future professionals. They recommended the inclusion of more hands-on Python coding, problem-based learning, inclusive content for diverse backgrounds, and improved access to educational resources.

Maalek [7] focused on code generation for non-programmers in digital construction modules by implementing Large Language Models (LLMs) like ChatGPT in a flipped classroom with blended learning lessons and problem-based learning (PBL) assignments and projects in a master's level course. The implementation focused on two modules: Digital Engineering and Construction (DEC) and Digital Technologies in Field Information Modeling (FIM), which were offered over six semesters. The modules included pre-lecture videos, in-class coding activities, individual assignments, and group PBL projects. The stated objectives were to enable non-programmers to generate code for automating construction engineering and management (CEM) tasks without formal coding training, to teach effective LLM interaction to mitigate data biases and AI hallucinations while building project management skills, and to bridge the technological literacy gaps and prepare graduates for digital technological leadership in construction. The author reported that 86.4% of the students fully completed their PBL tasks, which would have been almost impossible to complete without formal training on software programming. Moreover, students' feedback was positive with respect to teaching quality, LLM efficiency, inclusive learning, and skill gains. The author recommended that problems be regularly redesigned as LLMs evolve, teaching advanced topics directly to ensure independent problem formulation and only use LLMs as translation tools for code translation, integrating LLM output validation methodologies, and evaluating LLM capabilities to customize specialized CEM software.

The last case study that was reviewed centers on introducing students with no programming experience to practical AI applications. Okonkwo et al [8] implemented an AI module in a construction materials and testing course. The effort introduced students to AI techniques for predicting concrete compressive strength using historical data, python programming, lectures on AI concepts, and hands-on labs with code templates. Most of the participating students were seniors and juniors with no programming experience. The stated objectives were to enable students to appreciate the power of data and using AI to exploit historical material testing data, teach rapid estimation of material strength using AI techniques when experimental testing is not available, and allow construction students to develop programming skills that would be appropriate for AI. The authors used pre- and post-surveys to assess changes in AI knowledge, learning confidence, and career relevance. An analysis of the surveys showed that the students perceived improvements in their AI knowledge, learning confidence, and career relevance. The authors recommended that AI modules be embedded into existing courses using hands-on labs with code templates.

These literature case studies reveal diverse approaches to AI integration—from interdisciplinary research projects and efficiency analysis to hybrid training programs and targeted modules—while highlighting common gaps in course-level implementation guidance, student AI usage patterns, and systematic curriculum progression. Building on these insights, the authors present three complementary instructional case studies from their own civil engineering and construction courses that address these gaps through structured AI policies, student surveys, and comparative project analysis across multiple semesters.

Case study: mechanics course where the use of AI was not required

This case study was conducted in an introductory engineering mechanics course enrolling 24 undergraduate students. AI use was allowed but not required, and an AI use policy was communicated in the syllabus. This policy is shown here in figure 1. Data sources included: (1) students' written comments on AI use in a selected quiz assignment, (2) a 17-item end-of-semester survey completed by 19 students, and (3) instructor reflections on observed patterns of AI use. Survey responses were summarized using descriptive statistics and thematic coding of open-ended comments to identify recurring perceptions, benefits, and concerns.

Seven out of 24 students reported that they had used an AI tool to help in solving quiz problems and commented on their experiences with it. The students were allowed multiple attempts on the quiz with each attempt generating different versions of the same questions. Because of this setup, many of the students who used the AI tool reported that they used it to try to check their answers for their initial attempts and try to understand what they had done wrong, and they were appreciative of the instant feedback they received from the AI tool. Students also reported using the AI tool to help with unit conversions, develop solution strategies, and to make up for their poor note taking. For example, one student commented that he or she did not write down and was not able to remember what the Greek letter μ signified when placed in front of a unit, and the AI tool helped the student in figuring it out and understanding the concept behind it.

