Capstone and AI: A Case Study using Engineering Standards

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Abstract—
Capstone projects represent the culminating experience for both Engineering (EAC) and Engineering Technology (ETAC) students, requiring them to synthesize design knowledge, technical analysis, and professional standards. Capstone project design courses offer a critical opportunity to help students develop technical competence and acumen. These projects reinforce ABET criteria; part of the ABET Criteria 5d. for Accrediting Engineering Technology Programs (2025 – 2026) for Baccalaureate degree states that "The discipline specific content of the curriculum must focus on the applied aspects of science and engineering and must include design considerations appropriate to the discipline and degree level such as: industry and engineering standards and codes"[1]. Students, however, often struggle to locate and interpret relevant standards such as IEEE, NEC, IEC, and UL codes. The current challenge for a successful capstone project is to ensure students meet standards-based design expectations while fostering critical AI literacy.

This paper presents a pedagogical framework for integrating AI tools into senior capstone education through a structured sequence of four assignments. Developed for an Electrical Engineering and Renewable Energy capstone course at XYZ University, this new approach guides students to engage with AI not just as a design aid but as a subject of analysis, evaluating how AI contributes meaningfully to engineering standard design processes. The assignments emphasize identifying and applying industry standards, engineering codes, and ethical decision-making. Each assignment contrasts traditional research and reasoning with AI-assisted approaches. It also prompts students to reflect on the value, risks, and credibility of AI-generated outputs. By coupling technical rigor with critical reflection, the framework prepares students to navigate a profession increasingly shaped by AI while maintaining compliance with ABET EAC and ETAC outcomes.

This framework is adaptable to multiple engineering disciplines. It provides a pathway for programs seeking to incorporate responsible AI practices into accreditation-aligned outcomes, such as ABET criteria related to design under constraints with ethical responsibility.

[1]*Source: Criteria for Accrediting Engineering Technology Programs, 2025 - 2026 - ABET*

Keywords- Artificial Intelligence, Capstone Pedagogy, Standards-Based Design, ABET Accreditation, Engineering Education

Introduction

Capstone design courses occupy a unique position in engineering curricula. They serve as a culminating experience in which students integrate technical knowledge, professional skills, and ethical responsibilities while working on open-ended, real-world problems. Accreditation bodies such as ABET emphasize outcomes related to problem solving, application of engineering standards, ethical responsibility, and professional judgment. However, the rapid emergence of generative AI tools has created uncertainty for instructors about how to incorporate them into capstone experiences without undermining learning objectives, design rigor, or academic integrity.

Modern engineering design is shaped by standards and codes that define safety, reliability, and performance. As tools like ChatGPT, GitHub Copilot, Claude, and others become common design companions, engineers must be able to critically evaluate AI-generated interpretations of these standards. The challenge for contemporary engineering education is ensuring students meet standards-based design expectations while maintaining professional responsibility.

Artificial intelligence (AI) tools increasingly influence engineering education. A 2025 Inside Higher Ed survey found that 85% of college students now use AI for coursework. AI tools like ChatGPT, GitHub Copilot, MATLAB with AI Toolbox, and Elicit can generate design insights and summarize standards. However, their reliability remains uncertain. Faculty, therefore, have a responsibility to teach students how to use these tools effectively, ethically, and with critical awareness. Existing approaches to AI in engineering education have largely focused on either prohibiting AI use, allowing unrestricted use, or treating AI primarily as a productivity or coding aid. These approaches often fail to explicitly connect AI usage to engineering standards, formal design methodologies, or ethical frameworks. Moreover, students may adopt AI tools uncritically, accepting generated outputs without sufficient validation or reflection on their limitations, biases, or compliance with industry practices. This gap highlights the need for structured pedagogical models that position AI both as a tool and as an object of critical analysis within engineering design education.

Accreditation bodies such as ABET emphasize outcomes related to problem solving, application of engineering standards, ethical responsibility, and professional judgment. As a result, engineering education, particularly at the senior capstone level, must evolve to prepare students not only to use AI tools but also to critically assess their appropriateness, reliability, and ethical implications within formal engineering design processes. This paper presents a framework that consists of a structured sequence of four scaffolded assignments that deliberately contrast traditional engineering research and reasoning with AI-assisted approaches. Rather than treating AI as a shortcut or replacement for engineering judgment, the assignments guide students to evaluate when and how AI contributes meaningfully to established design workflows governed by standards, codes, and ethical obligations.

