Integrating Generative AI Tools into the Capstone Course

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1. Introduction

In recent years, many engineering programs have integrated entrepreneurship education into the capstone experience, blending technical engineering skills with entrepreneurial processes, namely ideation, customer discovery, client validation, and commercial viability [3] These processes enable students to translate their technical knowledge into economically relevant engineering practice. The objective is to produce graduates who are not only technically proficient but also capable of navigating the business landscape, ethically aware, and responsive to client and market needs.

In order to fully and effectively create such integration many programs, including our electrical engineering program at Sonoma State University, have adopted a two-course structure. In the first semester, students focus on the planning and conceptualization phase**,** where they define a problem statement, formulate a product idea, assemble teams, identify their customer base, and outline their development plans. In the second semester they actually complete the project and get ready for full presentation.

The activities in the first semester focus on fostering students' ability to generate innovative solutions for real-world problems while enhancing their team-building skills. Throughout the first semester, students are expected to perform key tasks, including defining problem statements, identifying engineering and customer requirements, mastering presentation techniques, forming successful teams, understanding project management, establishing milestones, and learning about product qualification techniques.

However, managing the capstone experience presents significant challenges, especially in smaller programs where a single faculty member may oversee multiple student teams. Faculty must balance guiding students through complex technological terminologies, assisting with idea development, identifying customers, designing effective customer survey questions, and formulating detailed marketing and engineering requirements. These responsibilities are often time-intensive, and the limited class time can result in suboptimal project outcomes. Moreover, an insufficient understanding of design requirements at the outset can have severe repercussions during the prototype development phase by students.

In parallel with these and other similar challenges, over the past several years AI-based platforms have gained significant popularity among students, teachers, and researchers [8] [9] [20] Platforms such as Khan Academy**,** Duolingo**,** Quizlet**,** Coursera**,** and Edmodo have integrated AI technologies to offer personalized and adaptive learning experiences. These tools analyze user performance and learning habits to deliver tailored content, adaptive quizzes, and real-time feedback. This shift has enhanced accessibility to education, enabled individualized learning, and provided teachers with greater range of tools to support students, more effectively.

In this paper we describe the integration of the Artificial Intelligence tool ChatGPT (Generative Pre-trained Transformer) into the engineering capstone course within our electrical engineering program. Specifically, we outline our methodology and tool development approach using generative AI and introduce the *Capstone Guide Chatbot* (CAPCHAT). The chatbot is designed to assist our electrical engineering students in refining design and marketing requirements, with the goal of improving the overall quality of their capstone projects.

The remainder of the paper is organized as follows: Section 2 discusses the capstone course structure and its challenges. Section 3 briefly reviews various tools and technologies within Artificial Intelligence. Section 4 presents key features and functionalities of CAPCHAT. Section 5 reports outcomes, including feedback from senior capstone students on their concerns, challenges, and the impact of generative AI tools on their learning. Additionally, we present a qualitative comparison of technical and marketing requirements between students who used the Capstone AI Guide and those who did not. Section 6 addresses faculty concerns and potential drawbacks of incorporating generative AI tools into the course setting, including ethical considerations and the balance between AI assistance and student creativity. Section 7 concludes the paper.

2. Capstone Course Structure

Capstone projects are a fundamental requirement for many accredited Electrical Engineering (EE) programs, as mandated by the Accreditation Board for Engineering and Technology (ABET). These projects are designed to foster student-driven innovation and problem-solving skills within a real-world context. Through industry mentorship and collaboration, students engage in projects that may involve research, simulations, or theoretical work. The current capstone structure in our electrical engineering program blends technical engineering skills with entrepreneurial experience. Thus, it breaks down the capstone project into two consecutive courses:

- EE 492**:** A one-unit planning course in Fall, focused on ideation and customer discovery.
- EE 493**:** A three-unit implementation course in Spring, dedicated to prototype development, testing, and market analysis.

The EE 492 course serves as the first phase of the capstone project, aimed at laying a solid foundation for successful project execution. In this course all senior project teams meet weekly for three hours. All students are expected to actively participate in the course discussions. Each class begins with a brief lecture from the instructor, followed by hands-on activities, workshops, or guest speaker presentations.

Guest speakers include faculty from other departments, professionals from the local industry, and community members with specific technical needs, such as representatives from non-profits or campus departments like the library and police services. These sessions expose students to diverse project ideas in areas such as wearable technologies, biomedical applications, and communication systems, and much more.

