2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
Paper ID #51773

Integrating Artificial Intelligence Across the Engineering Curriculum: Student Perceptions, Trust, and Ethical Awareness from Two Institutions

Dr. Solaleh Miar, University of Hartford

Solaleh Miar, Ph.D., is a Biomedical Engineering Assistant Professor at the University of Hartford, Connecticut. She teaches first-year Engineering Design, Biomedical Engineering Capstone, and Biomaterials. Her primary interests center on project-based and experiential learning, and student teamwork/communication. Recent work explores structured, responsible uses of AI to support design ideation and reflection, complementing course-embedded PBL practices.

Dr. Sarira Motaref, University of Connecticut

Dr. Sarira Motaref is a Professor in Residence in the School of Civil and Environmental Engineering at the University of Connecticut and a licensed Professional Engineer in Connecticut. She earned her Ph.D. in Civil Engineering from the University of Nevada, Reno in 2011. Her work focuses on engineering education, student success, inclusive teaching practices, and the integration of innovative instructional approaches in civil engineering education. She currently serves as Director of Innovation and Student Success in the School of Civil and Environmental Engineering, where she leads initiatives that promote student engagement, academic achievement, and inclusive excellence. From 2017 to 2025, she served as Assistant Director of Faculty Development for the College of Engineering and UConn's Center for Excellence in Teaching and Learning. Dr. Motaref is Co-Principal Investigator on multiple NSF-funded engineering education projects. Her teaching and educational leadership have been recognized through several awards, including the University Teaching Fellow Award, Distinguished Engineering Educator Award, and multiple Klewin Excellence in Teaching Awards.

Integrating Artificial Intelligence Across the Engineering Curriculum: Student Perceptions, Trust, and Ethical Awareness from Two Institutions

Abstract

Artificial intelligence (AI) platforms are increasingly used by engineering undergraduates for problem solving, technical writing, visualization, and conceptual scaffolding. However, many university policies still frame AI usage within the context of plagiarism, limiting its intentional integration into coursework. In engineering education, unmonitored AI use (e.g., generating homework or project solutions), without verifying accuracy, can undermine learning objectives and assessment validity. At the same time, engineering practice increasingly demands AI literacy and prompt-engineering skills, positioning responsible AI use as a core competency for future engineers

This study investigates structured AI integration across four engineering courses spanning the freshman, sophomore, junior, and senior levels at two institutions in the northeastern United States: The University of Connecticut (UConn), a public research university with large classrooms, and the University of Hartford (UHart), a private primarily undergraduate institution with smaller class sizes. The courses examined in this study were those taught by the authors during the Fall 2025 semester, enabling deliberate integration of AI activities across a range of engineering disciplines, academic levels, and instructional formats. At the public university, the study was implemented in two courses: Mechanics of Materials (enrollment ≈120 students) and Design of Reinforced Concrete Structures (enrollment ≈50 students). In the private undergraduate institution, AI was integrated into classes at the freshman-level Engineering and Design with 19 students from different engineering disciplines and senior-level Biomedical Engineering Capstone Design with 12 students. Students were encouraged to apply AI tools to diverse learning tasks, such as problem-solving, visualization, study-guide creation, and capstone project support. The instructional design emphasized prompt design, critical verification of AI outputs, and metacognitive reflection on the reliability and educational value of AI-generated content.

To evaluate the impact, students completed reflection assignments assessing AI capabilities and deficiencies, as well as an anonymous post-intervention survey measuring perceptions of learning, confidence in evaluating AI results, and awareness of ethical implications. The analysis will examine (a) whether academic level influences students' perceptions of AI integration, and (b) whether institutional type (public vs. private) affects students' attitudes and reported benefits. Preliminary results suggest that guided AI use can enhance engagement, foster self-monitoring skills, and promote a balanced understanding of both the potential and limitations of generative AI in engineering education.

This work contributes to the growing body of research on AI-inclusive pedagogy and offers a scalable framework for aligning AI integration with academic integrity and ABET-aligned learning outcomes.

Introduction:

The Generative AI Paradigm in Engineering Education

The integration of artificial intelligence within STEM education is a well-established field of inquiry, with systematic reviews highlighting its long-standing role in personalized learning and intelligent tutoring systems [1]. However, the recent emergence of Generative AI (GenAI), which is powered by large language models (LLMs) such as GPT-4, represents a fundamental shift in the educational landscape. Unlike earlier technologies that primarily accelerated calculations or provided static visualizations, LLM-based tools intervene directly in high-level cognitive processes such as brainstorming, code generation, and technical composition. This transition has led researchers to argue that these tools are revolutionizing engineering education by providing students with unprecedented access to personalized conceptual scaffolding and real-time feedback [2], [3].

The educational value of these systems is inextricably linked to the quality of user interaction. As Park and Choo (2023) observe, generative AI produces contextually relevant and personalized content only when the inputs are meticulously designed [4]. This has made prompt engineering, the writing, refining, and optimizing of natural-language instructions, a central competency for the modern engineering student. Frameworks such as PARTS, CLEAR, and REFINE have been proposed to help students and educators specify personas, aims, and structures within their prompts [5]. Without such careful construction, GenAI systems may generate responses that are irrelevant, inaccurate, or inappropriate for the rigorous standards of an engineering curriculum. The National Academies of Sciences, Engineering, and Medicine (2024) and UNESCO (2023) recently underscored this risk, highlighting the need for sustainable frameworks that integrate AI while maintaining the mental rigor and academic standards essential for professional practice [6], [7], [8].

