Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
Paper ID #46348

Integrating AI Chatbot Development in Construction Engineering and Management Education

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Abstract

The construction industry is undergoing a significant digital transformation, with generative artificial intelligence (AI) enhancing efficiency, precision, and decision-making. However, construction engineering and management (CEM) education lacks hands-on AI implementation opportunities. This study addresses this gap by developing and implementing a novel assignment where 78 undergraduate and graduate students developed custom AI chatbots for construction tasks using no-code platforms.

The methodology combined video tutorials, hands-on activities, and peer reviews. Students created AI chatbots to automate quantity takeoff calculations and deployed them on personal websites. Graduate students completed an additional independent assignment with minimal guidance. Effectiveness was evaluated through peer reviews, discussion boards, and pre- and post-assignment surveys.

Results showed significant improvements in students' understanding of AI technology, construction cost estimation, and AI integration. Peer reviews highlighted the chatbots' accuracy, functionality, input handling, and problem-solving capabilities. Students found the assignment moderately easy and highly relevant to their careers. Discussion board analysis provided insights into student challenges, AI perceptions, and chatbot improvements. The end-of-course survey reinforced the effectiveness of combining in-class activities with video tutorials for teaching new technologies.

This study contributes to CEM education by providing a practical framework for hands-on AI implementation. It makes advanced technology accessible without requiring extensive programming knowledge while addressing real-world construction challenges. The validated assignment materials, available online (https://www.electriai.com/electriai-lab/asee25-chatbot), offer a scalable model for integrating emerging technologies into CEM curricula. These findings highlight the potential of structured AI education in preparing future construction professionals for a technology-driven industry.

Introduction

The construction industry is experiencing a rapid digital transformation, with AI emerging as a pivotal technology for enhancing efficiency, accuracy, and decision-making processes [1]. As the industry evolves, there is a growing need to prepare future construction professionals with the skills necessary to leverage AI technologies effectively. While AI adoption in construction continues to accelerate, there remains a significant gap in CEM education regarding practical, hands-on experience with AI implementation [2], [3].

The integration of AI into CEM education presents both opportunities and challenges. Traditional CEM curricula often focus on theoretical concepts and established methodologies, with limited exposure to emerging technologies [4]. This approach creates a gap between traditional

education and the skills needed for an increasingly AI-driven industry. Moreover, while many educational institutions acknowledge the importance of AI literacy, there is often hesitation to incorporate AI into coursework due to perceived complexity and technical barriers [5], [6]. Walter [7] found that many teachers feel overwhelmed by AI technology and lack sufficient knowledge about how it could best be used, with some institutions lacking dedicated resources or financial support for AI training and implementation.

This study addresses these challenges by introducing a novel approach to integrating AI chatbot development into CEM education. By utilizing no-code platforms and focusing on practical applications, the approach makes AI technology more accessible to students without requiring extensive programming knowledge. The study specifically focuses on teaching students to develop custom AI chatbots for construction-specific tasks, such as cost estimation and project management, providing them with valuable hands-on experience in applying AI solutions to real-world construction challenges. The full details of the assignment used in this study, including tutorial videos, rubrics, and supplementary resources, are available on a dedicated website (https://www.electriai.com/electriai-lab/asee25-chatbot).

Literature Review

Using Scopus, the study searched for publications on the keyword "AI Chatbot" within article titles, abstracts, and keywords. As of January 2025, 1,424 relevant publications were identified. Figure 1(a) illustrates the growth in the number of publications over the years, while Figure 1(b) highlights the distribution of publications across various disciplines. Research interest in AI chatbots has grown exponentially over the past few years, signaling their increasing importance in both academic and professional domains.

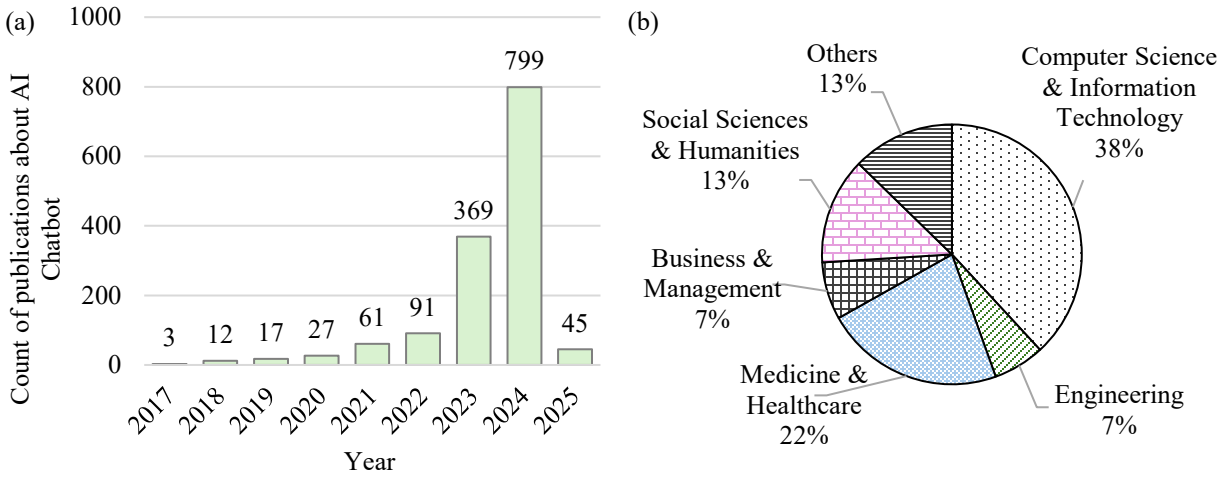


Figure 1. Count of publications discuss AI Chabot

The distribution of publications across disciplines shows that 38% are in the fields of Computer Science and Information Technology, reflecting the technical foundation of chatbot development. Key sources of publications include Lecture Notes in Computer Science (36 publications), ACM International Conference Proceeding Series (28 publications), Communications in Computer and

Information Science (23 publications), and Computers and Education: Artificial Intelligence (13 publications). Engineering-related research represents 7% of the total publications (91 studies), with a subset of five focusing specifically on CEM. Notably, the ASEE Annual Conference and Exposition has contributed three publications explicitly mentioning AI chatbots, further highlighting their relevance in engineering education and research. Although still a relatively new research area, AI chatbot studies are rapidly becoming more significant across a variety of fields, including CEM. This growing body of research underscores the potential for chatbots to address discipline-specific challenges, such as improving efficiency, cost estimation, and project management in the construction industry.