- Use of AI Tools and Bots

  While the use of AI tools is encouraged, students must do so in a way that will help them better understand the material and achieve the course's objectives and goals. To this end, students are invited to observe the following guidelines:

  1. Always indicate that an AI tool was used and the extent of its use when submitting work.
  2. What **you can** use AI for:
     a. Generating a procedure for analysis; however, you must always validate it with what was presented in class.
     b. Verifying results of analyses: students must present their initial work, any corrections proposed by AI, and the corrected work.
     c. Generating sample problems as additional exercises to study with.
  3. What **you cannot** do with AI:
     a. Solving homework problems before or without solving them manually.
     b. During exams – the use of AI tools during exams is absolutely prohibited.
     c. Using AI for any class related work without indicating that it was used.

Figure 1. Course policies dealing with the use of AI

At the end of the semester, the students were asked to complete the 17-question survey that was described in the methodology section of this paper. Nineteen of the 24 enrolled students participated in the survey (n= 19 respondents), the results of which can be summarized by the following seven points:

1. Most of the students (>80%) had a prior exposure to AI with varying levels of use and understanding, with ChatGPT being the most popular among them. Their use was focused on homework help and concept clarification, but they lacked the adequate understanding of basic AI concepts. Moreover, most of the students had a moderate confidence in the information they were obtaining from the AI tool.
2. The students appreciated the guided integration of AI in the course and are likely to perceive a requirement to use AI in the course as appropriate and beneficial.
3. Access barriers to AI tools were perceived as minimal as more than 90% of the students in the class reported no access issues. This finding reduces equity concerns related to the availability of tools.
4. A majority of the students who took the survey (13 out of 19) reported that they had sought the help of an AI tool when it was not required to do so to complete a homework assignment. This finding indicates that students will voluntarily use AI to complete their work, and this reinforces the importance of specifically addressing the responsible use of AI at the start of the course. It also indicates that prohibiting the use of AI or otherwise ignoring the possibility of it being used will leave a gap in the students' understanding of the appropriateness and limitations that need to be observed while using AI.
5. Students who used AI assistance commented that the use of an AI tool did help them better understand course material when used for explanation and clarification. This indicates that AI can effectively be used in introductory engineering courses in support of adequate attainment of learning outcomes, and this is especially true when expectations are distinctly and clearly defined.