Each assignment requires students to identify relevant industry standards, assess AI-generated information for accuracy and credibility, and reflect on ethical considerations associated with AI use in engineering contexts. Through this process, students develop technical rigor alongside professional judgment, learning to justify design decisions and AI usage in a manner consistent with real-world engineering practice. The framework is explicitly mapped to ABET Engineering Accreditation Commission (EAC) and Engineering Technology Accreditation Commission (ETAC) outcomes, ensuring alignment with accreditation requirements.

Literary Background

Capstone projects serve as the culminating experience in undergraduate engineering education, designed to synthesize academic knowledge and foster the technical and soft skills necessary for professional practice [1]-[3]. These projects represent the culminating pedagogical experience in undergraduate engineering, utilizing Project-Based Learning (PBL) to bridge the gap between theoretical knowledge and professional practice. Recent systematic reviews indicate substantial diversity in implementation, noting that although most courses are expected to last a full academic year, approximately 66% are restricted to a single semester due to curricular constraints [2], [3]. Despite their importance, research identifies a significant transition gap: only 2% to 5% of projects achieve commercialization, as many remain purely academic exercises without external clients [2]-[4].

The integration of Agile methodologies, such as Scrum and Kanban, has become a standard practice to simulate industrial environments [4]-[6]. Studies on multidisciplinary collaboration demonstrate that combining students from various fields, such as mechanical, electrical, and computer engineering, leads to more successful system-level integration, as seen in FSAE electric vehicles and complex AI-based mechatronic systems [1], [7], [8]. However, these collaborative environments present persistent assessment challenges, particularly in the fair evaluation of individual contributions and in aligning academic rubrics with diverse stakeholder expectations [7], [9].

In the era of Industry 4.0, the role of Artificial Intelligence (AI) has shifted from an elective topic to a core competency and a vital supportive tool [1], [3]. Students are increasingly tasked with designing AI-driven systems involving gesture detection, voice-controlled robotics, and smart infrastructure, even without prior AI experience [1]. Furthermore, Generative AI and AI Knowledge Assistants are being utilized to enhance the educational process by:

- Improving the clarity and readability of weekly StandUp reports through personalized feedback [5].
- Facilitating the transmission of collective knowledge across student generations to prevent the loss of "lessons learned" [6], [10].
- Providing context-aware recommendations by integrating local project databases with large language models like GPT-4 [6].

While students express high satisfaction with these AI tools for reducing knowledge gaps and optimizing workflows, they remain skeptical of AI's reliability in high-stakes design tasks [11]. Future research and curricula must focus on formal AI training and more dynamic project structures that prioritize independent learning and market relevance, ensuring graduates are prepared for an increasingly AI-driven workforce [3], [11].

Pedagogical Framework

The proposed framework consists of a four-assignment sequence designed for a class of twenty Electrical Engineering and Renewable Energy Capstone students. This approach contrasts traditional research with AI-assisted methods to highlight the value, risks, and credibility of automated outputs.

Phase 1: Initial Assessment and Awareness

To tailor instruction, students complete a pre-survey on their familiarity with concepts such as ISO, IEEE, ASHRAE, and sustainability standards like LEED. The survey assesses student confidence in identifying applicable standards and their prior experience using AI tools to interpret them. The survey assessed if the students had used AI tools to help identify or interpret industry standards in the past as shown in Fig. 1. As seen from the pie chart, it is evident that most of the students had used some AI tools for their previous projects/assignments.