The course curriculum mainly focuses on topics including defining problem statements and identifying engineering and customer requirements, as well as conducting customer discovery to

validate product ideas. Successful teams move on to EE 493 to develop functional prototypes and conduct further testing and analysis.

By splitting the capstone into two courses, the Department ensures that students have sufficient time to refine their ideas, produce higher-quality outcomes, and gain a comprehensive understanding of both engineering practice and entrepreneurial processes.

2.1 Entrepreneur Processes and Project Ideation

As mentioned earlier, we have integrated four entrepreneurial processes across the capstone course: (1) creative ideation, (2) customer discovery, (3) commercial viability, and (4) client validation. Creative ideation refers to generating new ideas or concepts, often through brainstorming and exploration. Customer discovery involves understanding the needs, wants, and pain points of potential customers. Commercial viability aligns with assessing the potential profitability and sustainability of a business venture. Client validation entails testing the feasibility and desirability of a product or service with potential clients [1] [2] Throughout these processes, a clear understanding of marketing and engineering requirements plays a significant role in assessing both commercial viability and client validation.

In the first semester, the EE 492 course focuses on the learning outcomes associated with the planning and conceptualization phase. During this phase, students define a problem statement, formulate a product idea, identify their customer base, outline development plans, and assemble teams. The course guides individual students and teams in developing their ideas and articulating their design thinking by formulating *marketing and engineering requirements*. Additionally, teams are expected to identify their customer base and demonstrate how the product can effectively address their problems.

2.2 Formulating Project Requirements

All capstone projects are expected to have clear and well-defined marketing and engineering requirements. Formulating such requirements demands iterative discussions and constructive feedback early in the idea development process. Currently, our feedback process heavily relies on student presentations to the class and the instructor, followed by the instructor's suggestions.

Providing and obtaining constructive feedback in the early stages of idea development is a time-intensive process, particularly when addressing the diverse requirements of multiple student teams. Limited class time and the high number of students make it challenging to thoroughly discuss each group's methods and provide detailed, positive feedback.

Furthermore, over the years, we have observed that many students struggle to embrace constructive criticism during class presentations. A significant number hesitate to engage in meaningful discussions to address the feedback provided by their peers or the instructor. As a result, numerous issues related to their projects remain unresolved, negatively affecting their approach to the prototyping phase.

To address these challenges, we have developed an AI-based tool, called Capstone Guide Chatbot (CAPCHAT). In the next two sections, we first review existing AI tools and baseline

technologies, followed by an outline of the key objectives of the CAPCHAT and the methodology employed in its development, leveraging OpenAI's ChatGPT 4.0.

3. Artificial Intelligence in Engineering Education

In this section, we briefly review advancements in Artificial Intelligence (AI) and explore its potential to transform engineering education.

3.1 Artificial Intelligence (AI) and Generative AI

Recent advancements in Artificial Intelligence (AI) have led to transformative innovations across various domains, revolutionizing how information is processed, created, and shared. Among these advancements, Generative AI (GenAI) is a specialized subset of AI, and it includes applications, platforms, and tools that create content such as text, images, music, videos, and code [10] [15] [20] In Appendix A we outline some of the common generative AI tools, their categories, notable examples, and specific functionalities.

GenAI leverages sophisticated models such as Generative Adversarial Networks (GANs) and Transformer-based architectures, the backbone of many modern AI systems, to produce high-quality and contextually relevant content. These models employ extensive datasets and cutting-edge algorithms to understand and respond to a wide range of prompts.

Generative AI powers a diverse range of applications, including automated report generation, creative content creation (e.g., storytelling, poetry, and marketing copy), and image synthesis. Its influence extends across numerous industries. For instance, in healthcare, it supports the creation of personalized medical reports, assists in interpreting medical imaging, and enhances diagnostic workflows. In journalism, it automates the production of news articles and streamlines editorial processes. In education, it facilitates the generation of personalized learning materials and enables the development of interactive teaching aids, thereby enhancing student engagement and understanding.

ChatGPT (Chat Generative Pre-Trained Transformer) is a notable example of a generative AI tool designed to interpret and respond to text inputs based on the Generative Pretrained Transformer (GPT) architecture[1]. GPTs are large language models (LLMs) trained on extensive datasets, enabling them to perform tasks such as text generation, code generation, and information retrieval ChatGPT currently utilizes the GPT-3.5 and GPT-4 models. GPT-3.5 powers the free version of ChatGPT, while GPT-4, one of the latest OpenAI models, excels in processing complex prompts and delivering highly accurate and context-aware responses [11] [12]

3.2 AI Chatbots

A common application of AI-powered tools is the use of chatbots [12] [14] [17] Chatbots are computer programs designed to simulate human conversation. Users can interact with chatbots through text-based interfaces or voice communication, making them versatile tools in various domains.