This paradigm shift offers a complex balance of opportunities and risks. Generative AI can act as a 24/7 tutor to help students visualize complex concepts, debug code, and explore alternative solution strategies. For example, recent studies have demonstrated that integrating ChatGPT into introductory undergraduate courses can provide students with immediate, iterative feedback on their initial designs and technical concepts [9]. However, reviews by Bobula (2024) and Xie et al. (2023) caution that the widespread adoption of large language models (LLMs) in higher education raises critical concerns related to academic integrity, misinformation, bias, and privacy [10], [11]. Universities are now tasked with updating assessment policies and establishing clear guidelines for responsible AI use. In engineering education, where students are expected to develop independent reasoning and ethical judgment, these concerns are particularly salient. The challenge for modern pedagogy is to leverage the benefits of AI without undermining a student’s ability to perform essential calculations manually or engage in critical independent thinking. This work contributes (1) an implementable template/rubric for accountable AI use, (2) multi-level evidence across the curriculum, and (3) comparative insights into how academic maturity and course context shape AI trust, verification behaviors, and ethical awareness.

Prompt Engineering, AI Literacy, and Student Self-Efficacy

Instruction in prompt engineering significantly enhances students’ AI literacy and confidence [12]. Research suggests that even brief workshops can improve a student’s AI self-efficacy, defined as the belief in one's ability to interact effectively with AI tools. This self-belief serves as a strong predictor of responsible technology adoption [13]. Furthermore, structured training in techniques such as few-shot prompting and chain prompting has been shown to improve technical performance across various levels of Bloom's taxonomy, particularly in data analysis and programming tasks [14]. These findings suggest that when prompt engineering is taught as a metacognitive skill, it enables students to decompose complex tasks and iteratively refine AI-generated outputs, thereby contributing to higher-order problem-solving skills.

Rationale for This Study

While current literature underscores the promise of AI-enabled instruction, several significant gaps remain. Most studies to date are limited to single courses, homogeneous student cohorts, or specific institutional contexts. Furthermore, many existing AI frameworks have been developed without explicit consideration for the varying pedagogical needs of different engineering disciplines or the varying levels of academic maturity among students. There is currently a lack of evidence regarding how institutional type, such as a large public research university compared to a small private institution, mediates the student experience with AI integration. Without cross-institutional research, it is difficult to develop generalizable guidelines that address equity concerns and faculty readiness.

Improvements in students' learning outcomes are not within the scope of this study and are therefore not evaluated. To investigate these questions, evaluation data from an anonymous student survey, along with the instructor's observational reflections, are analyzed and discussed. Because the evaluation activities informing this paper are limited to the *systematic collection of information about program activities, characteristics, and outcomes for the purposes of improving effectiveness and informing future instructional decisions*, Institutional Review Board (IRB) approval was not sought [15], [16].

The present study addresses these gaps by examining structured generative AI integration across four engineering courses selected to span the undergraduate curriculum: a first-year Engineering and Design course, Mechanics of Materials (sophomore/junior level), Design of Reinforced Concrete Structures (senior level), and a Biomedical Engineering Capstone (senior level). This sequence enables analysis of how AI support is experienced across increasing levels of task complexity, from foundational problem-solving to open-ended design, while also capturing differences in students' reasoning demands and autonomy. To examine contextual influences, the study compares implementations at a large public research university (UConn) and a smaller private institution (UHart), allowing consideration of how class size and instructional support may shape students' experiences. Consistent with the study scope, the focus is not on direct learning outcomes but on students' reported perceptions, evaluation practices, and ethical awareness when using AI tools. Accordingly, the study investigates the following research questions (RQ):

- **RQ1:** How do students' perceptions of generative AI's impact on conceptual understanding and learning support differ by academic level and institution type (public vs. private)?
- **RQ2:** How do students' trust in AI-generated outputs and their verification behaviors (e.g., checking sources, validating calculations/solutions) vary across academic levels and institutional contexts?

- **RQ3:** How do students' ethical awareness toward responsible AI use differ by academic level and institution type, and what contextual factors (e.g., class size, availability of instructional guidance) appear to shape these differences?
- **RQ4:** How do students' overall attitudes toward generative AI in engineering education differ by academic level and institution type, and how are these attitudes related to their reported trust and verification behaviors?

Class Descriptions and Implementation

Public University (UConn)

Mechanics of Materials was a required 3-credit course enrolling sophomore- and junior-level students from a wide range of engineering disciplines, including mechanical, civil, biomedical, robotics, materials science, manufacturing, and multidisciplinary engineering. The course had an enrollment of 120 students in Fall 2025 and was delivered using a flipped classroom model. Students were expected to watch instructional videos covering theory and sample problems outside of class, while in-class time was dedicated to real-world applications, collaborative problem solving, instructor-led demonstrations, and interaction with visual and physical models.

The use of generative AI was offered as an optional instructional activity. Students could earn up to 3 points towards their final grade by completing AI-integrated activities. The decision to offer these activities as optional was driven by several factors, including large class enrollment, the presence of multiple required course components (e.g., online quizzes, homework assignments, and in-class problem-solving activities, midterm exams), and limited teaching assistant resources. Students were offered the opportunity to submit one AI-integrated activity per chapter, for a total of nine chapters covered in the course. For each submission, students could choose from a variety of AI activity options, as described below. The activity types included: **A1**: Visualize a Concept– Create a labeled image or diagram illustrating a key concept or application, **A2**: Step-by-Step Tutorial– Develop a clear, course-aligned tutorial that includes a worked example and a checklist of common errors, **A3**: AI Cross-Check of a New Problem– Independently solve a problem, have AI generate and critique a solution, and then critically evaluate the AI-generated response, **A4**: AI-Generated Real-World Problem– Co-create a realistic, multi-concept engineering problem with AI, including a complete solution and verification.