While numerous studies have explored AI chatbots in CEM, most focus on using existing general-purpose AI tools rather than teaching students to develop custom solutions. In academic settings, general-purpose AI tools like ChatGPT, Claude 3, and Gemini have generated significant discussion and applications. For instance, Campbell [8] demonstrates their use in automating VBA code creation for Excel in steel design courses, while Cortez & Schmelzenbach [9] shows their potential in MATLAB coding assistance. Further educational applications include AI's integration into academic advising [10], engineering education [11], and cognitive flexibility development for smart city initiatives [12]. While some industry applications, such as Fernandes et al.'s [13] DAVE system, demonstrate custom GPT-powered solutions for BIM environments, our study uniquely focuses on teaching students to develop and deploy their own custom AI chatbots. Through our approach, students learn to create chatbots that can be deployed on their own websites and easily shared with stakeholders, without requiring extensive programming knowledge. By emphasizing tailored prompt engineering and leveraging no-code platforms, students learn to create industry-specific solutions that address distinct challenges in construction. This approach not only introduces students to practical AI implementation but also equips them with the skills to develop and share targeted solutions that can be readily accessed and utilized by construction professionals.

Methodology

This study employed a structured approach to develop and evaluate the integration of AI chatbot development into CEM education. The methodology was designed to assess student learning performances, and the overall effectiveness of the assignment in achieving educational objectives. The assignment aimed to introduce students to foundational concepts of AI chatbot integration, equip them with practical skills in applying AI chatbot tools, and evaluate the accuracy, relevance, and impact of AI outputs in enhancing construction project efficiency. The study involved both undergraduate and graduate students enrolled in different courses. Undergraduate participants were part of the "Project Planning & Regulations" course, divided into two sessions, with most majoring in Civil Engineering (CE) (84%) and the rest in Environmental Engineering (EE) (16%). Graduate students were enrolled in the "Comprehensive Estimating" course, part of a Master of Science in Engineering program focusing on Construction Management (CM). This graduate course is delivered asynchronously, requiring students to watch recorded videos each week and complete weekly assignments. Table 1 summarizes the demographics among the participants.

Table 1. Demographics among the participants

Class	Delivery Mode	Levels	Major			Gender	
			CE	EE	CM	Male	Female
Project Planning & Regulations (Session 1)	In-Person	Undergraduate	34	3		29	8
Project Planning & Regulations (Session 2)	In-Person	Undergraduate	25	8		24	9
Comprehensive Estimating	Asynchronous Online	Graduate			8	5	3

Figure 2 provides a summary of the study methodology. The process begins by presenting students with a real-world construction problem (e.g., cost estimation for windows in construction), encouraging them to evaluate multiple solution strategies. After exploring various alternative solutions, including traditional approaches, students are guided through the creation of AI chatbots using a combination of detailed instructional videos and hands-on in-class activities. Once they develop their chatbots, students participate in a structured peer review, evaluating each other's work based on a predefined rubric. This step fosters collaborative learning and critical assessment skills.

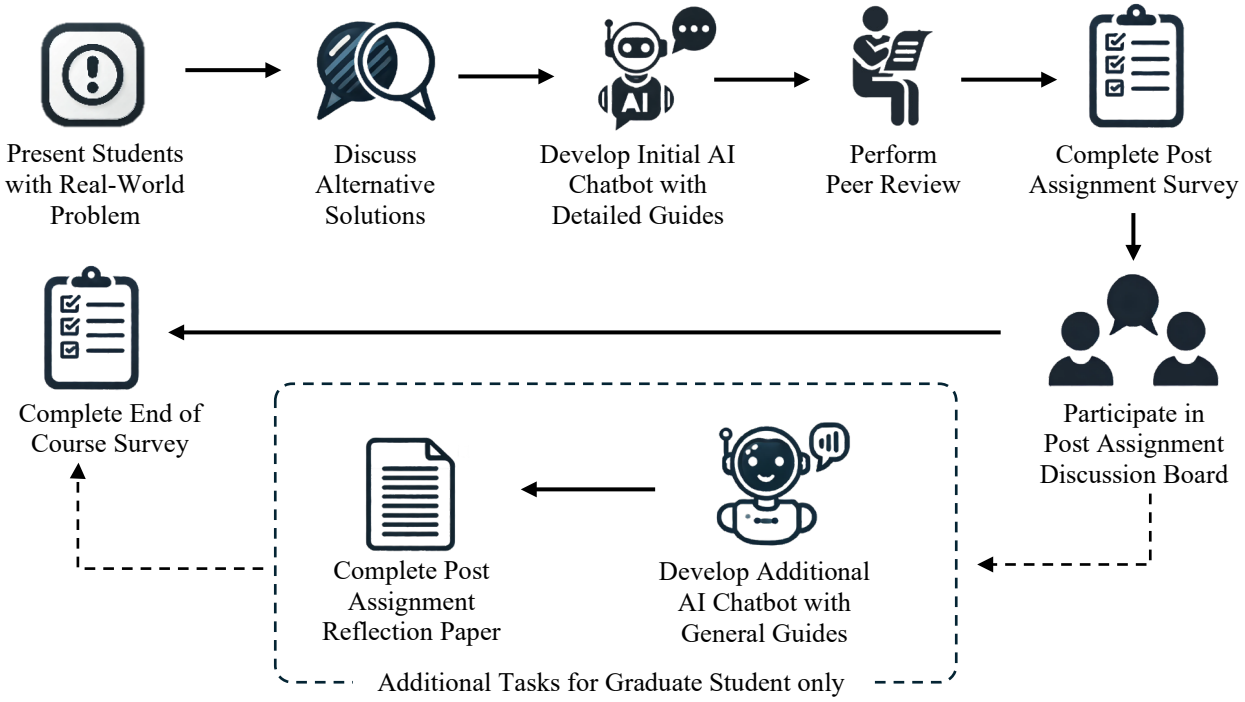


Figure 2. AI Chatbot Development Methodology for CEM Education

To further promote collaboration and knowledge exchange, all students participate in an online discussion board to share insights, challenges, and novel ideas related to AI chatbot development. Graduate students are assigned an additional task requiring them to develop a second AI chatbot. For this task, they receive general written guidance instead of detailed instructional videos or in-class hands-on activities. After completing this assignment, graduate students submit a reflection discussing the challenges they encountered and the strategies they employed to overcome them. The methodology concludes with an end-of-course survey to evaluate the effectiveness of the

teaching approaches used in the assignments. This survey captures student feedback on their learning experiences, providing valuable insights for refining future educational practices.

Initial AI Chatbot Development Assignment with Detailed Guides

Students are introduced to a cost estimation task for Division 8 Openings in the CSI MasterFormat (e.g., windows and doors). The assignment consists of two parts: quantity takeoff and pricing using RSMeans. This study focuses on the first part, aiming to enhance the efficiency and accuracy of the quantity takeoff process. The quantity takeoff involves interpreting construction drawings, specifically focusing on the schedules for windows and doors. Students are guided to examine these schedules and discuss methods for conducting the quantity takeoff effectively. Figure 3 illustrates a portion of the schedule table used in the assignment.