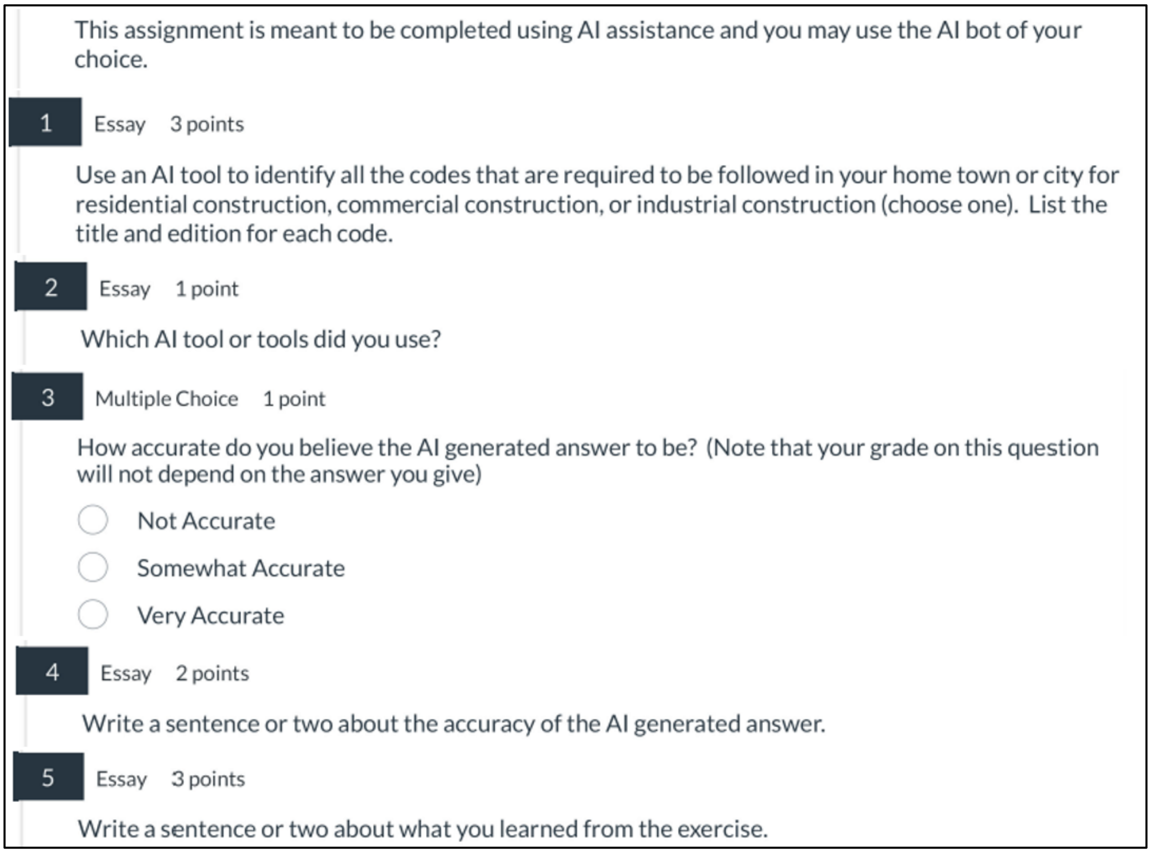
6. While students' perceptions of their understanding of basic AI concepts, such as machine learning, data training, data bias, and data quality was low to moderate, their perception of their understanding of ethical implications and the impact on society and the workforce were mostly and equally moderate to strong.
7. Nearly 85% of the students in this introductory engineering course were of the opinion that an introductory course on AI for non-computer science majors should be part of the curriculum, with 75% of them leaning towards the course being offered as an elective. It was interesting to see that the students had equal interest in all of the topics that were proposed to be included in an AI course, with the topics of ethical concerns related to the use of AI, the impact of AI on the workforce, and machine learning being at the top of the list. The next cohort of topics included concepts related to data quality, concepts related to what AI means, the impact of AI on society, the responsible use of AI, concepts related to data bias, the history of AI, and how to evaluate AI generated content. The topic that these students showed the least interest in has to deal with concepts related to data training.

In summary, the study indicates that an early, guided, and conceptually based AI integration can be very effective in enhancing learning and promoting ethical and responsible AI practices in introductory engineering courses. Students recognized AI as a learning support and clarification tool that is especially helpful for understanding new concepts. The ability of AI to break down problems, reword explanations, and provide examples was valued by the students. AI helped the students in building confidence in their abilities by allowing them to verify their thinking and approach before submitting work, and the students appreciated the immediate accessibility to AI assistance at any time. The students were also aware of the hazards of relying on AI, including overreliance, as it may be tempting to bypass personal effort or serious thinking about a problem, the possible inaccuracy of AI results, ethical pitfalls, and having the illusion of learning adequately while accepting AI generated responses without having a full conceptual understanding of the material.

Case study: structural design and construction course with AI assignments

This case study was conducted in a senior level structural design and construction course enrolling 24 undergraduate construction management students. The use of AI was required in a number of assignments and the same AI use policy shown in Figure 1 was communicated in the syllabus. Data sources included: (1) students' written comments on AI use in related quiz assignment, (2) a 17-item end-of-semester survey completed by 20 students, and (3) instructor reflections on observed patterns of AI use. Here again, survey responses were summarized using descriptive statistics and thematic coding of open-ended comments to identify recurring perceptions, benefits, and concerns.

In each assignment where the use of AI was required, the students were systematically presented with a topic and asked to investigate it using an AI tool of their choice. They were also asked to verify their finding through other sources and means, and finally asked to reflect on their experience of using AI for the assignment. A detailed analysis of each of these assignments is beyond the scope of this investigation, which is focused on lessons learned from the overall integration of AI in the course, but Figure 2 shows the questions from one of the assignments.



