Integration of Artificial Intelligence (AI) Technologies into the Capstone Design Model at Southern Arkansas University

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The rapid rise of Artificial Intelligence (AI) technologies poses serious challenges to engineering education, as these technologies open avenues for unethical use in learning and teaching. Even though AI poses significant challenges in education, it can become a valuable tool that enhances the teaching and learning process, especially in Capstone design. This paper discusses the integration of AI technologies in the Capstone model of the Department of Engineering and Physics at Southern Arkansas University (SAU) to provide enhanced design experience to its students.

Keywords: Capstone design, Senior design, AI, Academic integrity

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Introduction

Capstone design is a critical component of engineering education, serving as a bridge between theoretical knowledge and professional practice. It facilitates the smooth transition of graduating students into the engineering workforce by requiring them to apply concepts learned throughout their academic program to real-world problems.

Capstone design courses are inherently challenging because they demand the integration of prior coursework, independent learning through research, critical thinking, and the adoption of a design-oriented mindset. Since their introduction as senior-level requirements in engineering programs, Capstone courses have evolved to provide comprehensive design experience. These projects typically require students to develop cost-effective and marketable solutions to engineering problems. The Accreditation Board for Engineering and Technology (ABET) clearly defines the engineering design process and establishes expectations for Capstone design projects[1].

The rapid advancement of artificial intelligence (AI) presents both opportunities and challenges in engineering education. While AI technologies have the potential to enhance learning, there is growing concern that students may engage in unethical practices by using AI tools primarily for cheating.

The negative impact of AI technologies has not yet affected Capstone design courses to the same extent as other engineering courses; however, Capstone courses are not immune. DeBartolo[2] concluded that Capstone students could still contribute to team discussions using AI-generated responses. This observation highlights the potential for AI to be used constructively in Capstone design courses to enhance the overall design experience.

This paper presents the limited integration of AI technologies into the fall semester activities of the Capstone design model at Southern Arkansas University (SAU). The current SAU Capstone Model[3] consists of a two-semester design sequence. Because students complete their design on paper in the fall semester, it is the most appropriate semester to introduce AI to produce quality designs. In the spring semester, students focus on prototyping and showcasing design solutions.

Methodology

Most Capstone design work at SAU is completed in the fall semester. Problem formulation, Preliminary design, Embodiment, and Detail design are key design phases. AI technologies will be used in each of those design phases, as presented below. We have started integrating AI technologies in the SAU Capstone model, and the process began with the simple approach described below. Four design teams identified as ASGC Rover, Mini Dredger Arm, Mini Dredger Pontoon, and Ground Shakers implemented the process as follows. All teams used ChatGPT5.3 architecture, and each team was required to record its AI use in tabular form with the following column headings: Design phase, Specific activity, How AI was used (Tools, Prompts, Purpose), How the team verified AI output, AI suggestions adopted, Rationale for adoption, AI suggestions rejected, Rationale for rejection, Evidence/Artifacts- Proof of AI use and verification. Also, students were required to independently validate all AI-generated suggestions against engineering principles and project constraints.

Problem formulation -Literature Search
Each team asked AI modules to present a set of important research topics, including benchmark technologies, materials, safety aspects, industry standards, and manufacturing methods. Students then researched the topics suggested by AI and documented their findings. The prepared document is then submitted for AI review to receive feedback and improve the quality of the report. The instructor reviewed the report, made assessments, and took appropriate action before its adoption.

Problem formulation-Project Management Plan
In problem formulation and project management, students asked AI to critique and improve the quality of the written document prepared by students. Students then incorporated acceptable suggestions, rewrote the written document, and submitted it for the instructor's evaluation. The final version of this document was adopted after the review of the instructor, who decided on the acceptable content and the academic rigor of the content.

Problem formulation & Engineering Design Specifications
Each Team asked AI to produce a set of design constraints with special reference to multiple constraints, safety, manufacturability, operating conditions, industry standards, etc. The team reviewed the AI inputs and prepared the engineering design specifications. The instructor reviewed the document to see if multiple constraints, safety conditions, operational requirements, manufacturing constraints, and performance criteria are well established. Each team adopted the document after the review of the instructor for technical accuracy.

Preliminary Design
Preliminary design involves concept development and evaluation, configuration design, and parametric calculations. The following sections describe activities in each category.