FIRST FLOOR WINDOW SCHEDULE

No.	STYLE	SIZE		PROTECTION		MATERIAL	MFR
		WIDTH	HEIGHT	SHUTTER	IMPACT		
101	SINGLE HUNG	3’-1”	5’-3”				PGT
102	SINGLE HUNG	3’-1”	5’-3”				PGT
103	FIXED GLASS	4’-0”	4’-0”				PGT
104	SINGLE HUNG	3’-1”	5’-3”				PGT
105	FIXED GLASS	3’-1”	2’-0”				PGT
106	SINGLE HUNG	3’-1”	5’-3”				PGT
107	SINGLE HUNG	3’-1”	2’-0”				PGT
108	FIXED GLASS	3’-1”	6’-4”				PGT

Figure 3. Portion of Division 8 openings schedule table

Initially, most students suggested copying the table into Microsoft Excel to perform manual calculations. However, they quickly discovered that the table could not be directly copied into Excel with the correct formatting. Some students proposed manually entering each number into Excel, which was time-consuming and prone to errors. At this point, the instructors introduced a discussion of alternative approaches to help students explore more efficient solutions:

- *Alternative 1 (Manual Method)*: In this approach, dimensions were manually extracted from the PDF file and entered into MS Excel. Students converted each line of dimensions from feet and inches (e.g., 3’6”) to inches (e.g., 42”) and calculated the areas manually. This option required significant amounts of time and effort.
- *Alternative 2 (Semi-Automated)*: Using Bluebeam Revu 20, students extracted the door and window schedule tables into MS Excel. Bluebeam Revu is a powerful PDF markup and editing tool widely used in construction and engineering for tasks such as annotating, measuring, and extracting data from PDF files [14]. It was provided to students under a free academic license. Students then used MS Excel’s "Text to Columns" function to separate feet and inches into distinct columns, which allowed for area calculations with less manual input compared to Option 1.
- *Alternative 3 (Automated with General Conversational AI)*: Dimension texts for doors and windows were extracted using Bluebeam Revu 20.

    - *Alternative 3a (ChatGPT Free)*: Dimensions were converted from feet and inches to inches and areas are calculated using ChatGPT-4o-mini (free version).
    - *Alternative 3b (ChatGPT Plus)*: A similar conversion process was performed using ChatGPT-4o (paid version).
- *Option 4 (Custom Chatbot Solution)*: Dimension texts were extracted using Bluebeam Revu 20 as in Option 3.
    - *Alternative 4a (without parameters adjustment)*: Calculate areas using Different AI models (e.g., GPT-3.5 Turbo, GPT-4, GPT-4 Turbo, GPT-4o, GPT-4o-mini) without adjusting AI parameters. The developed chatbot is posted on a personal website which enables broader access and feedback from potential users.
    - *Alternative 4b (with parameters adjustment)*: The same AI models were tested with adjusted parameters, such as temperature, top P, frequency penalty, and presence penalty, to enhance performance.

Students discussed the merits and limitations of each approach based on their experiences. They noted that Option 1, being entirely manual, required the most time due to the labor-intensive effort of extracting and processing data. While straightforward, this method was inefficient and prone to human error. In contrast, Option 2 significantly reduced the time required by automating parts of the process, such as extracting schedules and converting data using Microsoft Excel functions. This approach was recognized as more efficient than Option 1 but still involved a notable amount of manual effort.

Option 3 was evaluated as faster than Option 2, leveraging conversational AI models for automation. However, its accuracy ranged from 70% to 90%, meaning it could correctly calculate 7 to 9 areas out of 10 dimensions provided. Additionally, students observed inconsistencies in the output format (e.g., "450," "450 square inches," etc.), which limited its reliability. Option 4a further improved efficiency by preloading the chatbot with task-specific questions, eliminating the need for manual input and enhancing user-friendliness. However, accuracy issues persisted, especially when processing long sequences of numbers where errors were common toward the end of the data. Finally, Option 4b addressed these challenges by optimizing AI parameters (e.g., Temperature, Top P), which improve accuracy and reliability, particularly for complex or lengthy inputs.

Building on the success of Option 4, which is the central focus of this study, students began by creating a simple website using Google Sites. They were guided through a series of four instructional videos, totaling approximately 12 minutes, to develop a website that would serve as a platform for deploying their AI chatbots. They then utilized Chatling to develop and deploy custom AI chatbots on the websites they created. Chatling is a no-code platform allows users to build AI-powered chatbots without coding expertise, offering features such as customization, multilingual support, and seamless embedding on any website [15]. It enables chatbots to be trained on various data sources, like PDFs or website URLs, and provides real-time insights to improve accuracy and functionality. This platform is particularly advantageous for construction and engineering students who often lack programming experience, as it simplifies the development process and allows them to focus on practical applications of AI in their field. An example of a student-deployed chatbot on their website is shown in Figure 4 below.