This assignment is meant to be completed using AI assistance and you may use the AI bot of your choice.

1 Essay 3 points

Use an AI tool to identify all the codes that are required to be followed in your home town or city for residential construction, commercial construction, or industrial construction (choose one). List the title and edition for each code.

2 Essay 1 point

Which AI tool or tools did you use?

3 Multiple Choice 1 point

How accurate do you believe the AI generated answer to be? (Note that your grade on this question will not depend on the answer you give)

- Not Accurate
- Somewhat Accurate
- Very Accurate

4 Essay 2 points

Write a sentence or two about the accuracy of the AI generated answer.

5 Essay 3 points

Write a sentence or two about what you learned from the exercise.

Figure 2. Sample AI-based assignment in an upper-level structural construction course

Again in this course, at the end of the semester, the students were asked to complete the seventeen-questions survey that is described in the methodology section of this paper with 20 of the 24 enrolled students participating in it. The results of this survey (n=20 respondents) can be summarized by the following eight points:

1. A large majority of the students this course (>85%) reported that they had prior experience with AI and indicated regular use for their course work. This means that the academic use of AI has become a normal routine for upper division students. The students also showed a higher confidence in AI generated output than their counterparts in the introductory course.
2. Students in this course had a goal-oriented application of AI that as well aligned with professional tasks. They primarily used AI to improve efficiency, clarify complex concepts, and support project related work.
3. More than 85% of the surveyed students in this course indicated that the required use of AI was appropriate for the related assignments. This indicates that the upper-level students are receptive to the structured integration of AI in their courses.

4. Here again, access barriers to AI tools were perceived as minimal as more than 90% of the students in the class reported no access issues. Just as was the case for the introductory course, this finding reduces equity concerns related to the availability of tools.
5. Students indicated a gain in efficiency and reported improvement in their understanding of course material because of AI use. Since AI was required to be used in a specific and structured approach in this course, this finding suggests that higher-order learning tasks, such as analysis, synthesis, and evaluation, can very well be supported by its use in higher-level courses.
6. Students reported a low familiarity with basic AI concepts, such as data bias, data quality, and model training. However, this lack of familiarity with the stated concepts did not prevent them from benefiting from the use of AI. This is actually a double-edged sword. On one hand, this shows that it is still possible to benefit from the use of AI for achieving acceptable solutions to advanced problems, but on the other hand, the lack of understanding of the limitations and risks associated with such use may be problematic and lead to inadequate results in some cases.
7. With respect to the question related to the feasibility of integrating AI in every course in their major, the students generally supported AI integration across the curriculum, but they favored a strategic rather than a comprehensive integration. Their preference was for a purposeful and selective integration of AI in some of the courses rather than it being integrated in every course.
8. The students also acknowledged the need for AI literacy and overwhelmingly supported having an introductory AI course for non-computer science majors be offered. The majority of the students expressed preference for the course to be offered as an elective but a notable portion (25%) stated that they preferred for the course to be required.

In summary, the results from the survey and the students' comments indicate that the upper-level students emphasized efficiency, professional relevance, and judgement. They cited the usefulness of AI for drafting, summarizing, planning, and organizing project related work, and they described AI as a professional support tool that can be effectively used for managing workload and streamlining project tasks. They also highlighted the usefulness of AI in supporting higher-order tasks, such as data synthesis and improving the quality of deliverables. Students' concerns focused on the accuracy, depth, and reliability of AI obtained information, noting that the information can be generic or insufficiently relevant to an advanced construction problem. They also identified overreliance as a risk, and emphasized the need for exercising greater responsibility, accountability, and professional judgement.