Concept Development and Evaluations
Teams were not allowed to use AI in concept development to guard against using AI to replace their critical thinking and imagination. After the final concept was selected, teams were allowed to get feedback from the AI on the selected concept and compare the AI feedback with their own selection.

Embodiment Design
Teams were allowed to provide their own final design concept to AI and used its image generation capabilities to generate an image. This image was compared with the original. Any AI concept image that is not aligned with project objectives, too complicated for prototyping, or unrealistic concepts was rejected. However, AI suggested images of a given part or parts that improved the functional performance of a given design were selected for incorporation into the original design.

Parametric Calculation, Design optimization, & Detail Design
In parametric calculations, teams had the freedom to ask AI what engineering analysis is required in the design process to begin with. However, Teams were not allowed to use AI-produced calculations or simulations, and all analysis tasks were completed under the strict guidelines of the instructor. The use of AI is partially allowed in the detail design phase to obtain a critique of 2D drawings and to determine if the drawings comply with the ASME Y14.5 standard.

Spring Semester Activities
The main design activity in the spring semester is prototyping, testing, and performance evaluation. Here, the use of AI was optional. If AI were used, it would only be to evaluate the test plans and seek improvements.

Preparation of Final Design Report and other Documentation
Preparation of the final design report was initiated in the fall semester as each design phase was concluded. In the fall semester, each sectional report was checked for English grammar using AI technologies so that the compilation of the final design report could be quickly completed in the spring semester.

Review of Design Team Documentations of AI Use
As mentioned previously, four design teams recorded their use of AI in each design phase. The following sections summarize their documented AI use in design phases, which include literature search, project management, engineering design specifications, concept development and evaluations, parametric calculations, detail design, manufacturing and prototyping, and testing and evaluations.

1. ASGC Rover Team
The ASGC Rover team was developing an autonomous rover, which could pick up objects based on color and relocate them. The team has used AI in almost every aspect of the design process. Prominent interactions with AI are noted in the literature search, project management plan, engineering design specification, navigation system identification, and the detail design phase. In the literature search, the team's AI prompts focused on reorganizing the document into a clear engineering format, strengthening technical language, and improving the integration of references. The Team has adopted AI suggestions to replace generic rover descriptions with specific real-world rover systems, such as DuAxel, CADRE, and Rosalind Franklin. In the Rover team's project management plan, AI has guided the team in

better structuring the content. The team has accepted the AI suggestion to use lighter material with strong mechanical properties and rejected some of the AI-suggested material due to cost. The team has received significant help in "Navigation" to define pipeline control logic, and the team selected the camera suggested by AI. However, the team has rejected some sensor infusions due to complexity. The team has used AI to obtain a cleaner component layout of its hand-drawn layout.

2. Team-Ground Shakers

The Ground Shaker team was developing a remote-controlled surface mine laying system. This team also had significant interactions with AI in every design phase. The team's notable interactions are recorded in literature search, project management, engineering design specifications, concept design improvements, electrical wiring layout, manufacturing, and prototyping. The team has asked AI to produce a cleaner wiring diagram. Their original diagram and the AI-produced one are shown in Figure 1(a), and 1(b). The team had trouble identifying a mine dispenser system and asked AI to produce a prototype friendly rover with a chute system to dispense mines. The AI-produced system is shown in Figure 2(a), and the Team's prototype is shown in Figure 2(b). The team has incorporated the AI-suggested chute as the mine dispenser and introduced a servo mechanism to dispense mines.