[1] We note that GPT is a specialized use of Transformer-based architecture tailored to text generation.

Traditionally, chatbots relied on decision tree-style models, offering predefined and limited interactions. These conventional chatbots were typically categorized as rule-based, menu-driven, or keyword-based systems. However, with advancements in Artificial Intelligence (AI) and the emergence of platforms like OpenAI's ChatGPT, AI-powered chatbots have become significantly more sophisticated. Unlike their traditional counterparts, AI-powered chatbots can self-learn, adapt to user interactions, and provide dynamic and personalized responses. They excel at understanding context, interpreting complex queries, and maintaining engaging conversations with remarkable accuracy.

Several platforms now offer robust chatbot development capabilities, including OpenAI's ChatGPT, Google's Gemini, Hugging Face, Amazon Lex, IBM Watson, and more. These platforms have redefined the potential applications of chatbots, enabling them to go beyond basic interactions and cater to complex use cases across industries.

Using the OpenAI ChatGPT platform, developers can create chatbots in two primary ways [18] [19]

1. *Direct Access via the ChatGPT Interface:* This method involves using ChatGPT directly through its official website, requiring no programming or technical expertise.
2. *Integration through OpenAI's API:* This approach allows integrating ChatGPT's powerful functionalities into customized websites or applications, enabling tailored solutions that leverage the full potential of generative AI.

Chatbots are widely adopted in industries such as customer service, e-commerce, and marketing to streamline communication and enhance user experience. Additionally, educational institutions are increasingly leveraging chatbots to assist students with FAQs, scheduling, and even as part of the student admission process.

While AI-powered tools, including chatbots, are increasingly widespread across industries, their potential in engineering education can be particularly promising. In fact, a growing number of advanced tools, including large language models like ChatGPT and Gemini 2.0, as well as specialized platforms like NotebookLM, are becoming integral to educational environments. For example, in the context of engineering education, generative AI-powered tools such as ChatGPT can facilitate brainstorming, prototype ideation, and technical documentation.

4. CAPCHAT Development Methodology

In this section we elaborate on key features and development methodology of our proposed AI-based tool, CAPCHAT**,** to assist students in defining their marketing and engineering requirements. A snapshot of CAPCHAT page is shown in Appendix B. This tool not only encourages students to articulate their project ideas, elaborate on their target customer base, and identify project features and limitations but also prompts them to consider less familiar aspects such as potential failure cases, power consumption, and ethical implications. Additionally, the tool supports students in evaluating the product's lifecycle and disposal process, addressing social issues, and assessing sustainability. Beyond its practical benefits, the tool helps less experienced students overcome the fear of criticism and ensures they receive constructive feedback in an unbiased and supportive manner.

4.1 Key Features

Below, we highlight the key areas which CAPCHAT focuses on and assists the students with their capstone project:

- *Defining the Application and Customer Base:* Helping students clearly articulate the application of their product and identify their target customer base. As the result students can critically assess who the product is intended for and what specific problems it aims to address. By focusing on the end user, students can align their design goals with real-world needs, ensuring that their product serves a meaningful purpose.

- *Identifying Key Marketing Features and Attributes:* Guiding the students to understand the key marketing features and attributes of their product. As the result the students can identify attractive and functional characteristics that the intended user is likely to value. For example, students might highlight features that enhance usability, aesthetic appeal, or efficiency, ensuring their product stands out in the market and meets user expectations.

- *Formulating Engineering Requirements:* Assisting the students in translating marketing requirements into specific engineering specifications. For instance, if the product must last six months on a single charge, the students must design an efficient power management system. This feature ensures that students can technically implement the desired attributes, bridging the gap between conceptual ideas and practical engineering solutions.

- *Considering Product Lifecycle and End-of-Life Management:* Encouraging the students to think critically about the entire lifecycle of their product, including its usage and disposal. This involves addressing questions such as: How will the product be used over time? What happens to the device when it is no longer functional? How can components like batteries be disposed of responsibly? These considerations are particularly vital for teams working on hardware projects, ensuring environmental and social responsibility.

- *Evaluating Societal Impact and Ethical Concerns:* Prompting the students to analyze their product's broader impact on society, including its benefits and potential drawbacks. Ethical concerns, such as privacy issues, environmental implications, and accessibility, are explored to ensure that the product aligns with societal values and promotes responsible innovation.