Design of Reinforced Concrete (RC) Structure was a 4-credit elective course offered within the structural engineering technical area for civil engineering students. The course enrolled 50 students, of whom 96% were seniors and the remainder were juniors. The course included a laboratory component focused on reinforced concrete structural modeling and analysis using industry-relevant software tools.

Due to the design-focused nature of the course, students in the RC Structures course, unlike those in Mechanics of Materials, were offered only **A3 (AI Cross-Check of a New Problem)** as the AI-integrated activity. Students could submit up to nine activities (one per chapter) to earn extra credit toward their final course grade. Students were asked to select one additional end-of-chapter design problem, solve it manually, use AI to generate a solution, critically evaluate the outcomes, and document their reflections on the comparison.

For both courses, a detailed grading rubric (Table 1) was provided to students in advance, along with a standardized submission form and a handout outlining the learning objectives, purpose, and instructions. The submission form required students to include: (a) hand calculations (when applicable), (b) AI prompts used, (c) verification of results, and (d) reflective commentary on the AI interaction.

Table 1. Rubrics for AI activities grading

Criterion	**Meets**	**Below**
Correctness	Fully correct calculations & assumptions	Errors in concept/calcs
Alignment	Tied to chapter learning outcomes	Off-topic/mismatched
Clarity & Structure	Organized & legible	Disorganized
Verification	2+ meaningful checks	Missing/incomplete
AI Transparency	Log included	Log missing/incomplete
Reflection	Specific & evidence-based	Vague

Private University (UHart)

In the ***Engineering and Design*** course, 19 first-year students from multiple engineering disciplines, including Aerospace, Acoustical, Robotics, Electrical, Mechanical, Computer, and Biomedical Engineering, as well as exploratory majors, participated in structured AI-integrated activities throughout the semester. The course is required for all first-year engineering students and introduces the fundamentals of engineering, the engineering profession, and engineering design, with an emphasis on guided design and structured problem-solving methodologies. Students completed practice-oriented group design projects supported by formal written reports and oral presentations.

A major component of the course involved Arduino-based programming and hands-on hardware integration using the Elegoo starter kit, enabling students to work with sensors and components relevant to different engineering majors. AI activities were embedded within these assignments to support coding, debugging, explanation, and verification tasks. Students were required to log their AI prompts and reflect on the corresponding AI outputs.

To minimize additional workload, students reused an existing project or homework assignment developed for the course and demonstrated how AI could improve or clarify it. No new hardware builds were required. AI was used to enhance documentation for existing figures and circuits, suggest minor improvements such as clearer pin mapping or safer wiring practices, and generate troubleshooting notes for specific technical issues, including noisy sensors or baud rate mismatches.

Submissions followed a standardized four-part template consisting of an AI log containing two to four prompts and relevant responses, a “Before/After” section highlighting the modified code block or wiring table, evidence of improvement such as a Serial Monitor screenshot or circuit photograph, and a 100-word reflection discussing what the AI got right or wrong and how the results were verified. Students were also required to sign a declaration confirming that they retained only AI outputs they understood and could explain.

In the senior-level ***Biomedical Engineering Capstone*** course, 12 students worked in teams on five distinct capstone projects during the academic year. The course serves as the culminating design experience in the biomedical engineering curriculum and emphasizes open-ended problem definition, literature-driven design justification, project planning, prototyping, and validation. Students were responsible for documenting design decisions, conducting testing, and communicating results through formal written reports and presentations.

Unlike the freshman-level course, capstone students addressed highly individualized, project-specific problems that required independent research, design tradeoff analysis, and sustained technical judgment. AI was integrated as a support mechanism to improve documentation quality, analytical clarity, and project planning, rather than to replace engineering decision-making.

Students selected two specific components of their capstone work for AI review from a predefined list that included literature reviews, user needs, Pugh matrices, testing protocols, materials lists, and Gantt charts. Acceptable uses of AI included improving professional tone, checking logical consistency, and identifying missing constraints. The use of AI to generate complete designs or to make engineering decisions without team evaluation was explicitly prohibited.

The instructional design employed a Biomedical Engineering Capstone AI Use Documentation Template. This template required students to log two to four AI prompts, provide a direct Before and After comparison of the revised section, and include evidence showing the updated content in context. A required 100-word reflection prompted students to explain which AI suggestions were accepted or rejected and how correctness was verified. Each team also signed a declaration confirming that all AI use was fully documented and that the final submission remained the team’s original capstone design.

AI activities were implemented through a structured AI add-on template that guided students in documenting AI use within specific project components. Students identified the aspect of their project supported by AI, such as literature review, constraints and user needs, design explanations, Pugh matrices, testing protocols, materials lists, or project planning, and reflected on the accuracy, usefulness, and limitations of the AI-generated outputs.

Observations and Results

In **Mechanics of Materials** 38 students participated in AI activities at least once during the semester with the total of 127 submissions. The percentage of submissions in each AI activity category were calculated and shown in Figure 1. Students participated in A.3 category (AI cross-check a new problem activity) the most and the least favorite AI application was A.2 (generating Step-by-Step Tutorial for the course concepts). Student feedback suggested that the A.3 category is perceived as less time-intensive and less complex compared to the other categories.