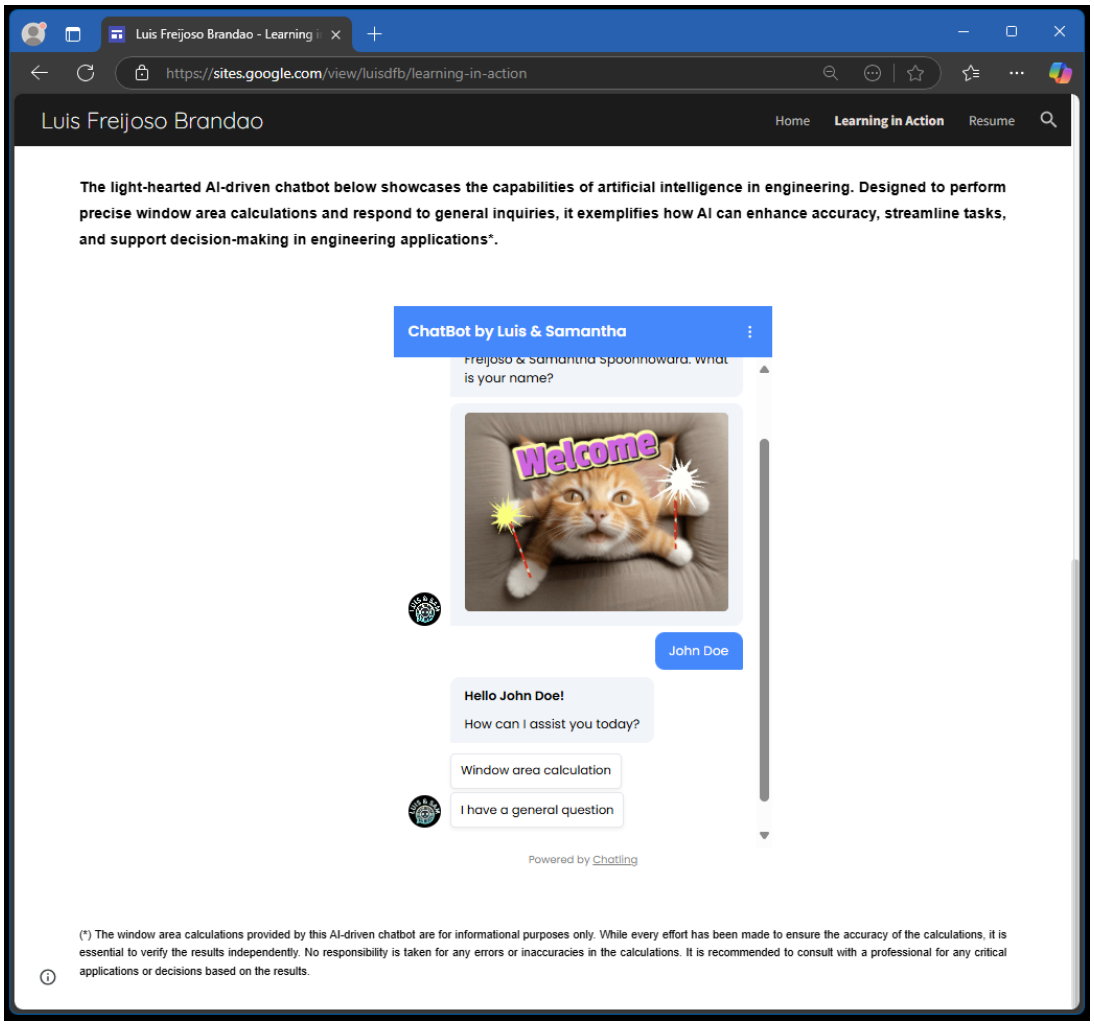


Figure 4. Example of student-deployed chatbot on a website

Undergraduate students were assigned to work in pairs, while graduate students completed the assignment individually. Following the completion of their work, students conducted peer reviews. Undergraduate students were tasked with reviewing the work of four other teams, whereas graduate students reviewed the work of their classmates due to the smaller class size. All students utilized the rubric outlined in Table 2 to perform their peer assessments. The peer review results are summarized in Figure 5. Overall, most students achieved proficiency levels across the four rubric criteria, demonstrating competence in accuracy and functionality, the ability to handle various inputs, clarity of instructions and prompts, and creative problem-solving in chatbot design.

To evaluate the significance of these results, a Shapiro-Wilk test for normality was conducted, revealing non-normal distributions across both groups for all four grading criteria (e.g., Accuracy and functionality: $W = 0.811$, $p < 0.001$). Consequently, the Wilcoxon signed-rank test was employed for paired comparisons. The analysis indicated no significant differences in peer review scores between graduate and undergraduate students.

Table 2. AI chatbot development and evaluation rubric

Criteria	Exemplary (10-9)	Proficient (9-8)	Developing (8-7)	Beginner (7-0)
Accuracy and functionality (25%)	Highly accurate for all tasks. Handles complex requests effectively.	Generally accurate. Manages most tasks well.	Somewhat accurate. Struggles with complex tasks.	Often inaccurate. Handles only basic tasks.
Ability to handle various inputs (25%)	Understand various input types easily. Adapts well to different user styles.	Handles most common inputs. Generally adaptable.	Manages basic inputs. Limited adaptability.	Struggles with different inputs. Not very adaptable.
Clarity of instructions and prompts (25%)	Very clear instructions. Excellent guidance. Easy to use and understand.	Clear instructions. Good guidance. Generally user-friendly.	Clear instructions. Good guidance. Generally user-friendly.	Clear instructions. Good guidance. Generally user-friendly.
Creative problem-solving in chatbot design (25%)	Highly creative solutions. Unique features. Great potential for expansion.	Good problem-solving. Some creative elements. Potential for growth.	Some creative attempts. Mostly standard approaches. Limited growth potential.	Lacks creativity. No unique features. Little room for improvement.