- *Identifying Potential Failure Points:* Understanding potential failure points is critical for ensuring product reliability. The tool guides students to anticipate and address possible issues, particularly in systems with multiple components. For example, in a sensor-based system, students must consider how the device will notify users if the sensor's battery is low or malfunctioning. Proactively addressing such failure points improves the robustness and usability of the final product.

4.2 Development Methodology

CAPCHAT is a customized ChatGPT chatbot specifically designed to align with the capstone curriculum. It provides targeted support to electrical engineering students, assisting them in developing and refining their capstone project ideas. The following subsections briefly outline the design methodology used in developing CAPCHAT.

4.2.2 Developing a Capstone Chatbot

Development of CAPCHAT is based on utilizing the OpenAI interface and GPT builder, as described in sub-section 3.2. The steps we took to develop CAPCHAT are summarized in Table 1. In this paper we avoid detailed description of each step, as our focus is mainly how the tool benefited students.

Table 1: Summary of steps to develop the Capstone Guide Chatbot (CAPCHAT).

Step Number	Step Name	Description	Objectives
1	Define the Purpose	Decide on the chatbot's goals, such as answering questions or providing assignment assistance.	Assigning role for the Chatbot – An assistant for guiding students to define their capstone design objectives.
2	Prepare Content	Gather and organize relevant course materials, FAQs, and lesson plans.	Uploading selected literature, available lecture materials, and exercises t to extract key information on how to perform its role described in Step 1.
3	Use a Prebuilt Platform	Choose OpenAI Chatbot builder.	Customizing the chatbot by manually adding instructions, and conversation starters.
4	Train the Chatbot based on its functional features	Fine-tune the model with course-specific datasets, including examples of student queries.	Identifying functional features and adding goals, rules, and constrains.
5	Test the Chatbot	Simulate interactions to verify accuracy and helpfulness, refining the chatbot as needed.	Asking students to try out the Chatbot and compare the results with their initial work.
6	Deploy the Chatbot	Share the chatbot.	Providing the link to all students to use.
7	Iterate and improve	Monitor performance, collect feedback, and update content to ensure continued relevance.	In Process.

4.2.3 Functional Features of the Capstone Assistant Chatbot

The functional features of the CAPCHAT, as mentioned in Step 4 of Table 1, encompass specific capabilities designed to assist students in achieving a comprehensive description of their

capstone project. These features are tailored to guide students through critical aspects of the capstone project development, without providing a concrete solution, while ensuring alignment with engineering principles and marketing requirements. The following functional features were defined for the CAPCHAT:

1. *Project Idea Assistance:* The chatbot provides curated suggestions based on electrical engineering discipline[2]. For instance, it can suggest enhancements like adding specific hardware capabilities to a project or considering the design's power consumption. Additionally, the bot keeps students informed about trending technologies, such as Internet of Things (IoT), artificial intelligence (AI), and renewable energy solutions, offering innovative ideas to incorporate into the capstone projects. As an example, a team working on a smart home device might be guided to explore IoT protocols like MQTT or ZigBee for device communication.

2. *Project Complexity Assessment:* The chatbot helps students assess their project's complexity by aligning their team's abilities and skills with the scope of the proposed project. This ensures the project is feasible within the team's resources and technical expertise. For example, for a team with limited experience in embedded systems, the chatbot may suggest simplifying the design by using off-the-shelf modules instead of custom-built solutions.

3. *Identifying the Client Base:* The chatbot prompts students to define their target audience or customer base, helping them articulate who the product is intended for and what specific needs it addresses. For example, for a wearable health monitor, the chatbot may guide students to focus on potential users like athletes, elderly individuals, or healthcare providers.

4. *Defining Design Tolerances:* The chatbot assists students in considering design tolerances, such as size constraints, power consumption, and operating temperature ranges. This ensures that overlooked factors are accounted for during the design phase. For example, for a portable medical device, the chatbot might prompt students to consider power limitations, size constraints for portability, and temperature tolerances for varying climates.

5. *Marketing Requirements:* The chatbot helps students identify the product's target users and value propositions. It can guide them in creating a marketing strategy that aligns with their project goals. The bot also provides templates for defining marketing plans, making it easier for students to structure their ideas effectively. For example, a team designing a low-cost solar powered system might be guided to highlight sustainability as key selling points.