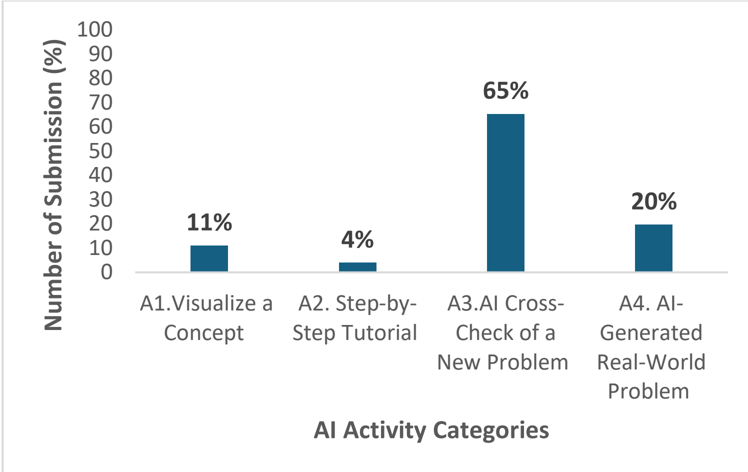

Figure 1. Percentage of submission for each AI application activity in Mechanics of Materials

Analyzing students' reflection on AI activity submissions revealed that overall, students had a positive and reflective experience interacting with AI, demonstrating a nuanced understanding of both its benefits and limitations. The AI-integrated activities were widely perceived as valuable for reinforcing course material, providing additional practice, and deepening conceptual understanding through clear, step-by-step explanations that extended beyond the textbook, particularly when applied to simpler problems. Students noted that AI was effective at breaking down foundational concepts and offering alternative solution approaches; however, they consistently identified limitations related to accuracy, problem complexity, and the interpretation of diagrams and images. AI was reported to perform well on straightforward problems but to struggle with complex, multi-step engineering tasks, even when additional prompting or resources were provided. Importantly, students emphasized the educational value of critically evaluating AI-generated solutions, comparing methods, and identifying errors, which reinforced the necessity of independent reasoning, verification, and sound engineering judgment. Through these activities, students also reported increased awareness of appropriate AI use in engineering, recognizing AI as a supportive learning tool rather than a substitute for critical thinking or professional expertise. One of the students stated:

"Breaking down the problem into clear stages—resolving loads, calculating reactions, building diagrams, and interpreting results—made the entire process more approachable and less overwhelming."

One of the students highlighted ChatGPT's limitations as follows:

"One limitation of ChatGPT is definitely its image analysis. It gets all sorts of things wrong when scanning through an image or a PDF that is uploaded. However, if the values and directions are uploaded manually, AI can be very useful."

One of the participants shared the following vision about AI integration in the field of engineering:

"I believe AI remains as a tool that supports engineers rather than replaces them. The field of Engineering requires ethical judgment and intuition, qualities that AI cannot replicate. It should only be viewed as a tool that enhances problem-solving efficiency rather than being completely responsible for design decisions."

Students identified several challenges and concerns when using AI in the course, with verification emerging as a primary issue. Many students reported difficulty determining whether their own solutions or AI-generated responses were correct, particularly when creating original problems or when multiple solution methods produced different answers. This uncertainty made validation of results time-consuming and, in some cases, frustrating. Students also noted that the AI-integrated activities required a significant time investment, especially when developing original problems and refining prompts to obtain meaningful responses. Overall, these challenges reinforced the need for strong problem formulation, careful verification, and sustained critical engagement when using AI as part of the learning process.

In **Design of Reinforced Concrete Structures**, 22 students participated in AI activities at least once during the semester, with a total of 115 submissions.

In response to the question *“What was the most valuable part of the AI activities for your learning?”*, students highlighted several instructional and practical benefits of AI integration. Many students valued seeing how ChatGPT approached problems differently from their own methods, which exposed them to alternative solution strategies and ways of thinking. Students emphasized the usefulness of AI as an accessible support tool when they became stuck on homework, noting that it helped them overcome learning roadblocks without waiting for office hours or instructor assistance, while still recognizing that AI responses required verification. Several students identified value in using AI to check their work, fact-check solutions, and compare reasoning processes, which strengthened their understanding of both correct answers and solution pathways. Others appreciated gaining insight into AI’s current capabilities and limitations when applied to complex design problems, reinforcing the importance of learning how to use AI appropriately rather than avoiding it altogether. Additional benefits included access to more worked examples, opportunities to explore concepts in greater depth than covered in class, and the motivational incentive provided by extra credit. Overall, students viewed the AI activities as a flexible learning aid that supported independent problem-solving, deeper engagement with course material, and responsible use of AI in engineering contexts.

Students identified several recurring AI failures, most notably difficulties interpreting information from images, such as distances and reinforcement cover. AI also struggled with applying appropriate ACI (Building Code Requirements for Structural Concrete and Commentary, ACI-318-25) design methods, often referencing incorrect tables, equations, or criteria, sometimes due to incomplete or unclear prompts. Additional limitations included resistance to correction, omission of required design checks and documentation steps, occasional mathematical errors, and reduced reliability when addressing complex, open-ended, or less common design problems such as member sizing and crack-width control. Overall, these challenges reinforced the importance of prompt literacy, critical evaluation, and careful verification when using AI as a supplementary learning tool rather than a definitive problem solver. One of the students highlighted the experience as follows:

“With hand calculations that we learned in class, this should have been pretty easy to solve overall. The AI I used was ChatGPT and the equations it wanted to use were different from the ones we learned from class. I am unsure if their way was correct, but it did give different values than what I had found. I had to walk the AI through on what equations I needed them to solve with, and then it would get confused on how the equations worked.”

In **Engineering and Design**, student survey responses indicate a measured and reflective experience with generative AI. A post-course open-ended survey was completed by 13 students, capturing perceptions of the value, challenges, and recommended improvements related to AI use. The percentage of prompts in the Engineering and Design course associated with each AI task category was calculated and is shown in Table 2. Across the course, 29 AI prompt submissions were collected, with approximately 50% focused on code improvement and debugging.