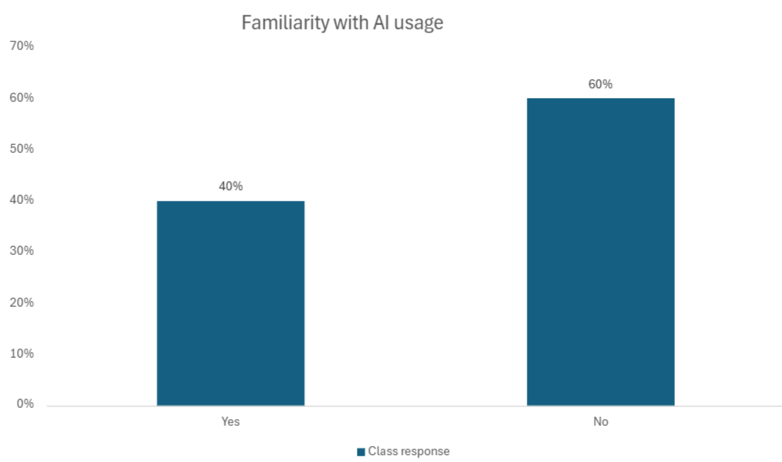

Fig. 1 Past usage of AI tools (e.g., ChatGPT, Copilot, Elicit) to help identify or interpret industry standards.

Familiarity with Industry Standards was assessed in a class of twenty students for the Capstone Project. Fig. 2 shows the percentage of familiarity among students, with only fifteen percent of the class being aware of it.

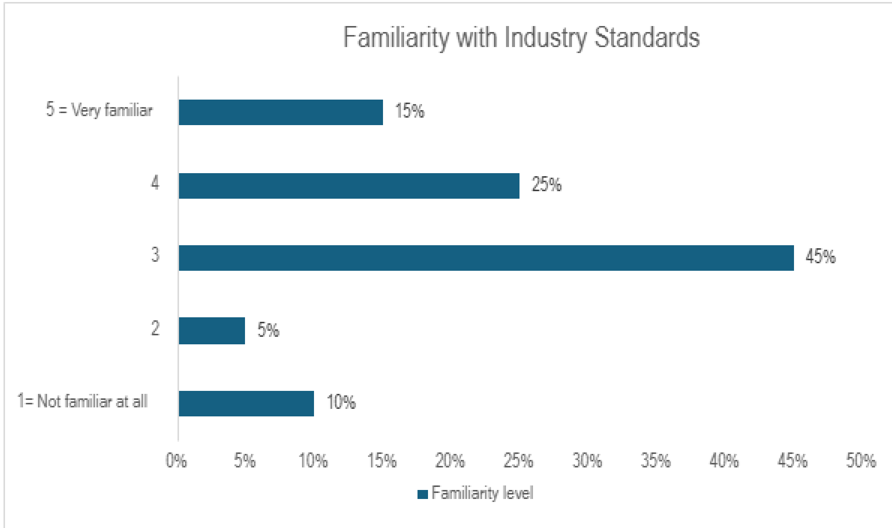

Fig. 2 Familiarity with Industry Standards.

Most of the class (about 90%) were not confident in applying Engineering Standards to a given Engineering problem. Preliminary data suggests that common student challenges include finding relevant standards, understanding technical language, navigating paywalls, and integrating standards into their design process, as shown in Fig. 3 below.

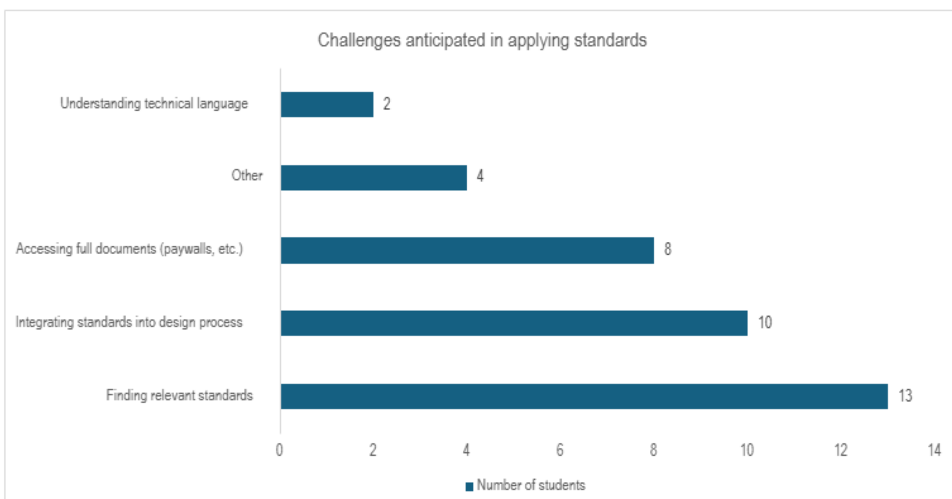

Fig. 3 Challenges anticipated in applying standards in the capstone project.