6. *Engineering Requirements:* The chatbot helps students define technical specifications and provides references to relevant engineering standards (e.g., IEEE, ISO) to ensure compliance. It also suggests tools and software for simulations or modeling, streamlining

[2] In our case we limited the responses to electrical engineering disciplines. However, the algorithm can easily be modified to fit other engineering disciplines.

the development process. For example, for a robotics project, the bot may recommend CAD tools like SolidWorks for design and ROS (Robot Operating System) for control programming.

7. *Reference to Standards:* The chatbot guides students incorporate existing standards and requirements into their project. This includes technology-specific standards (e.g., Wi-Fi protocols, USB compliance) and broader engineering standards (e.g., ISO 9001 for quality management). For example, for a wireless communication device, the chatbot might guide students to comply with 802.11 standards for Wi-Fi.

8. *Failure Analysis:* The chatbot encourages students to perform failure analysis by identifying potential risks in their capstone project and suggesting mitigation strategies. This ensures that projects are robust and reliable. For example, for an end-to-end communication system the bot might highlight failure points and suggest ways to identify how to detect node, verses, gateway, or network failure under various conditions.

9. *Life After Production and Sustainability:* The chatbot encourages students to think about a sustainable design. It provides guidance on improving the design in case of failure and adapting it for long-term usability. For instance, in the case of an electronic device, the chatbot might suggest strategies for recycling components or reducing environmental impact, thereby fostering a sustainable approach to engineering design.

5. Results and Student Feedback

Over the past year, CAPCHAT has been piloted with 22 senior students completing their capstone projects. As part of their assignment, the students were initially tasked with forming teams, developing a project idea, and defining their project features. Each team was instructed to clearly outline both the marketing and engineering requirements while paying particular attention to the sustainability aspects and potential failure scenarios of their projects. As described in Section 2, during the EE 492 course, relevant materials were introduced through lectures and assigned readings. All assignments were conducted as a team effort and were presented to the class in 15-minute sessions. Following feedback from the instructor and their peers, each team was required to revise their project designs and resubmit them for further evaluation.

Subsequently, students were asked to use CAPCHAT via a designated webpage link. Each team member was instructed to individually interact with the tool and submit their results within a one-week timeframe. For this submission, students were required to include their initial version of the project definition, created prior to using the CAPCHAT, alongside their revised version.

After submitting their revised project definitions, students were asked to complete a short survey to provide feedback on their experience with CAPCHAT. It is important to note that the submissions and surveys were not anonymous, as we needed to ensure all students completed the assignments.

In the following subsections, we present the raw student responses and discuss the key findings from this research.

5.1 Student Responses

The student survey findings are presented in Figure 1. The results indicate that 8 out of 22 students, approximately one-third, reported that they had not used ChatGPT. This finding was unexpected, as faculty had generally assumed that almost all students routinely utilized ChatGPT for their assignments.

The majority of students found CAPCHAT to be highly beneficial in various ways. According to student feedback, the tool was particularly effective in refining formatting and encouraging deeper critical thinking about their projects.

In addressing marketing and engineering requirements - including areas such as referencing standards, failure analysis, and considerations for life after production and sustainability - nearly 70% of students found the tool to be beneficial. A higher proportion of students noted that the tool was especially effective in defining marketing requirements, such as the general description of the product, its client base, and its features. This positive feedback underscores CAPCHAT's utility in guiding students through complex capstone project tasks.

Figure 2 presents freestyle feedback collected as part of the survey, highlighting several key themes related to the use of CAPCHAT in refining capstone project requirements. Many students found the tool highly effective in organizing and refining their existing ideas. Several students noted that CAPCHAT clarified engineering specifications, particularly by introducing tolerances and enhancing the integration of marketing requirements. The tool also prompted students to consider additional details that had not been previously addressed, improving the overall quality and precision of their project deliverables. For instance, one student reported significant improvements in their Value Proposition and Marketing Requirements after engaging with CAPCHAT. Another student observed that the tool shifted their focus from general descriptions to emphasizing the unique aspects of their device.

A common recommendation in the survey was to introduce CAPCHAT earlier in the capstone process. Students felt that using the tool during the initial stages of their projects would have been more beneficial in helping them organize and structure their ideas. Late integration limited the tool's potential to save time, as many requirements had already been refined through advisor meetings and practice presentations. Additionally, students expressed the need for more guidance on effectively using the tool. While CAPCHAT was praised for being simple and intuitive, students suggested that formal instruction on its application could further enhance its impact. Overall, the feedback underscores the value of incorporating CAPCHAT into the capstone process and highlights the importance of early implementation and proper training to maximize its benefits.