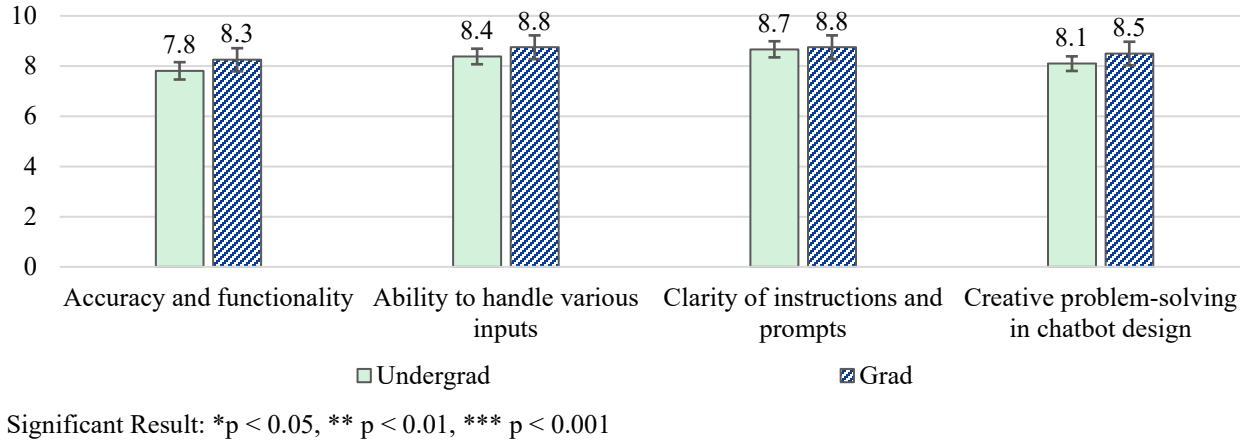


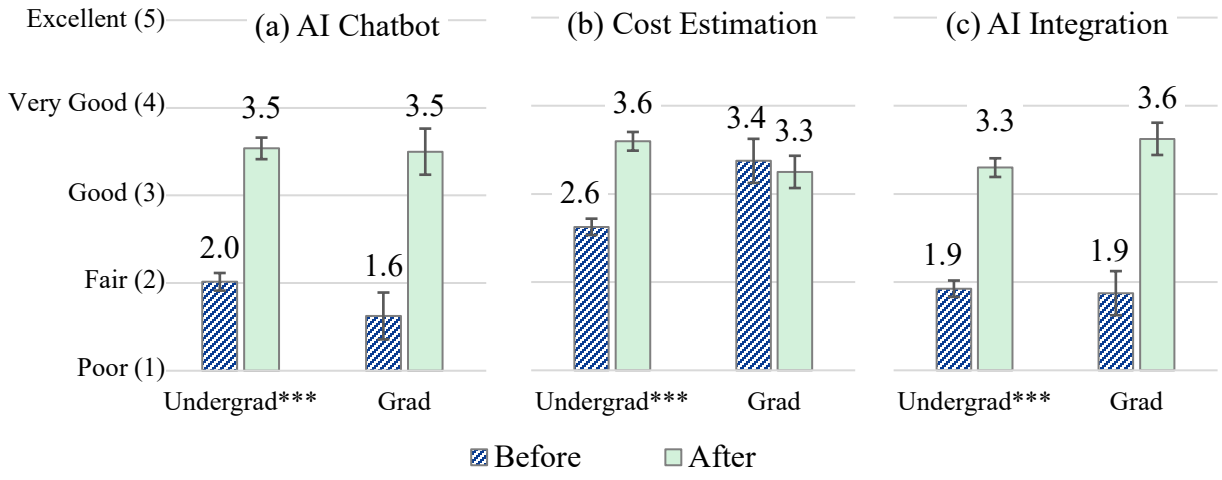
Figure 5. Peer review grades of undergraduate and graduate students

Post-Assignment Survey

As shown in Figure 6, students were asked to evaluate their understanding of three key areas: AI and chatbot technology, construction cost estimation, and AI integration in construction management. Before the assignment, most undergraduate students reported having a fair to good understanding of these topics, while graduate students indicated slightly higher initial understanding level of cost estimation. Notably, for AI integration in construction management, most students rated their understanding as poor to fair. However, after completing the assignment, the majority of students rated their understanding as good to very good across all three areas.

To assess the significance of these improvements, a Shapiro-Wilk test for normality was conducted, which shows non-normal distributions for two groups of all three areas (e.g., AI and

chatbot technology of the undergraduate group: $W = 0.835$, $p < 0.001$). Consequently, the Wilcoxon signed-rank test was used for paired comparisons. The results showed significant improvements in student understanding before and after the assignment for undergraduate students ($p < 0.001$). These findings demonstrate not only an enhanced understanding of AI but also an increased appreciation for its application in construction cost estimation, thereby opening new avenues for integrating AI in CEM education. Although significant results were not obtained for the graduate group due to the small sample size, the results indicate a trend of increased understanding among graduate students. The slight decrease in cost estimation of graduate student group may be due to random errors or variability from the small sample size ($n = 8$) and subjective factors like survey interpretation or external conditions.



Significant Result: *p < 0.05, ** p < 0.01, *** p < 0.001

Figure 6. Student perceptions of understanding before and after chatbot development assignments in (a) AI and chatbot technology, (b) construction cost estimation, and (c) AI integration in construction management

As shown in Figure 7, students were surveyed to evaluate four aspects of the chatbot development assignments: overall difficulty, engagement, career relevance, and the time spent completing the assignment. On a scale of 1 (very difficult) to 5 (very easy), both undergraduate and graduate students rated the difficulty of the assignment between 3 and 4, indicating that the task was generally perceived as leaning towards easy rather than difficult, with undergraduate students finding it slightly easier compared to graduates. When asked about the engagement level of the chatbot development process, undergraduate students rated it at 3.4 (moderately to very engaging), while graduate students rated it slightly higher at 3.8, suggesting that both groups found the assignment engaging, with graduate students showing a stronger perception of its engagement.

Students also evaluated the relevance of the skills learned in the assignment to their future careers in construction. Undergraduate students rated the career relevance at 3.0 (moderately relevant), while graduate students rated it higher at 3.8 (very relevant), indicating that graduate students perceived the assignment as more closely aligned with their career goals. Regarding the time spent completing the assignment, undergraduate students reported spending approximately

3.5 hours on average, including 1.5 hours of in-class hands-on sessions and an additional 2 hours of work at home. In contrast, graduate students spent about 2.5 hours on average, reflecting a lighter time commitment compared to undergraduates. Overall, the results demonstrate that the chatbot development assignment was perceived as moderately easy, engaging, and relevant to students' careers, with manageable time requirements for both undergraduate and graduate students.

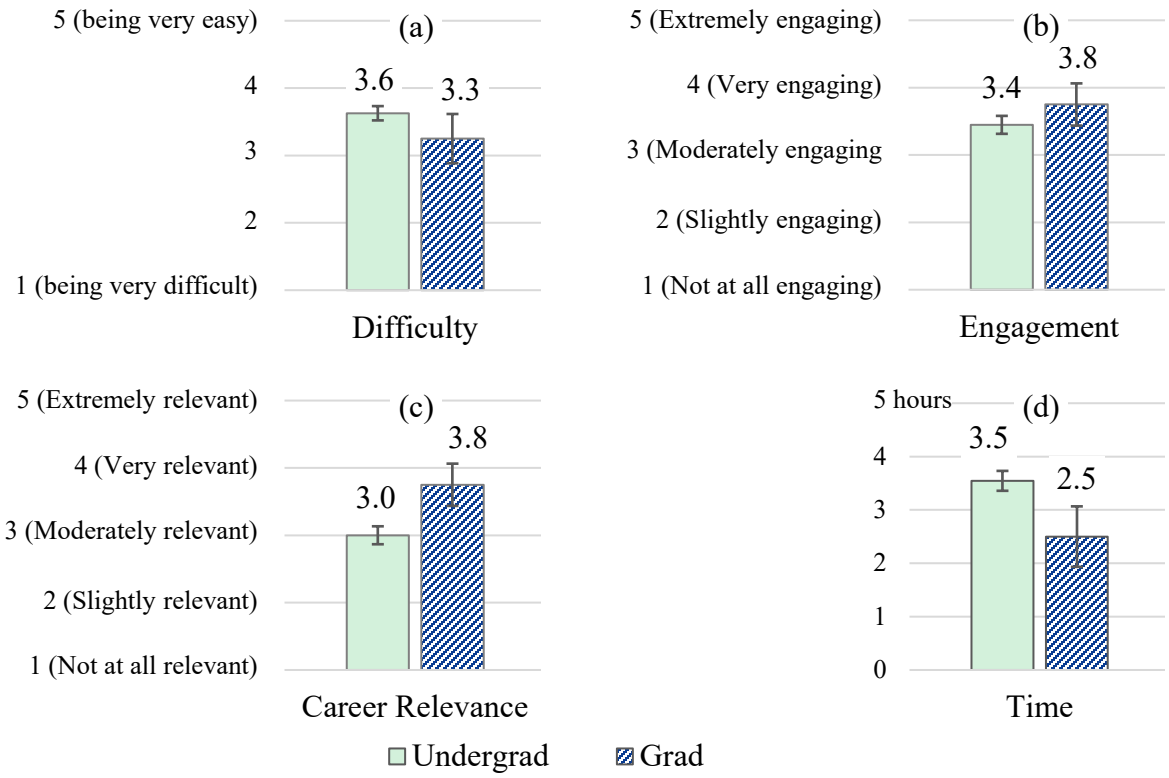


Figure 7. Student ratings of chatbot development assignments in terms of difficulty, engagement, and career relevance and time to complete the chatbot development assignments

Post Assignment Discussion Board

Students participated in structured discussions on online discussion boards, guided by prompts specifically designed to obtain thoughtful insights into their experiences with AI chatbot development. These prompts included:

- What challenges did you encounter while creating your chatbot, and how did you overcome them?
- In what ways do you think AI chatbots could be useful in real-world construction project management?
- How has this experience changed your perspective on the role of AI in the construction industry?
- What additional features or capabilities would you like to add to your chatbot to make it more useful for construction professionals?