Table 2. Percentage of AI prompt submissions by task category in the freshman Introduction to Engineering course.

AI Task Category	Submission (%)
Code improvement/debugging	48
Report writing/editing	17
Summary/explanation	10
Guide /visual assistance	3
Other/mixed	21

Regarding perceived value, 77% of respondents (10/13) identified AI as beneficial for learning support, including understanding concepts, exploring alternative solution approaches, or improving confidence in their work. More specifically, 54% (7/13) emphasized AI's usefulness for code-related tasks, such as generating code, improving efficiency, or verifying results. Students noted that AI-supported problem-solving was effective when used for well-scoped tasks, with comments such as *"getting the code from the AI itself"* and *"double-checking work and improving my understanding on a concept that I didn't fully grasp."*

In addition, 38% of respondents (5/13) noted that the activities helped them learn to use AI appropriately rather than rely on it uncritically. Students valued explanations that supported understanding, as reflected in statements such as *"it taught me how to correctly use AI"* and *"the way AI explains its train of thought and how it arrives to its conclusion."* Only 8% (1/13) reported that the AI activities were not beneficial, describing them as redundant.

Students also identified several challenges and concerns when using AI in the course. 62% of respondents (8/13) cited accuracy and reliability as their primary concern, emphasizing the need to verify AI-generated outputs. This concern was reflected in comments such as *"having to check to make sure that AI wasn't feeding me false info or advice"* and *"not knowing whether or not something is completely true."* Additionally, 31% (4/13) reported difficulty with AI failing to follow constraints or instructions, particularly in hardware-related contexts where AI produced impractical or incorrect wiring suggestions.

Ethical and perception-related concerns were also present. 23% of respondents (3/13) described AI use as *"feeling like cheating"* or expressed uncertainty about how AI-assisted work might be perceived by instructors. A smaller proportion, 15% (2/13), raised concerns about overreliance on AI, noting that it *"makes you lazy."*

Students offered several constructive recommendations for improving future AI activities. 54% of respondents (7/13) recommended clearer instructions and more specific task descriptions, while 31% (4/13) suggested shorter or more focused activities. Notably, 15% (2/13) explicitly recommended limiting AI use to code rather than physical circuitry, arguing that *"code can be tested and retested quickly in contrast to a wiring assembly."* This qualitative feedback from the freshman Engineering and Design course highlights an important difference between verifying AI outputs for digital versus physical tasks. Students noted that code can be tested and retested quickly, allowing them to identify errors through iterative debugging and immediate feedback. In contrast, verifying AI-generated suggestions for wiring or hardware setup required more time and careful manual checking, particularly when outputs did not align with physical constraints or produced impractical recommendations. This suggests that AI may be easier for students to use productively in programming-related tasks, where rapid testing supports verification, than in physical engineering tasks, where validation is slower and more dependent on hands-on judgment. This distinction reinforces verification as a task-dependent requirement when integrating AI into engineering education.

Across **the Biomedical Engineering Capstone Design** course, a total of 11 AI Add-On submissions were collected, containing approximately 25 AI prompts. The percentage of prompts associated with each AI task category was calculated and is shown in Table 3. AI use was distributed across technical design tasks (20%), design and planning tasks (16%), materials and components lists (16%), report writing (8%), literature research (4%), and other or mixed uses (36%), reflecting the diversity and open-ended nature of capstone projects.

Table 3. Percentage of AI prompt submissions by task category in the senior Biomedical Engineering capstone course.

AI Task Category	Submission (%)
Technical design tasks	20
Design / planning tasks	16
Materials / components lists	16
Report writing / editing	8
Literature research	4
Other / mixed	36

Overall, capstone students reported a measured, pragmatic experience with generative AI. Reflection data were available for all 11 submissions, enabling analysis of students' perceptions regarding the value and limitations of AI use in advanced design work.

Regarding perceived value, 36% of reflections (4/11) were predominantly positive. These students reported that AI was particularly useful for literature discovery, early-stage planning, and documentation support. Students described AI-assisted research tools as effective for identifying relevant papers and clarifying background concepts, with one student noting that AI-supported literature search was a *"lifesaver"* during the early stages of the project. Others reported that AI improved clarity and organization of testing protocols or helped articulate design tradeoffs more clearly.

The majority of reflections, 45% (5/11), were classified as neutral or mixed. These students acknowledged that AI provided a helpful starting point but required substantial verification and revision. For example, students reported that AI-generated templates or explanations were useful conceptually but often included extraneous information, crude formatting, or content that did not fully align with project-specific constraints. One student noted that while AI captured much of the relevant information, *"it still needed to be fixed to match the actual design."*

Negative reflections accounted for 18% (2/11) of submissions and were most strongly associated with technical design and modeling tasks. Students reported that AI struggled with highly specific or novel design problems, particularly those involving flow charts, CAD guidance, or physical system representations. In one case, a student described AI-generated guidance as misleading and noted the need to rely instead on experimentation and instructor feedback.

Across reflections, verification emerged as a central theme. Students consistently emphasized checking AI outputs against peer-reviewed literature, instructor guidance, experimental results, or external resources. Several students explicitly rejected AI suggestions when they conflicted with domain knowledge or feasibility constraints, reinforcing the role of human judgment in capstone design.

Ethical awareness was also evident in capstone reflections. Students acknowledged concerns about AI reliability and authorship, particularly regarding citations, and emphasized that AI-assisted content was incorporated only after careful review and rewriting. These reflections suggest that capstone students viewed AI as a supportive but limited tool, rather than a decision-maker.