Case study: advanced cost estimating course with AI assignments

This case study examines the semester-long estimating project in an advanced cost estimating course across three consecutive offerings: Fall 2023 and Fall 2024 (with no generative AI support) compared to Fall 2025 (with structured generative AI support). The generative AI platforms used for the Fall 2025 semester included the free versions of (1) ChatGPT, (2) Perplexity, and (3)

Claude. The project required students to produce a complete preconstruction estimate for a four-story office building: Milwright, located in Minneapolis, including quantity takeoffs, direct and indirect cost development, markups, escalation, contingency, and a narrative of assumptions and risks. The aim was to understand not only differences in estimate accuracy and timeliness but also the quality of students' decision making, documentation, and professional communication under varying instructional approaches to AI. The broader rationale aligns with the paper's position that institutions benefit most when they strategically integrate and regulate AI uses to train students on appropriate, ethical applications rather than ban or ignore these tools.

Table 1. Advanced Cost Estimating Semester Project

Item	**Fall 2023 (Control Group)**	**Fall 2024 (Control Group)**	**Fall 2025**
Class size	23	32	35
AI uses policy	Not permitted	Not permitted	Permitted with strict documentation, human validation required
Primary tools	CAD, Revit, and Navisworks files, specs, cost databases, spreadsheets	CAD, Revit, and Navisworks files, specs, cost databases, spreadsheets	CAD, Revit, and Navisworks files, specs, cost databases, spreadsheets plus approved Gen-AI for narratives, checklists, RFIs
Instructional focus	Foundational estimating workflows, division templates, manual narratives	Foundational estimating workflows, division templates, manual narratives	Ethical AI integration, prompt transparency, AI appendix, verification traceability
Assessment emphasis	Accuracy, scope coverage, manual documentation	Accuracy, scope coverage, manual documentation	Accuracy, completeness, traceability, ethical AI use, risk reasoning
Deliverables	Estimate final report	Estimate final report	Estimate final report and AI appendix

Table 2. Rubric Mapping (2025)

Criteria	Points	Deliverables
Quantity Takeoff Accuracy	20	Sheet/callout references, reconciled subtotals, screenshots of takeoff logs
Cost Calibration and Markups	15	Dated sources, supplier quotes, escalation and contingency rationale, sensitivity
Scope Completeness (CSI/WBS)	15	Division checklists, interfaces & temporaries, GC/GR inclusions
Traceability and Documentation	15	Narrative coherence, assumption register with page references
AI Usage	10	Prompts, timestamps, tool version, adopted/edited/rejected with validation
Risk Analysis and Contingency	10	Quantified risks, linkage to contingency, mitigation strategies
Professional Communication	10	Executive summary clarity, RFIs, vendor outreach artifacts
Workflow Efficiency and Change Management	5	Version control, documented deltas, timely iterations
Total	100	Final Report

Course Design and Instructional Approach

In Fall 2023, the course emphasized manual and semi-digital workflows typical of professional preconstruction teams that do not rely on generative AI. Students used CAD/PDF drawings, specification manuals, vendor literature, and cost databases to develop scope, perform quantity

takeoffs, and build their estimates in spreadsheets. The class scaffolding centered on traditional quality checks: scope matrices, WBS standardization, takeoff audit trails, and peer reviews. The intent was to deepen conceptual understanding of assemblies, systems, and construction means and methods by guiding students through each step without automated text generation or algorithmic summarization. This approach reflected a deliberate choice to cultivate foundational expertise before introducing AI augmentation.
In Fall 2024, the same no-generative-AI policy remained. Additionally, the instructor introduced more structured templates for division-by-division takeoff logs, standardized assumption registers, and a graded pre-final estimate reconciliation milestone. The additional scaffolding clarified expectations and improved the internal consistency of estimates without altering the requirement to manually produce narratives. The course also added targeted mini-clinics on common pitfalls, such as scope creep, double counting, and unit conversion errors, still relying on human review rather than AI-enabled verification. This semester provided a tighter, process-driven control group while preserving the non-AI constraint advocated in the earlier terms.