The prompts encouraged students to reflect on key aspects of the assignment, such as the challenges they faced during chatbot development, the strategies they employed to overcome these challenges, potential real-world applications of AI chatbots in construction project management, and the ways the assignment shaped their perspectives on AI's role in the construction industry.

Students were also prompted to propose additional features that could enhance the functionality and utility of their chatbots for construction professionals. After sharing their original reflections, students engaged in a second phase of discussion, responding to their peers' posts by expanding on ideas, offering constructive critiques, or thoughtfully challenging viewpoints. This two-tiered structure fostered a dynamic exchange of ideas, promoting collaboration, critical thinking, and deeper engagement. Using thematic analysis, the outcomes of these discussions were systematically analyzed and are summarized in Table 3.

Table 3. Thematic analysis results of student discussion board

Group	Themes	Undergrad	Grad
Challenges in Chatbot Development	Accuracy of outputs	44%	29%
	Prompt engineering	13%	
	Minimal or no challenges	13%	14%
	Technical skills and familiarity	11%	43%
	Debugging and testing	11%	
	Chatbot integration and formatting	8%	14%
The Perceived Usefulness of AI Chatbots	Error reduction and accuracy	38%	23%
	Communication and collaboration	31%	31%
	Cost and resource management	13%	31%
	Efficiency and productivity	12%	8%
	Training and knowledge management	6%	8%
The Shift of Student Perspectives on AI	Efficiency and productivity	30%	20%
	Skepticism and limitations	21%	20%
	Future potential of ai	19%	50%
	Learning and accessibility of ai	12%	10%
	Automation and task simplification	10%	
	Decision-making and precision	8%	
Enhancements for AI Chatbots	Advanced calculations and cost estimation	32%	57%
	Real-time project management features	21%	29%
	Enhanced user interaction	13%	
	Visualization capabilities	8%	
	Data storage and retrieval	6%	14%
	Integration with external tools and data	3%	
	Miscellaneous	16%	

Challenges in Chatbot Development

The results indicate that both undergraduate and graduate students encountered a variety of challenges during AI chatbot development. For undergraduates, the most common challenge was ensuring accuracy in chatbot outputs (44%). For example, one student noted, *"My main challenge was to ensure that the chatbot accurately understood the input and provided the correct output. The videos provided context for solving this, ensuring information processing and improving the flow of interactions"*. Graduate students, on the other hand, primarily struggled

with technical skills and tool familiarity (43%). One graduate student noted, *"My challenge this week was just following with the processes because AI can be complex and creating this is new territory for me. However, the lecture videos were extremely helpful."* These results highlight the differing needs and learning curves of undergraduate and graduate students, emphasizing the importance of tailored instructional resources and support to address their distinct challenges effectively.

Prompt engineering (13%) proved to be a significant challenge for many students, underscoring its critical role in developing effective AI chatbots. One undergraduate student shared, "*The main challenge was formatting the AI to understand the prompt and give correct answers. It was overcome by researching ways to respond to various prompts.*" Similarly, another student noted, "*Language is very important when writing prompts for AI to read. By using the correct words, I was able to overcome this problem and get accurate area calculations*." Interestingly, graduate students did not explicitly mention prompt engineering as a challenge. However, their responses indicate that their difficulties were more foundational, such as learning to navigate AI tools, understanding chatbot functionality, and improving accuracy. One graduate student described struggling with chatbot accuracy and attempting to improve responses by "rephrasing instructions", which aligns with prompt engineering principles but was not labeled as such. This suggests that while graduate students engaged in aspects of prompt engineering, they may not have recognized or articulated it as a distinct challenge.

Meanwhile, a small portion of students (13% of undergraduates and 14% of graduates) reported minimal or no challenges, often crediting the ease of the video tutorials. One undergraduate shared, " *Our chatbot was rather easy to create using the provided tutorials, with a few minor exceptions. By revisiting the films, we were able to overcome them.*" Another graduate student mentioned that "*I can't think of a challenge found this week on the AI assignment, the videos were really good and easy to follow. It's a great tool!*"

The Perceived Usefulness of AI Chatbots

Regarding the usefulness of AI chatbots in construction, the results reveal that both undergraduate and graduate students recognized their potential, highlighting specific applications and providing helpful examples. For undergraduates, the most emphasized benefit was error reduction and accuracy (38%). As one student explained, "*The chatbot minimizes calculation errors and improves efficiency, especially for repetitive tasks like sizing and measuring windows for multiple rooms or buildings.*" Another noted, "*It helps streamline calculations while also yielding results that are less at risk of human error.*" Graduate students, in contrast, focused on the potential of chatbots to enhance communication and collaboration (31%). One graduate student explained, "*Chatbots could be useful to manage documents, track schedules, and support cost and resource management, ensuring better coordination among team members*."

Cost and resource management (13%) was another key area where students saw the potential for chatbot application. A student noted, "*AI has massive potential to assist in cost and material estimations…Chatbots can also help optimize costs expenditures if you program them correctly.*" For efficiency and productivity (12%), students appreciated the chatbot's ability to automate time-consuming tasks. As one undergraduate mentioned, "*They can streamline tasks such as*

scheduling client meetings, assisting engineers with repetitive tasks, or guiding customers to the appropriate department within a company" Although training and knowledge management (6%) received less attention, its importance was noted for on-demand support and field references. One student explained, "*In real-world construction project management I think that an AI chatbot could provide quick references and calculations for people in the workforce*"

The Shift of Student Perspectives on AI

The discussion board revealed that students developed nuanced perspectives on the role of AI in construction, shaped by their experiences with the chatbot assignment. For undergraduates, the dominant theme was efficiency and productivity, highlighted by 30% of responses. For instance, one undergraduate noted, *"Creating this chatbot has definitely shifted my perspective on AI's potential in the construction industry. I now understand how AI can streamline workflows"* Graduate students, on the other hand, focused more on the future potential of AI (50%). One graduate student reflected, *"I am impressed on how many different websites and tools there are already that implement AI … the assignment will be able to be completed way faster in the future by using AI."* This forward-looking perspective suggests graduate students are already considering strategic ways to incorporate AI into their professional contexts.