Figure 3 illustrates sample submissions from students both before and after using CAPCHAT, showcasing the improvements in their project descriptions, value propositions, and engineering requirements. The "before" submissions often provided generalized or basic descriptions of the project, focusing more on functionality rather than emphasizing unique features or detailed specifications. For example, an initial Value Proposition described wireless data transmission as a convenient alternative to wired connections. After utilizing CAPCHAT, the revised Value Proposition highlighted specific benefits, such as adaptive transmission, high bit rate support,

and environment-specific configurations, offering a more compelling and professional pitch tailored to potential client needs.

Similarly, the engineering and marketing requirements improved significantly in terms of precision and clarity. Initial engineering requirements often lacked measurable parameters and detailed technical constraints. After using CAPCHAT, the updated requirements included specific tolerances, power consumption limits, and environmental stability ranges, providing a more robust and professional framework for their designs. Marketing requirements also evolved to reflect a clearer understanding of scalability, non-intrusive installation, and adaptability to varying environmental conditions. These enhancements demonstrate CAPCHAT's effectiveness in refining student work and guiding them toward higher-quality deliverables.

Figure 1: Student Survey Results

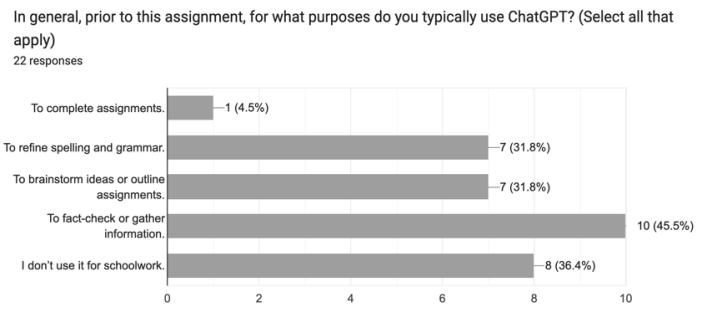

Figure 1a: General usage of CAPCHAT.

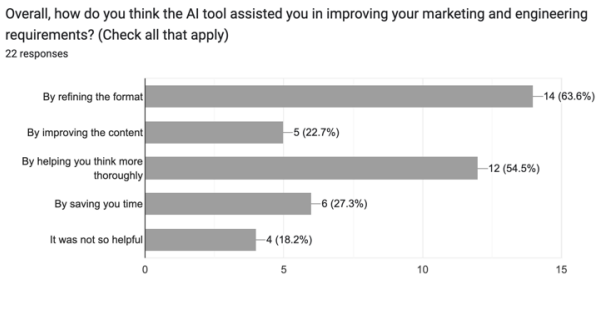

Figure 1b: Helpfulness of CAPCHAT.

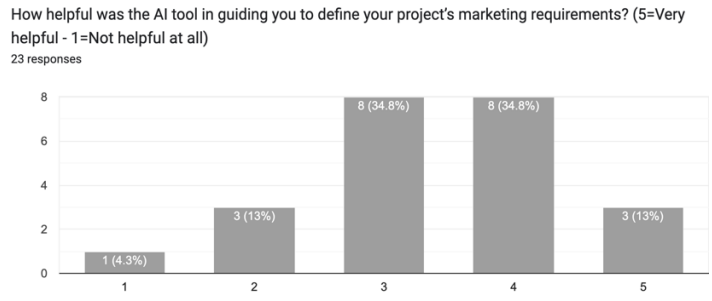

Figure 1c: Assistance in defining the marketing requirements.

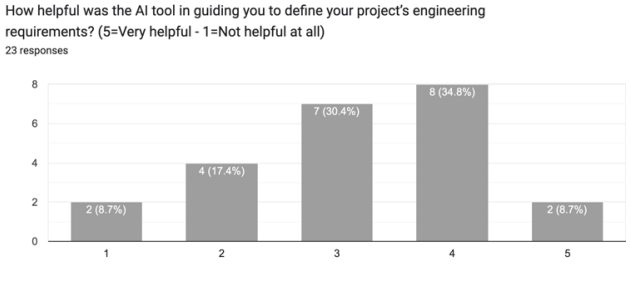

Figure 1d: Assistance in defining the engineering requirements.