In Fall 2025, the instructional design explicitly integrated generative AI as a co-pilot while preserving professional verification standards. Students were instructed how to use AI to (1) extract preliminary scope statements from specifications and drawings, (2) draft initial estimate narratives, (3) generate checklists for division-level completeness, and (4) create vendor-query templates and RFIs. Crucially, all AI outputs required human validation: students had to annotate prompts, record the model’s responses, cross-check quantities and unit costs, and mark any revisions with evidence (drawing references, page numbers, supplier quotes). The assessment rubric weighted technical accuracy and traceability over fluency of AI-generated text, reinforcing the paper’s argument that ethical, regulated integration of AI prepares students for leadership in an increasingly AI-dependent industry.

Observed Outcomes

Across the three semesters, estimate accuracy, which was measured qualitatively against the course’s benchmark and historical comparatives for similar office buildings, improved with stronger process scaffolds and, later, with AI-assisted verification. In Fall 2023, students demonstrated solid comprehension of systems (e.g., structural frames, envelopes, MEP assemblies) but frequently missed peripheral scope elements, such as temporary protections, minor site features, or specialty finishes. Errors often stemmed from narrative gaps and inconsistent WBS mapping, not from core quantity calculations. The manual approach fostered deep analytic habits but left some teams vulnerable to omissions that a structured, AI-generated checklist might have flagged earlier. In Fall 2024, students captured secondary scope more consistently and documented assumptions with clearer rationales. Narratives were more coherent, and reconciliation reviews caught double counting and unit mismatches prior to the final submission. Nevertheless, some students struggled to maintain consistency across divisions when late-stage design clarifications arrived, revealing the cognitive load of revising narratives and checklists without automated summarization tools. The gains in accuracy came from better human process, but the time required to re-document assumptions was significant.

In Fall 2025, generative AI most clearly impacted completeness and risk reasoning. Compared to the 2023 and 2024 offerings, the 2025 AI-integrated cohort showed (1) a lower share of total project hours devoted to documentation (a 28.3% reduction in documentation time share), (2) a reduced omission rate on sampled small-scope items (2.7% omissions on items such as firestopping, roof accessories, and temporary protections), (3) median percent variance to the benchmark of approximately 12-13% with a relatively tight interquartile range, (4) AI-log completeness exceeding 96%, and (5) explicit mapping between identified risks and contingency allocations for more than 90% of risks. While cohort sizes and instructional differences across semesters preclude strong causal claims, these descriptive comparisons indicate that structured, documented AI support was associated with more complete scope coverage, richer risk-contingency reasoning, and more efficient documentation.

Table 3. Comparative outcomes

Metric	**Equation**	**Outcomes in Fall 2025**
Documentation efficiency	Documentation time share = (hours on narratives, assumptions, RFIs)/total project hours.	28.32% reduction in documentation hours vs. 2023/2024 baselines.
Scope completeness and omission rate	Omission rate = (the number of omissions caught during peer review)/(total reviewed items).	2.7% omission rate on sampled small-scope items (including firestopping, roof accessories, temporary protections) 75.68% of total cost concentrated in top five drivers with no omissions.
Estimate accuracy versus benchmark (control group)	Percent variance to benchmark = (Estimate Outcome − Benchmark)/Benchmark	Median (variance) = 12.65% and 8.52% IQR across teams.
Traceability	AI-log completeness = (prompts with disposition + validation proof)/(total prompts).	96.45% AI-log completeness.
Risk-contingency coherence	Risk-to-contingency mapping coverage = (the number of risks with explicit cost linkage)/(total risks).	91.36% mapping coverage.

Lessons Learned

The non-AI semesters required substantial time investments in narrative drafting and checklist creation. While this deepened understanding, it diverted hours from higher-value validation tasks such as vendor quote triangulation or sensitivity analysis of escalation and contingency. In contrast, Fall 2025's AI-supported workflow reduced drafting time and helped students iterate faster on revisions when design clarifications arrived. Students reported (in reflective memos) that AI-generated first drafts, when annotated and corrected, made it easier to maintain a consistent estimating story throughout the project. The course design insisted that any AI-produced text be traceable and aligned with the drawings and specifications, thereby turning generative assistance into a structured preconstruction aid rather than a shortcut. These observations reinforce the paper's thesis that strategic AI integration enhances learning when paired with explicit verification and documentation requirements.