Skepticism about AI's current limitations was a shared theme across both groups, mentioned by 21% of undergraduates and 20% of graduates. One undergraduate remarked, *"Seeing how different AI models can calculate different values from the same prompt, I would be too worried about the potential for these errors if I were the project manager"* Similarly, a graduate student added, *"While AI holds great potential in construction, it's not as reliable as I'd hoped, especially due to the balance between accuracy and affordability"* These concerns highlight the need for educators to address the limitations of emerging technologies while emphasizing their potential.

Themes of learning and accessibility were also significant, with 12% of undergraduates and 10% of graduates highlighting how the assignment made AI technology approachable. As one undergraduate described, *"I discovered that integrating an AI chatbot into a website can be surprisingly straightforward. Before this assignment, I assumed it required extensive coding knowledge."* This underscores how structured learning experiences not only simplify complex technologies but also boost students' confidence in tackling advanced challenges. Assignments like these inspire creativity and encourage students to explore new applications of AI, opening pathways to novel solutions in construction and beyond.

Enhancements for AI Chatbots

When students were asked to discuss additional features or capabilities to enhance the chatbot, the majority highlighted advanced calculations and cost estimation, with 32% of undergraduates and 57% of graduate students emphasizing this area. Among undergraduates, one student suggested, "*It would also be able to estimate the cost for materials, labor, and installation. Being a one stop to obtain all the information.*" Another added, "*Calculating the quantity of concrete required for a slab is an extra capability I would like to include.*"

Real-time project management features were frequently highlighted as a desired enhancement. One student suggested, *"To make the chatbot more useful for construction professionals, I would like to add features such as real-time project tracking.*" Many students also emphasized the importance of integrating external tools and datasets, such as RSMeans, Procore, and Microsoft Project. For instance, one student remarked, "*I think it would be helpful to link it to data from RSMeans so that users can input different material and labor values.*" These ideas demonstrate a shared interest among students in leveraging chatbots to streamline project coordination and enhance overall efficiency.

Additional AI Chatbot Development Assignment with General Guides

The additional AI chatbot development assignment was designed to foster autonomous learning by challenging students to independently create a chatbot using only general instructions, without relying on video tutorials or hands-on, instructor-led guidance. Graduate students were tasked with identifying complex, construction-related problems that could benefit from AI automation and developing tailored solutions. Many of these students, working full-time in the construction industry, were encouraged to select challenges directly related to their professional roles. The assignment emphasized creativity and critical thinking, guiding students through steps such as problem identification, platform selection, justification of platform choice, addressing the problem's significance, and documenting the development process. Students were specifically instructed to use a platform other than Chatling, encouraging them to explore and adapt to new tools and technologies.

Unlike the initial assignment, where a specific problem was provided, students were given the freedom to identify and address challenges relevant to their field. To support their efforts, structured written instructions were provided, focusing on building essential skills such as problem-solving and solution development with advanced AI tools. Recognizing the task's complexity, students were offered the option to submit a detailed account of the challenges they encountered if they faced difficulties completing the assignment. This flexibility aimed to support their independent learning journey while acknowledging the inherent challenges of working autonomously. Finally, students reflected on their experiences, documenting the obstacles they faced and the strategies they employed to overcome them. These reflections provided valuable insights into the learning process and the effectiveness of the assignment. Full details of the assignment are available on the webpage (https://www.electriai.com/electriai-lab/asee25-chatbot).

Out of eight students, three were able to fully complete the assignment, demonstrating creativity and delivering well-documented solutions. These students achieved high grades, with average scores of 96.6% for accuracy and functionality, 93.3% for handling various inputs, 93.3% for clarity of instructions and prompts, and 93.3% for creative problem-solving in chatbot design. Their reflections revealed how they navigated challenges by leveraging foundational knowledge from earlier Chatling instruction, adapting to new platforms, and employing diverse learning strategies. Figure 8 below illustrates an example of a student who used Voiceflow [16], a platform similar to Chatling to create an AI chatbot designed to provide a Procore Punch List tutorial, assisting with onboarding new hires and enhancing their ability to manage punch lists effectively.