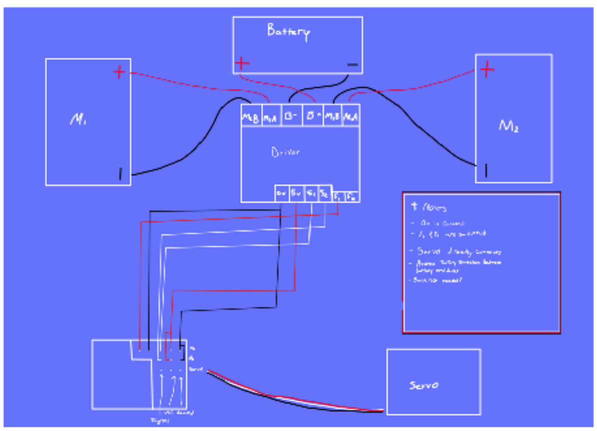

Figure 1(a): Original wiring diagram

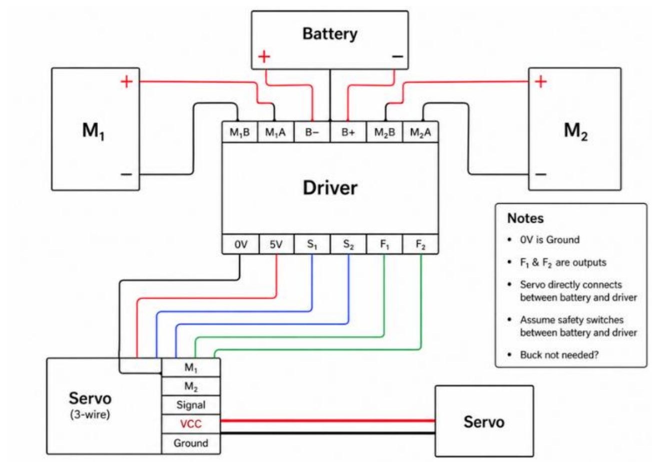

Figure 1(b): AI produced cleaner wiring diagram

3. Team – Mini Dredger Arm

Team mini dredger arm was developing a dredger arm to be incorporated into a mini dredger. They used AI mainly to improve the quality of their literature survey, project management plan, and engineering design specifications, and to compare their final design concept with the AI-produced one. The team has rejected AI suggestions in detail design, manufacturing, and prototyping, citing the over-complexity of suggestions and not being compatible with the available resources to them. The team provided a rudimentary design of a dredger arm to AI and asked for an improved version. Team rejected the AI-produced version, citing, "AI generated an awkward, unrealistic design for the dredger arm. Hydraulic cylinders cannot be bent and function properly". The team later developed a mini dredger arm independently. The rudimentary design provided to AI and the AI-produced design are shown in Figure 3.

4. Team – Mini Dredger Pontoon

This team was building the pontoon of the mini dredger. The team mainly used AI to improve the writing quality of its literature search, project management plan, and engineering design specifications. The team has asked AI to review its final design. The suggestion by AI to include safety railings was adopted by the team. However, they rejected additional floating barrels, citing, "The suggestions would have been far too heavy and expensive for our project".

Figure 2(a): AI proposed rover with a built-in chute

Figure 2(b): Actual prototype with mine dispenser

Figure 3: AI produced dredger arm

Reflections on AI Use by Design Teams

Each team summarized its experience and reflected. The ASGC Rover team noted," Overall, AI was most helpful when generating ideas and improving clarity, but less helpful when it came to highly specific engineering decisions that required real-world testing." Team mini dredger pontoon noted, "AI served as a beneficial tool that helped significantly with research throughout the project. "AI can also summarize complex material into simpler terms, making it easier to understand and apply". the Ground Shakers team noted. The ASGC Rover team and the Mini Dredger Arm teams recommended the use of AI with reservations, whereas the teams Ground Shakers and Mini Dredger Pontoon recommended the use of AI in Capstone design.

Discussion and Conclusion

The integration of AI technologies reveals a trend where student reliance is highest during initial, information-heavy stages and becomes more critical as projects move toward physical reality. In early literature search and project management phases, AI served as a catalyst, helping teams bridge the gap between abstract concepts and professional documentation. For example, the ASGC Rover team used AI to transition from generic descriptions to specific real-world systems, enhancing technical depth. However, as teams entered embodiment and detail design, AI's limitations became apparent. The "reality check" of physical constraints—such as the Mini Dredger Arm team identifying mechanically impossible AI-generated hydraulic cylinders—highlights AI's lack of inherent understanding regarding physics and manufacturing. This underscores the "human-in-the-loop" necessity, where students act as the final authority, filtering suggestions through the lens of cost, resource availability, and feasibility.

In conclusion, guided AI integration in Capstone design enhances learning without compromising educational or ethical standards. Through rigorous documentation, the instructor and the department ensured that students maintained ownership and developed the critical skill of verifying automated outputs against engineering principles. The instructor's role is evolving from lecturer to senior validator, ensuring decisions are grounded in reality rather than digital hallucination. This model provides a framework for engineering programs to embrace modern tools while upholding ABET standards. Future implementations should focus on quantitative methods to measure AI's impact on prototype quality and student learning outcomes.

References

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