Effects of Academic Level and Institution Type on Students' AI Learning Experiences

Students from four engineering courses completed an anonymous survey to provide feedback on: (RQ1) perceived learning associated with AI-integrated activities, (RQ2) confidence in evaluating AI-generated results, (RQ3) ethical awareness, and (RQ4) student attitudes and perceived benefits related to AI use. The survey data were primarily used to examine differences in student responses based on academic level and institutional type. Class enrollments at the studied private university are generally small, whereas large class enrollments are common at the studied public university. To facilitate comparison across courses, course identifiers were coded to reflect the course name, institution type, and academic level. Each row in the dataset presents the course name followed by the institution type and academic level (Fr = Freshman, So = Sophomore, Ju = Junior, Se = Senior; Pr = Private, Pu = Public). For example, *Engineering and Design (Pr–Fr)* denotes a freshman-level course offered at a private institution.

Table 4 summarizes the number of students who participated in the AI-integrated activities and the number of respondents to the anonymous survey. The survey response rate for each course was calculated as the number of students who completed the survey divided by the total number of students who participated in the AI activities. Because participation in some courses was optional and/or incentivized (e.g., extra credit) and survey response rates varied substantially across courses, the respondent pool may reflect self-selection, and cross-course or cross-institution comparisons should therefore be interpreted cautiously.

Table 4. Anonymous survey response rate

Course	Participated in AI activity	Responded to the survey	AI Survey response rate (%)
Engineering and Design (Pr-Fr)	19	15	79
Mechanics of Materials (Pu-So/Ju)	38	11	29
Biomedical Engineering Capstone Design (Pr-Se)	12	7	58
Design of RC Structures (Pu-Se)	22	10	45

72% of respondents used ChatGPT, followed by Microsoft Copilot (12%) and Google Gemini (6%); the remaining respondents (10%) used other platforms. Most students used free accounts (67%), while 17% reported using a paid personal subscription; the remaining 16% were unsure of their account type.

Table 5. Students' perception of learning

Students Feedback	Course	Strongly Disagree (%)	Disagree (%)	Neither Agree nor Disagree (%)	Agree(%)	Strongly Agree (%)
The AI activities helped me learn course concepts more deeply.	Pr-Fr	7	21	29	43	0
	Pu-So/Ju	0	10	20	50	20
	Pr-Se	0	0	0	43	57
	Pu-Se	0	0	50	40	10
Creating or critiquing AI-generated visuals improved my conceptual understanding.	Pr-Fr	21	14	64	0	0
	Pu-So/Ju	10	20	40	20	10
	Pr-Se	14	0	29	43	14
	Pu-Se	0	10	60	10	20
Using AI increased my engagement with the course material.	Pr-Fr	8	38	46	8	0
	Pu-So/Ju	27	9	27	27	9
	Pr-Se	0	0	43	29	29
	Pu-Se	30	10	40	10	10

Table 5 presents students' levels of agreement with survey questions related to the impact of AI use on their learning. In the Biomedical Engineering Capstone course, all senior-level students at the private university (100%) agreed or strongly agreed that AI integration helped them learn course concepts more deeply, whereas 50% of senior-level students at the public university reported the same. This difference may reflect contextual factors associated with the two settings, such as class size, instructional support, and the structure of AI-related activities, though the present study does not isolate the contribution of any single factor.

Across academic levels, freshman students enrolled in the Engineering and Design course reported the lowest level of agreement, with only 43% indicating that AI helped them learn course material more deeply. A similar trend was observed for survey questions addressing the impact of AI-generated visuals on conceptual understanding and student engagement. More than 57% of senior students at the private institution reported that AI generated visual enhanced their conceptual understanding, compared to only 30% of senior students at the public institution. Freshman students also exhibited the highest levels of disagreement on both questions related to AI's impact on course understanding and engagement, with 34% and 46% disagreeing or strongly disagreeing, respectively.

Sophomore- and junior-level students enrolled in Mechanics of Materials demonstrated more divided perceptions regarding the impact of AI on learning and engagement. Approximately 35% of students in this group agreed or strongly agreed with these statements, while a comparable percentage disagreed or strongly disagreed, indicating mixed experiences with AI integration at this academic level.

Table 6. Students' Confidence in Evaluating AI-generated results

Students Feedback	Course	Strongly Disagree (%)	Disagree (%)	Neither Agree nor Disagree (%)	Agree (%)	Strongly Agree (%)
I can detect when an AI-generated solution contains conceptual errors.	Pr-Fr	0	13	27	33	27
	Pu-So/Ju	0	9	9	36	45
	Pr-Se	0	0	0	71	29
	Pu-Se	0	0	0	22	78
I can reconcile differences between my solution and AI's solution using engineering judgment.	Pr-Fr	7	7	20	53	13
	Pu-So/Ju	0	9	0	45	45
	Pr-Se	0	0	14	71	14
	Pu-Se	0	0	11	22	67

Table 6 presents students' responses to survey questions regarding their confidence in evaluating AI-generated results. The findings indicate that academic level strongly influences students' ability to exercise judgment when interpreting AI outputs. In both senior-level engineering courses, 100% of students agreed or strongly agreed that they could confidently detect errors in AI-generated information. In comparison, only 60% of freshmen agreed with this statement. Sophomore- and junior-level students enrolled in Mechanics of Materials also reported high confidence, with 81% agreeing or strongly agreeing that they could identify conceptual errors in AI-generated results. No significant differences were observed between students at private and public institutions, suggesting that institutional type did not meaningfully affect students' confidence in evaluating AI outputs.

A similar pattern emerged in responses regarding the application of engineering judgment during the cross-check process between students' solutions and AI-generated answers. On average, approximately 90% of sophomore-, junior-, and senior-level students agreed or strongly agreed that they effectively employed engineering judgment during this process, compared to 66% of freshman students. Collectively, these results suggest that students' confidence in evaluating and validating AI-generated information increases with academic maturity rather than institutional context.