Phase 2: Mapping Standards (In-Class Activity I)

In this phase, student teams identify at least three to five standards relevant to their specific capstone project. The task requires manual research (via professional databases or library resources) followed by AI-assisted research. Students must create a comparison table documenting the source, standard name, and their confidence level in its applicability. This activity forces students to reflect on whether AI helped them discover new information or if it missed key technical details. After this activity, students became more familiar with Industry Standards, as shown in Fig. 4.

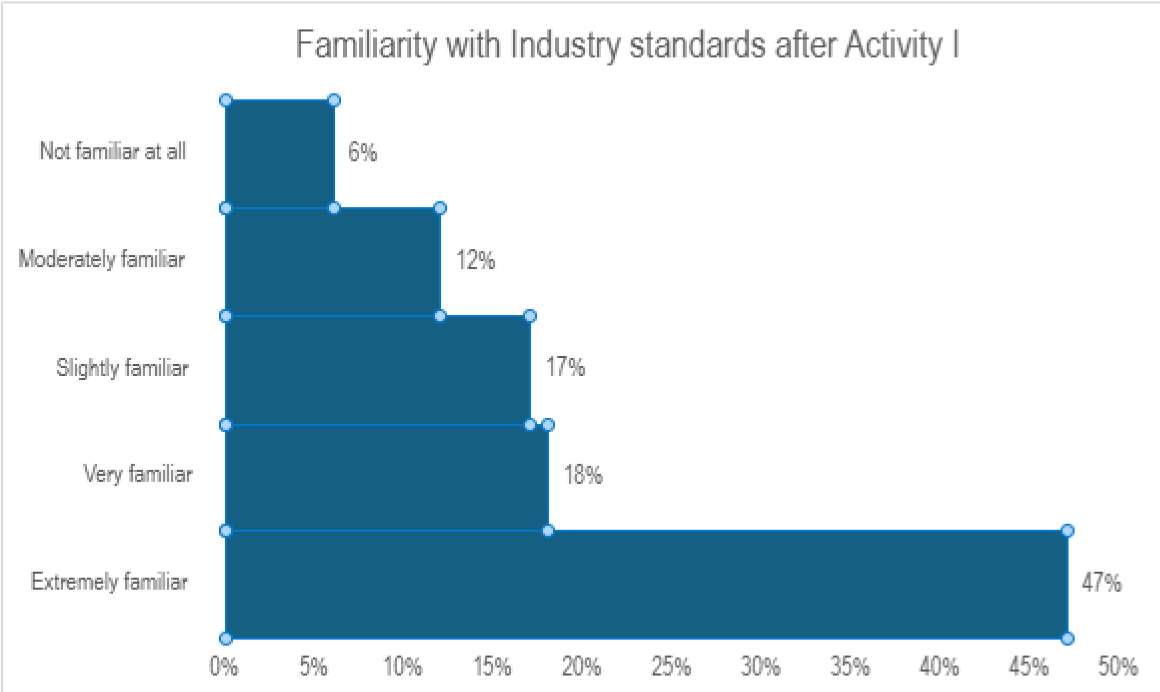

Fig. 4 Percentage of Students Familiar with Industry Standards after Activity I.

A manual vs. AI search-based activity was also involved in realizing the usefulness of Industry Standards. Usefulness of Activity components is tabulated as follows (numerals represent number of students):

Table 1. Usefulness of Manual vs. AI assisted search for Industry Standards

Search Method	Not at all useful	Slightly useful	Moderately useful	Very useful	Extremely useful
Manual standards search	1	3	4	4	3
AI-assisted standards search	2	2	2	5	3
Comparing manual vs. AI results	0	1	3	6	4

Some excerpts of what the students learnt from comparing manual research vs. AI-assisted research are documented below:

- "Comparing manual research with AI-assisted research showed that AI is very effective for quickly summarizing topics, identifying relevant standards, and generating initial ideas. However, manual research was necessary to verify accuracy, understand context, and confirm details such as specific standard requirements and limitations. The comparison highlighted that AI is a useful support tool, but reliable engineering work still requires human judgment, validation, and direct review of original sources."