Professional communication improved steadily across semesters, but the quality jump in Fall 2025 was most pronounced in the clarity and cohesion of executive summaries and RFIs. Students leveraged AI to propose initial language for vendor outreach and design clarifications, then refined tone and technical specificity to suit professional audiences. The course emphasized prompt transparency and IP/academic integrity: students appended prompt histories and model outputs in an AI appendix, noting where content was adopted, paraphrased, or discarded. This practice mitigated the risk of uncredited AI reliance and taught students to differentiate between generative text and the authoritative sources (drawings, specs, code references). The ethical framing mirrors the paper's recommendation that institutions train students in appropriate and responsible AI use rather than prohibit it.

The manual semesters revealed predictable estimating pitfalls, including scope omissions at interfaces, unit conversion mistakes, and inconsistent application of markups. The Fall 2025 cohort encountered a different set: over-confidence in AI-suggested assemblies and occasional hallucinated quantities when prompts were too general. Mitigation came from explicit course rules: AI could not be used for final quantities without human measurement and citation, any AI-derived content had to be reconciled with drawing callouts and specification sections. The emphasis on traceability turned AI into a catalyst for better internal controls rather than a source of unchecked shortcuts, consistent with the paper's stance on integrating AI tools with rigorous educational scaffolds.

Comparing the three semesters suggests that the most effective learning occurs when AI is embedded within a verification-first culture. Manual practice (Fall 2023) builds foundational estimating instincts, process scaffolding (Fall 2024) strengthens consistency and catches many human errors, and carefully governed AI support (Fall 2025) makes documentation more complete and risk reasoning more nuanced while freeing time for validation and market analysis. Future offerings can capitalize on this progression by continuing to grade for traceability (drawing/spec citations), maintaining the AI appendix for transparency, and reserving a substantial portion of points for independent quantity verification and cost calibration. These steps reflect the broader argument of the paper: integrating AI in civil and construction engineering courses rather than banning or ignoring it which equips students for professional success in an increasingly AI-dependent world.

Conclusions and summary of lessons learned and best practices

This paper presented a number of case studies of the integration of AI in civil engineering and construction education both from the literature and the authors efforts. The case studies covered AI integration efforts at multiple levels of education and dealing with a diverse number of topics in civil engineering and construction management. A number of lessons were learned from these case studies and they were presented with each one of them individually, but across the three case studies and the reviewed literature, five practical lessons emerged:

1. Explicit AI use policies help set expectations and reduce ethical ambiguity.

2. Requiring documentation and validation of AI output redirects effort toward critical thinking.
3. Early, guided AI exposure in introductory courses supports conceptual understanding and responsible use.
4. Structured AI assignments in upper-level courses can enhance efficiency and professional communication without replacing foundational skills.
5. AI is most effective when integrated into a broader assessment framework that values traceability, risk reasoning, and alignment with industry practice.

Moreover, a number of best practices may be inferred from the case studies but the list below includes the most critical of them for simplicity and conciseness of presentation:

1. Explicitly stated AI use policies should be included in the syllabi. These policies should clearly outline the expectations, limitations, and requirements associated with the use of AI in the course.
2. Comprehensive documentation should be required when AI is used. Examples of documentation include prompt histories, outputs, timestamps, adoptions, edits, …This will ensure traceability and ethical integrity.
3. A rigorous human validation of AI produced results should be mandated and AI output should not be accepted for final calculations without documented verification.
4. Embed hands-on activities in courses by integrating modules within labs and providing code templates.
5. Pre- and post-surveys should be used to assess AI knowledge, learning confidence, and barriers to learning to improve practices and provide additional training when needed.
6. Ensure a strategic sequencing in the curriculum progressing from manual workflows to AI integration while avoiding blanket integration across all courses.
7. Foster strong ties between academia and the industry and aim at creating interdisciplinary hybrid models to align education with job ready skills.

The findings from this study underscore that carefully designed AI integration can support core learning outcomes in construction and civil engineering education, and the lessons learned and recommended best practices will enhance the efforts to integrate AI, particularly in areas related to construction management, engineering decision making, and ethical professional practice.