Table 7. Students' ethical awareness in AI-integrated classes

Students Feedback	Course	Strongly Disagree (%)	Disagree (%)	Neither Agree nor Disagree (%)	Agree (%)	Strongly Agree (%)
I am aware of potential ethical risks of AI use (e.g., privacy, plagiarism, bias).	Pr-Fr	0	0	20	20	60
	Pu-So/Ju	0	0	9	9	82
	Pr-Se	0	0	0	29	71
	Pu-Se	0	0	10	10	80
I understand when AI use is appropriate vs. inappropriate for coursework in this class.	Pr-Fr	0	0	13	40	47
	Pu-So/Ju	0	0	0	9	91
	Pr-Se	0	0	0	14	86
	Pu-Se	0	10	0	20	70
The AI activity requirements (logs, verification, originality) encouraged ethical use of AI.	Pr-Fr	0	7	33	33	27
	Pu-So/Ju	0	0	0	18	82
	Pr-Se	0	0	0	57	43
	Pu-Se	0	10	10	30	50

Table 7 summarizes students' feedback related to ethical awareness when using AI in engineering coursework. The highest level of uncertainty regarding the ethical implications of AI use (20% selecting "neither agree nor disagree") was observed among freshman students, indicating less developed awareness of potential ethical concerns. This finding suggests a need for earlier and more explicit instruction in engineering curricula on the ethical use of AI, including issues related to plagiarism, bias, data integrity, and data privacy. A similar pattern was observed when students were asked whether they could distinguish between appropriate and inappropriate uses of AI in coursework, with freshman students again demonstrating the greatest uncertainty.

Students were also asked to evaluate whether the implementation strategy used in this study, requiring submission of AI interaction logs, verification steps, and reflective commentary, encouraged ethical AI use. Students enrolled in Mechanics of Materials and Biomedical Engineering Capstone courses reported the highest levels of agreement, with 100% agreeing or strongly agreeing that these requirements promoted ethical use of AI, while freshman students reported the lowest levels of agreement. Across all four courses, most students indicated that they would not feel comfortable submitting AI-generated work without first verifying its accuracy. Collectively, these results suggest that structured AI integration, coupled with instructor guidance and accountability mechanisms, can enhance students' awareness of responsible and ethical use of AI in engineering education.

Table 8. Students' Attitude and Potential Benefits

Students Feedback	Course	Strongly Disagree (%)	Disagree (%)	Neither Agree or Disagree (%)	Agree (%)	Strongly Agree (%)
AI made me more efficient without reducing rigor.	Pr-Fr	0	31	38	31	0
	Pu-So/Ju	9	18	18	18	36
	Pr-Se	0	0	29	57	14
	Pu-Se	22	0	22	33	22
AI helped me connect course content to my discipline/interest area.	Pr-Fr	14	21	29	36	0
	Pu-So/Ju	18	9	27	18	27
	Pr-Se	0	0	0	57	43
	Pu-Se	22	11	22	33	11
I intend to use AI responsibly in future engineering courses or internship	Pr-Fr	7	14	29	43	7
	Pu-So/Ju	9	0	9	27	55
	Pr-Se	0	0	29	14	57
	Pu-Se	10	0	0	30	60
AI reduced my motivation to learn the underlying mechanics/design methods.	Pr-Fr	27	27	33	0	13
	Pu-So/Ju	36	9	18	9	27
	Pr-Se	50	17	0	33	0
	Pu-Se	63	13	13	13	0

Table 8 suggests that students generally perceived AI as beneficial, but the strength of reported benefits varied by course level and context. Senior students, especially those in the private Biomedical Engineering Capstone, reported the most consistently positive outcomes: most agreed that AI improved efficiency without reducing rigor (71% agree/strongly agree) and strongly supported its value for connecting course content to their discipline (100% agree/strongly agree). Across all courses, intention to use AI responsibly in future coursework or internships was high, particularly among upper-level students (e.g., 82% in Mechanics of Materials, 71% in Capstone, and 90% in Reinforced Concrete Structures agreed/strongly agreed). In contrast, freshmen in Engineering and Design expressed more mixed perceptions of efficiency (only 31% agree; 69% neutral/disagree) and disciplinary connection (36% agree; 64% neutral/disagree), though a majority still indicated intent to use AI responsibly (50% agree/strongly agree).

Importantly, concerns that AI reduced motivation to learn underlying mechanics/design methods were not dominant overall: most students in the senior Reinforced Concrete course (76% disagree/strongly disagree) and the freshman course (54% disagree/strongly disagree) rejected this concern, while Mechanics of Materials showed the most polarized responses (36% agree/strongly agree vs. 45% disagree/strongly disagree). Collectively, these results indicate that students largely view AI as a useful and future-relevant tool, with the most positive perceptions appearing in advanced, design-focused courses, while lower-level courses show greater uncertainty and variability.

Tables 6 through 8 indicate that the structured AI activity improved students’ ability to work with generative AI by developing three practical competencies that are essential for effective use in engineering contexts: intentional prompting, critical evaluation, and responsible application. Because students were required to document their prompts, reflect on how they used their outputs, and revise their interactions when responses were incomplete or misaligned, the activity encouraged more deliberate and iterative prompting rather than one-shot answer-seeking (Table 6). In addition, the rubric’s emphasis on checking AI results against engineering principles, assumptions, and calculations appears to have strengthened verification habits and students’ confidence in judging output quality, an important safeguard against plausible but incorrect responses (Tables 6–7). Finally, students’ responses also suggest increased awareness of ethical boundaries (e.g., appropriate use, integrity, and privacy considerations), implying that the activity helped operationalize responsible-use expectations into concrete decision-making rather than leaving them as abstract policy statements (Table 8). Collectively, these findings support the conclusion that the intervention enhanced not just comfort with AI, but students’ disciplined capability to prompt effectively, validate outputs, and use AI within appropriate academic and professional norms.