- "I learned that you should use a combination of manual and AI-guided techniques for the most robust research findings. Just leaning on one technique is simply not as effective, accurate, or efficient."
- "AI makes lots of mistakes but is able to produce lots of results. This is helpful in a standards search because you can start with a long list of standards that 'might' be applicable, then research each individually to see how it actually fits."
- "From comparing, I could see that AI is helpful for research because it can look for information all around the internet and gather it, but it is very general. At the end, I have to make a decision on what is useful and what is useless."
- "AI can give helpful information to aid the research process, but the accuracy is questionable. Manual confirmation is needed after."
- "Manual research takes a lot of time to browse and find the standard/s that are applicable to the project, while AI-assisted research is fast, just need to make sure the standard accurately covers and applies to the project idea by doing further research."

Phase 3: Critical Evaluation of AI Interpretation (In-Class Activity II)

Students select critical design elements—such as circuit protection or thermal management—and research the governing standards. They then consult an AI tool with the same design question and compare their interpretation to the AI's.

- Example Findings: In a project involving a portable LED power supply, students identified IEC 60127 for fuse selection. The AI, however, recommended IEC 60601 (a medical device standard) and failed to address the requirements for slow-blow characteristics. In the case study of a portable LED power supply, the AI misinterpreted medical standards, directing the design team toward IEC 60601, which is specifically for medical electrical equipment. The misinterpretation occurred during a comparison between a student team's manual research and an AI's interpretation of standards for fuse selection. Key points of the AI's failure included:

  1. Misapplied Context: The AI recommended checking medical device standards (IEC 60601) for a project that was a general portable LED power supply, rather than the relevant standard for miniature fuses, IEC 60127.

  2. Incorrect Specifications: The AI suggested using a 1 A fuse to handle inrush current, whereas the team's interpretation of the correct standard (IEC 60127-2) determined that a 500 mA fuse was required for the 5 V line.

  3. Missing Technical Requirements: The AI failed to recognize the need for slow-blow characteristics, a critical detail for the circuit protection. The reflection on this specific case

noted that while AI can be a useful tool for brainstorming, it often lacks the contextual awareness required to understand specific circuit current profiles and can lead to "hallucinated" or misapplied limits.

4. Risk Identification: Through these comparisons, students recognize risks such as outdated citations, overgeneralizations, and "hallucinated" or invented standards. A summary of these risks is specified in the table below (numerals represent the number of students).

Table 2. Evaluating AI accuracy

	Never	Occasionally	Often	Frequently
Provide correct/useful standards	0	4	7	3
Misinterpret standards	1	7	4	2
Hallucinate standards	4	6	3	1

Phase 4: Ethics, Accountability, and AI

The AI, Accountability, and Engineering Ethics assignment examines the integration of automation into engineering design and compliance by synthesizing professional ethical codes, such as those from the NSPE and IEEE, with analyses of technical failure chains. Students investigate how breakdowns in documentation, communication, and ethical review impact the transition from automated sensors to human interfaces and identify how transparency and traceability can maintain professional responsibility across design and management teams. By drawing parallels between historical automation issues and modern AI-based engineering tools, including structural simulation, autonomous vehicle control, and medical device design, the curriculum highlights the controls and documentation needed to maintain accountability. Finally, the assignment requires proposing actionable Ethical AI Design Compliance practices, such as model explainability, redundancy, and audit trails, to ensure safety and honesty in automated engineering systems.

Assessment, Exit Survey, and Grading Criteria

The effectiveness of this framework is measured through specific grading rubrics that prioritize:

- Identification of Standards: Relevance and documentation context.
- Comparison of Interpretations: Clear, analytical support for examples.
- Reflection on AI Reliability: Insightful highlighting of real-world risks.