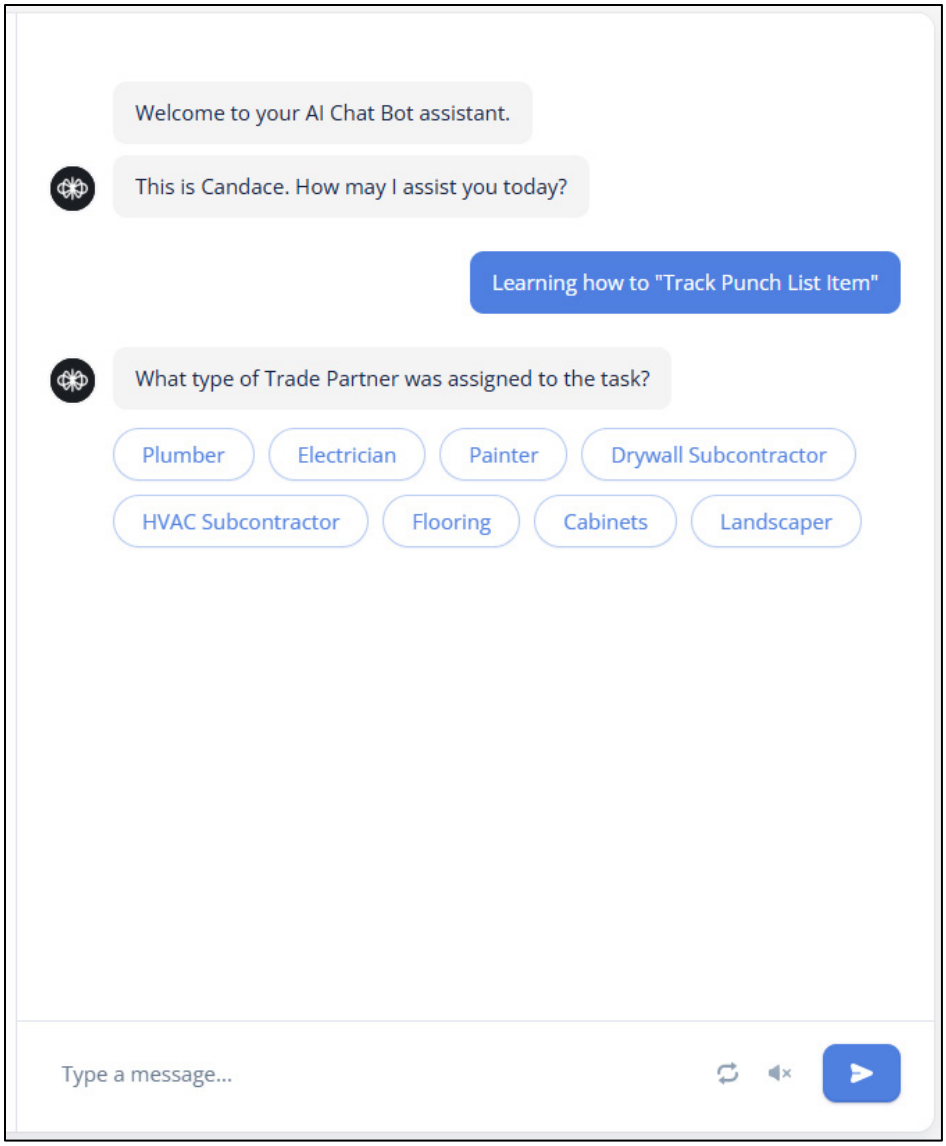


Figure 8. Student-Developed AI Chatbot Example: Procore Punch List Tutorial

Student reflections highlighted key strategies for overcoming obstacles. For instance, one student noted how the structured, step-by-step guidance from ChatLing provided a valuable foundation but also exposed gaps in independent application. "*The familiarity with nodes and responses helped a bit*," they shared, "*but I quickly realized how much I relied on having a detailed, step-by-step guide like the one provided for ChatLing*." Another student emphasized trial and error as a critical learning method, explaining that "*watching tutorials and experimenting with the platform allowed me to piece together a working solution, though it was time-intensive.*" Additionally, students cited the importance of connecting the project to real-world challenges, with one stating, "*Understanding problems and knowing how to create a solution are two very different things. Conversations about industry pain points guided me in developing a useful tool.*"

The successful students shared common themes of resilience and resourcefulness. While all acknowledged the difficulty of transitioning from guided learning to independent exploration, they highlighted the intrinsic value of the process. "*The creative process of identifying an industry challenge and addressing it with an AI solution pushed me to think critically and deeply about problem-solving*," one student remarked. This combination of foundational knowledge, iterative experimentation, and real-world contextualization proved instrumental in enabling these students to excel despite the inherent complexity of the assignment.

Opposite to the initial assignment, which was heavily scaffolded with detailed guides, video tutorials, and step-by-step instructor-led guidance, the second assignment revealed a notable gap in student performance when transitioning to assignments supported solely by general guides. This discrepancy underscores the challenges students face when moving from highly structured learning environments to more open-ended tasks that demand greater autonomy. It highlights the potential need for an intermediary scaffolding approach to bridge this transition effectively. An intermediary approach, such as semi-guided assignments, could balance structured support and independent exploration. For example, students might be provided with partial guides that outline key steps while leaving space for them to make critical decisions independently. These semi-guided assignments could include optional checkpoints for feedback or access to supplemental resources for troubleshooting, offering a safety net without undermining the autonomy-building intent.

Despite this gap, the second assignment demonstrated significant potential to promote student autonomy and critical thinking by encouraging them to identify real-world construction challenges, explore alternative platforms beyond Chatling, and justify their problem-solving approaches. These tasks not only enhance technical skills but also prepare students for tackling complex, real-world scenarios in the construction industry.

End of Course Survey

At the end of the semester, a survey integrated into the student exam was conducted to gather insights on the effectiveness of various learning approaches, including AI chatbot development. Students were asked to rank their preferred methods for learning construction and engineering technologies, such as developing an AI chatbot, on a scale of 1 to 7, with 7 indicating the most effective and 1 the least effective. Figure 9 summarizes their perceptions of these learning methods.

The survey results revealed that both undergraduate and graduate students found in-class activities and video tutorials to be the most effective learning methods. In-class activities were rated highly (mean = 7.0 for undergraduates and 6.3 for graduates), emphasizing the value of interactive, instructor-led sessions. Similarly, video tutorials created by instructors were also highly preferred, with graduate students rating them as the most effective method (mean = 7.9) and undergraduates ranking them second (mean = 5.8). Other tools, such as AI tools (e.g., ChatGPT), group projects, and resources like Google/YouTube searches, were considered moderately to be less effective.

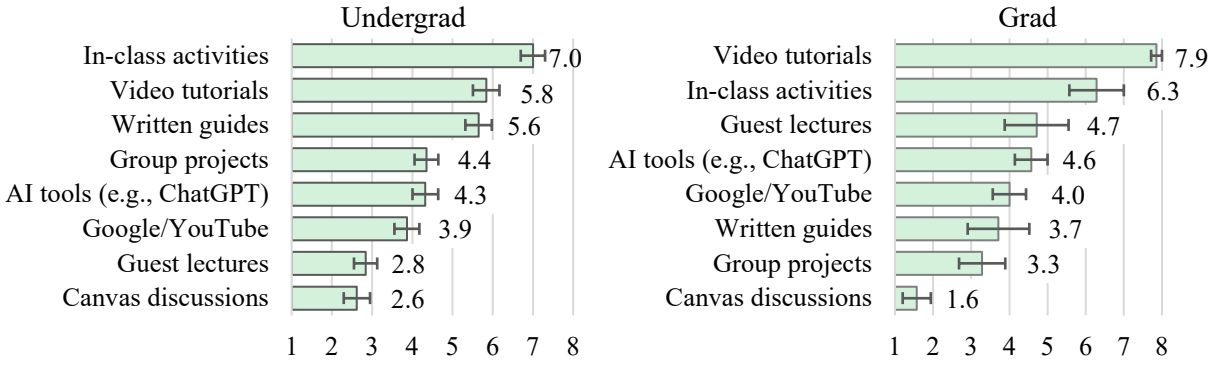


Figure 9. Student perceptions on the effectiveness of learning methods for learning new construction and engineering technologies

Conclusion

The study makes several significant contributions to the body of knowledge in CEM education. By integrating AI chatbot development into the curriculum, it provides a practical framework for teaching students how to apply cutting-edge AI tools to address real-world challenges. This is exemplified by the development and deployment of custom AI chatbots for cost estimation tasks in construction, which not only enhanced technical proficiency but also highlighted the potential of AI in automating complex, repetitive tasks. The study underscores the efficacy of no-code platforms like Chatling in empowering students with varying levels of technical expertise to engage in AI-driven application, thereby broadening access to advanced technology within the field. Moreover, this study provides an effective and fully validated assignment that can be seamlessly embedded into courses via the webpage (https://www.electriai.com/electriai-lab/asee25-chatbot). By sharing teaching materials exclusively via a dedicated webpage, the assignment ensures easy accessibility and continuous updates, fostering a sustainable and scalable model for integrating emerging technologies into the curriculum.

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