Conclusion

Across four engineering courses spanning the undergraduate curriculum at two institutions, students’ experiences indicate that structured and accountable AI integration, including prompt logging, verification, and reflection, supports learning by strengthening self-monitoring and engineering judgment, while reinforcing that AI functions as a supplement rather than a substitute for reasoning. Students most frequently used AI to cross-check solutions, troubleshoot, and explore alternative approaches, reporting the greatest value when comparing methods and identifying errors. At the same time, students consistently noted limitations in AI accuracy, particularly for diagram-dependent problems and code- or standards-driven design tasks (e.g., ACI-based procedures), making verification both time-consuming and educationally essential.

Survey results demonstrate that academic maturity plays a stronger role than institutional type in shaping confidence and ethical clarity when using AI. Upper-level students reported greater ability to detect errors, reconcile discrepancies, and apply professional judgment, while first-year students expressed more uncertainty regarding ethical boundaries and appropriate use, underscoring the need for earlier and clearer scaffolding. The results suggest that students' perceived benefits of guided AI use may vary with institutional and course context, potentially including factors such as class size and the availability of instructional support, underscoring the need for scalable implementation strategies that maintain opportunities for feedback and verification.

Overall, students viewed AI as future-relevant and expressed a strong intent to use it responsibly. These findings support a scalable framework for integrating generative AI across engineering curricula that aligns with academic integrity and ABET-oriented outcomes by emphasizing transparency, verification, reflection, and the development of sound engineering judgment.

Acknowledgements

This material is based upon work that was partially supported by the National Science Foundation under IUSE/PFE:RED Grant No. 2449870. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. ChatGPT was used as a writing assistant to check grammar.

References

[1] Xu, W., & Ouyang, F. (2022). The application of AI technologies in STEM education: A systematic review. *International Journal of STEM Education*, 9(1). https://link.springer.com/article/10.1186/s40594-022-00377-5

[2] Vidalis, S. M., Subramanian, R., & Najafi, F. T. (2024). *Revolutionizing Engineering Education: The Impact of AI Tools on Student Learning. ASEE Annual Conference & Exposition.* https://peer.asee.org/revolutionizing-engineering-education-the-impact-of-ai-tools-on-student-learning

[3] Munir, M. T., Li, B., Carter, S., & Hussain, S. (2025). *Engineering education's odyssey with ChatGPT: Opportunities, challenges, and theoretical foundations*. *International Journal of Mechanical Engineering Education*, 1–22. https://doi.org/10.1177/03064190251337477

[4] Park, J., & Choo, H. (2023). https://www.damiantgordon.com/WebLessons/PromptEngineering/Papers/Generative_AI_Prompt_Engineering_for_Educators_Practical_Strategies.pdf

[5] Lee, D., & Palmer, E. (2025). *Prompt engineering in higher education: A systematic review to help inform curricula*. *International Journal of Educational Technology in Higher Education, 22*, Article 7. https://doi.org/10.1186/s41239-025-00503-7

[6] National Academies of Sciences, Engineering, and Medicine. (2024). *Artificial Intelligence in Education and Mental Health for a Sustainable Future: Proceedings of a Workshop—In Brief.*

[7] UNESCO. (2023). *Guidance for generative AI in education and research*. https://www.unesco.org/en/articles/guidance-generative-ai-education-and-research

[8] The National Academies Press. https://www.nationalacademies.org/read/27995

[9] Cortez, A. (2024). Integrating ChatGPT in an Introductory Engineering Undergraduate Course as a Tool for Feedback. *ASEE Annual Conference*. https://peer.asee.org/integrating-chatgpt-in-an-introductory-engineering-undergraduate-course-as-a-tool-for-feedback.pdf

[10] Bobula, M. (2024). Generative artificial intelligence (AI) in higher education. *Journal of Learning Development in Higher Education*. https://journal.aldinhe.ac.uk/index.php/jldhe/article/view/1137

[11] Xie, Y., Wu, S., & Chakravarty, S. (2023). AI meets AI: Artificial intelligence and academic integrity. In *Proceedings of the 24th Annual Conference on Information Technology Education (SIGITE '23)* (pp. 1–8). Association for Computing Machinery. https://doi.org/10.1145/3585059.3611449

[12] Knoth, N., Tolzin, A., Janson, A., & Leimeister, J. M. (2024). *AI literacy and its implications for prompt engineering strategies*. *Computers and Education: Artificial Intelligence*, *6*, 100225. https://doi.org/10.1016/j.caeai.2024.100225

[13] Woo, D. J., Wang, D., Yung, T., & Guo, K. (2025). *Effects of a prompt engineering intervention on undergraduate students' AI self-efficacy, AI knowledge and prompt engineering ability: A mixed methods study*. *British Educational Research Journal*. Advance online publication. https://doi.org/10.1002/berj.70087 .

[14] Garg, S., Soodhani, K., & Rajendran, S. (2023). Enhancing data analysis and programming skills through structured prompt training: The impact of generative AI in engineering education https://www.sciencedirect.com/science/article/pii/S2666920X25000207

[15] https://ovpr.uconn.edu/services/rics/irb/researcher-guide/does-evaluation-require-irb-review/

[16] https://www.hartford.edu/about/campus-leadership/office-provost/faculty-development/human-subjects-committee/#accordion-group-1-section-5-label