Phase I activity involves assessing students' familiarity with AI use. Phases 2, 3, and 4 involved in-class activities with deliverables graded using rubrics. In Phase 2, students identify standards and codes relevant to their project through both manual research and AI-assisted exploration, comparing accuracy, completeness, and relevance. Evaluation criteria for this phase are provided in Table 3.

Table 3. Evaluation Criteria for Phase 2

Criteria (equal weightage)
Accuracy and relevance of standards identified
Depth of comparison (manual vs AI)
Reflection on AI effectiveness and limitations

In Phase 3, teams implement identified standards in specific design components, using AI tools to verify or suggest design parameters and critically assess AI's interpretive validity. They are evaluated in accordance with the performance metrics mentioned in Table 4.

Table 4. Evaluation Criteria for Phase 3

Criteria (equal weightage)
Proper interpretation and application of standards
Quality of AI vs human comparison
Risk analysis of AI use

Phase 4 helps students analyze case studies on compliance and professional responsibility, reflecting on the ethical boundaries of AI use in engineering decision-making. The performance metrics are discussed in Table 5 below.

Table 5. Evaluation Criteria for Phase 4

Criteria (equal weightage)
Depth of ethical analysis
Connection between AI, standards, and accountability
Quality (subjective?) of case study discussion

Each team documents their design process, Standards integration, and evaluation of AI's effectiveness in a comprehensive report and presentation.

The study's effectiveness is also measured through a final Exit Survey that tracks student growth. Table 6 below summarizes the assignments and their intended learning outcomes.

Table 6. Summary of Assignments and Intended Learning Outcomes

Assignment Title	Intended Learning Outcomes
Mapping Design Standards	Identify and evaluate relevant engineering standards using both traditional and AI-assisted methods; assess AI's accuracy and limitations.
Applying Standards to Design Decisions	Integrate identified standards into technical design components; compare AI-generated interpretations with professional reasoning.
Ethical and Regulatory Implications	Analyze ethical considerations and accountability issues in using AI for standards compliance.
Final Integration Report	Demonstrate full standards integration, document AI's impact on design rigor, and reflect on responsible use in engineering practice.

• Growth Metrics: The survey measures improvements in identifying standards and the ability to critically evaluate AI.

• AI Reliability Findings: Students report the frequency with which AI tools provided useful standards versus how often they hallucinated or misinterpreted them.

• Success Factors: The survey identifies which methods—manual search, instructor guidance, or AI helped students most in successfully identifying key standards for their capstone project. Fifty percent of the class asserted that using AI-assisted manual search for Industry Standards was the most successful and time-efficient method to incorporate Standards in their capstone project.

Students were also asked about what aspects of the standards and AI curriculum were most valuable. Some excerpts:

- "The most valuable aspect was learning how to critically evaluate AI outputs instead of trusting them blindly. The activities reinforced the importance of traceability, verification, and professional responsibility when using AI in engineering contexts, especially for safety-critical standards."

- "I was able to pull the information quickly, and with a lower degree of error than in an unassisted search."

- "The direct comparisons between manual research and AI-assisted research provided a good foundational understanding of what to expect from AI and what problems might come up."

- "The most important thing I learned is that AI can sound very confident while still being wrong or incomplete when it comes to engineering standards. AI tools may cite outdated versions, reference the wrong standard entirely, or oversimplify requirements without understanding the specific context of the design. Relying on AI alone creates a risk of missing critical safety, compliance, or documentation details. This showed me that AI should be used as a starting point or cross-check, but engineers must always verify standards directly from official sources to ensure accuracy and accountability."

Conclusion

This framework is adaptable across various engineering disciplines and provides education programs with a pathway to incorporate responsible AI practices into accreditation-aligned outcomes. By embedding AI literacy, ethical reflection, and standards-based reasoning directly into the capstone structure, this work offers a practical and transferable model for engineering educators seeking to responsibly integrate AI into senior design education while reinforcing ABET criteria. The framework supports students in navigating a profession increasingly shaped by AI while reinforcing the foundational principles of engineering accountability, safety, and professionalism.

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