Figure 2: Sample Student Freestyle Feedback	
• "The AI tool was great for refining what we already had and with talking through ideas." • "We only used the AI tool at the end of the process, it would be much more beneficial to use it earlier in the process to help wrap our head around all the ideas and organize them a bit clearer. I like how the department can help guide student how to use this relatively new tool in a productive manner." • "The bot itself was extremely helpful, and I am currently kicking myself for not trying it sooner. In terms of using the bot itself, I just went with the flow the AI was taking me, analyzing what it was saying, and going off of that. As such, I have had major improvements to my Value Proposition, and my Marketing Requirements. I should be bringing up everything I discussed with the chatbot to my project members shortly!" • "The capstone AI generated version of our requirements provided some notable improvements, particularly by introducing tolerances to our engineering specifications and enhancing the clarity of integration in our marketing requirements."	• "It was simple and straightforward to use, and introduced some additional details we had not considered before such as tolerances." • "The AI tool was useful, if we did this assignment earlier in the year it would have provided better feedback. at the time we completed the assignment most of our ERs and MRs we very refined due to advisor meetings and practice presentations." • "I think it was useful as a tool to help refine our marketing and engineering requirements. However, it was introduced a little too late to save any significant amount of time." • "The main change here is the shift in focus from a general "what-we-are-doing" to a precise "what makes our device special." It highlights more functions than the previous iteration. Additionally, because of its shorter, and less wordy."

Figure 3: Sample Student Submissions[3].	
BEFORE Using CAPCHAT	**AFTER Using CAPCHAT**
Value Proposition: Wireless PTP Signal for Remote Sites helps sites with no access to the internet transfer data to the main site to be stored in a database. It would also be able to receive instructions from the main to control the remote sites' machines. Doing this wirelessly is an easier alternative than making a wired connection underground which would require more drastic changes to the already existing infrastructure.	**Value Proposition:** Our device provides consistent and reliable data communication in challenging environments by leveraging adaptive transmission, high bit rate support, and environment-specific configuration through interchangeable antennas. It offers non-intrusive installation and seamless deployment for installers, ensuring flexibility and scalability for diverse client needs.
Engineering Requirements: 1. The device must be able to match a load impedance with a startng VSWR of 2.0 or less to within a VSWR of 1.22 (20 dB return loss). (MR1) 2. The device must have a power consumption of less than 700 mW during operation. (MR2) 3. The device must be able to make adjustments autonomously when in operation. (MR3) 4. The device must respond to changes in impedance within 100ms to ensure minimal delay in performance. (MR4) 5. The device must operate effectively at a frequency of 2.44 GHz. (MR5) 6. The insertion loss of the matching network should be less than 2 dB. (MR6)	**Engineering Requirements:** 1. Return Loss: ≥ 20 dB from 2.4 GHz to 2.485 GHz, accuracy ±0.5 dB. 2. Impedance Range: Match impedances from 10 Ω to 100 Ω. 3. Adaptation Speed: Detect and respond to impedance changes within 100 ms. 4. Power Consumption: ≤ 150 mW total (100 mW for control system + 50 mW for varactor network). 5. Size: ≤ 40 mm x 30 mm x 10 mm. 6. Environmental Stability: Operate reliably from 0°C to 60°C

[3] These three samples in describing the value proposition, engineering and marketing requirements, are from three different students.

Marketing Requirements:	**Marketing Requirements:**
- The device will integrate RS-485 protocol to communicate with the PLCs. - The device will be able to make effective wireless communications between sites at moderate distances like across a corporate campus. - The device must transmit data at sufficient speeds - The system will use a low-to-moderate amount of power. - The system will be low maintenance to minimize labor costs. - The device will be easy to install or modify.	1. Consistency and Reliability in Challenging Environments: ○ Maintain a maximum packet error rate of 0.0001% under typical interferences such as walls, weather, and distance. ○ Transmit data effectively over a range of 1 kilometer with minimal signal degradation. 2. Adaptive Transmission: ○ Temporarily store incoming data to adaptively transmit at a feasible bit rate without data loss. ○ Include a fallback mechanism for retransmitting lost packets to enhance reliability. 3. High Bit Rate Support: ○ Accept and process data at an input rate of 38400 bps seamlessly. ○ Optimize transmission throughput to balance bit rate and error correction. 4. Interchangeable Antennas: ○ Support multiple antenna types (e.g., directional and omnidirectional) to match varying environmental needs. ○ Ensure antennas can be swapped without requiring specialized tools or expertise. 5. Non-Intrusive Installation: ○ Maintain a compact form factor, with final dimensions and weight to be determined based on prototype and antenna specifications. ○ Installation must not require drilling, permanent modifications, or external wiring. 6. Ease of Deployment: ○ Provide user-friendly instructions for setup and antenna selection. ○ Ensure non-technical users with basic training can configure and maintain the device. 7. Scalability: ○ Enable firmware updates for expanding features or adapting to new communication standards. ○ Ensure seamless integration with existing PLC systems.