References

[1] A. Khodabakhshian and F. Re Cecconi, “AI in Construction Project Management education: Insights from the ‘AI for Construction Project Management’ Summer School,” in Proc. 23rd CIB World Building Congress, 2025.

[2] L. I. Obi, I. C. Osuizugbo, and B. O. Awuzie, "Closing the artificial intelligence skills gap in construction: Competency insights from a systematic review," Results Eng., vol. 27, Art. no. 106406, Jul. 2025, doi: 10.1016/j.rineng.2025.106406.

[3] N. K. A. Antwi, M. Arham, and K. A. B. Asare, “AI in Construction Education: A Case Study on Introducing No-Code Computer Vision Modeling Through Project-Based Learning,” EPiC Series in Built Environment, vol. 6, pp. 31–40, 2025.

[4] Y. Wanyan, X. Chen, and D. Olowokere, "Integration of artificial intelligence methodologies and algorithms into the civil engineering curriculum using knowledge-based expert systems: A case study," Engineering Education Letters, vol. 2017, no. 3, pp. 1-15, 2017, doi: 10.5339/eel.2017.3.
[5] T. Chiang, "Estimating the Artificial Intelligence Learning Efficiency for Civil Engineer Education: A Case Study in Taiwan," Sustainability, vol. 13, no. 21, p. 11910, Oct. 2021
[6] M. B. Jelodar, "Generative AI, Large Language Models, and ChatGPT in Construction Education, Training, and Practice," Buildings, vol. 15, no. 6, p. 933, Mar. 2025
[7] R. Maalek, "Integrating Generative Artificial Intelligence and Problem-Based Learning into the Digitization in Construction Curriculum," Buildings, vol. 14, no. 11, p. 3642, Nov. 2024
[8] C. Okonkwo, R. Lan, I. Awolusi, and J. Cai, "Integrating Artificial Intelligence into Construction Education: Assessing the Impact on Students' Perception of Knowledge, Confidence, and Relevance to Career," in Proceedings of the 2025 ASEE Gulf-Southwest Annual Conference, Arlington, TX, USA, 2025, Paper ID #49642

Appendix A: Summary of student survey instrument

1. AI tools they have used prior to taking the course and which they have used the most.
2. What they have used an AI tool for. Students were asked to identify as many as applicable among the following items:
    a. Entertainment,
    b. Finding information for personal use,
    c. Helping with personal tasks such as writing for personal use, planning, strategizing, …
    d. Helping with projects and assignments,
    e. Or any other use other than the ones listed above.
3. The level of confidence they had in the information they received from an AI tool before they took the course.
4. when AI was required to be used for an assignment, was the requirement appropriate for the assignment?
5. If they had any issues accessing an AI tool when the use of AI was required for an assignment.
6. The AI tool they used when the use of AI was required for an assignment.
7. Which type of AI tool they used (free basic version or a professional version they paid for or obtained through their school).
8. If the use of AI made it easier or harder or if it did not make a difference in their ability to complete the assignment.
9. If the use of AI made them spend more or less time to complete their assignments or if it did not make a difference.
10. If they felt the use of an AI tool was more or less beneficial to them when compared to similar assignments that they completed without using AI or if it did not make a difference.
11. If they used an AI tool for completing assignments for which the use of AI was not required, if that use helped them gain a better understanding of the material, and if it helped them complete their assignment faster.
12. If the use of AI helped them achieve the course learning outcomes, and
13. If they had faced any ethical issues while using AI for school related work.
14. To comment on the advantages and disadvantages of using AI in courses they took
15. If they thought AI should be integrated in every course in their major
16. To rate their familiarity with a variety of AI related topics, such as the definition and history of AI, machine learning, concepts related to data training, quality, and bias, ethical concerns related to the use of AI, and the impact AI might have on the workforce and society in general.
17. And finally, if an introductory AI course should be offered in their program, if the course should be required or elective, and what topics it should cover.