5.2 Analyzing the Student Feedback

The feedback collected from students after using CAPCHAT revealed several key insights. Below, we list some of our key findings:

1. Familiarity with ChatGPT:

    - Although many students were generally familiar with ChatGPT, they lacked specific knowledge on how to leverage it for academic purposes, such as refining engineering requirements.
2. Resistance to Use:
    - A small subset of students reported reluctance to use ChatGPT, with a few stating they had never used it for assignments. This suggests a gap in adoption and highlights the need for targeted support for such students.
3. Need for Clear Instructions:
    - A significant number of students emphasized the importance of providing more comprehensive instructions on how to effectively use the tool.
    - Many suggested that the tool should be introduced earlier in the course to allow them to familiarize themselves with its capabilities and limitations.
4. Prompting and Expectations:
    - While issues with prompting were largely resolved, many students expected the tool to provide complete solutions rather than assist with iterative feedback.
5. Accuracy of Requirements:
    - Some students noted that the requirements generated by the tool were not always accurate and required additional refinement.
6. Organization and Grammar:
    - The majority of students appreciated the organizational improvements and grammatical corrections provided by the tool. Many expressed satisfactions with how well-structured their revised requirements were after using the Chatbot.

Overall, most students recognized that the tool significantly improved their work. It was especially appreciated for enhancing clarity, fostering deeper project analysis, improving organization, and ensuring grammatical accuracy. However, the results underline the need for additional guidance and instructional resources on how to utilize CAPCHAT in order to ensure students maximize the benefits of the tool. By addressing these challenges, we believe future iterations of the tool can better meet the needs of students.

6. Risks and Potential Drawbacks of AI-Based Chatbots

While CAPCHAT offers substantial benefits, it is crucial to address certain risks and potential drawbacks to ensure its effective use.

A primary concern revolves around student expectations. Many students expected the chatbot to provide complete solutions, rather than assisting them in an iterative process of refining their ideas and project requirements. This misunderstanding of the tool's purpose can lead to over-reliance and a missed opportunity for developing critical thinking and problem-solving skills. It is important to emphasize that the CAPCHAT is not intended to deliver final answers but to serve as a support system that helps students brainstorm, structure, and improve their work.

Another critical issue is accuracy. While the chatbot generates detailed suggestions and feedback, the outputs are not always correct or aligned with project requirements. This is particularly true for open-ended problems, where the responses may require significant refinement or validation. Students must critically analyze the chatbot's recommendations, ensuring that they align with the overall project goals and meet necessary standards.

In addition, as with any AI-based tool, there are inherent risks and potential drawbacks that must be considered when using CAPCHAT, and students should be made aware of these challenges. Below, we outline some of these concerns, many of which have been highlighted by other researchers [16] [12] [9] We believe these issues are valid for any AI-based chatbot, including CAPCHAT in its current form.

- *Over-dependence on Technology:* Students might develop an over-reliance on the AI-based tools, reducing their initiative to research independently or think critically. This could hinder their ability to tackle similar tasks without the tool, impacting their long-term learning and problem-solving skills.

- *Bias in AI Responses:* The chatbot's responses are based on its training data, which might include inherent biases. These biases could lead to inappropriate or incomplete suggestions that do not align with the project's goals or ethical considerations.

- *Technical Limitations and Accessibility:* Students without reliable internet access or familiarity with AI tools might face difficulties using the chatbot effectively.

- *Erosion of Collaboration Skills:* Overusing the chatbot might discourage students from collaborating with peers or seeking guidance from instructors. This could limit their ability to work effectively in teams, a critical skill in engineering and professional settings.

- *Privacy and Data Security Concerns:* If students input sensitive project information into the chatbot, there may be concerns about data privacy and security, particularly if the tool is hosted on third-party platforms.

7. Conclusion

This paper examined the implementation and effectiveness of our custom-designed AI-based Capstone Guide Chatbot (CAPCHAT). The tool, developed using the OpenAI interface and GPT Builder, was designed to support senior electrical engineering students in refining their capstone project requirements. By evaluating student feedback and project outcomes, the study demonstrated the chatbot's ability to enhance project quality, clarify requirements, and foster critical thinking. However, several challenges were identified, including managing student expectations, ensuring accuracy, and reducing over-reliance on the tool. Addressing these challenges necessitates the early integration of the chatbot into the capstone process, providing structured training on its use, and reinforcing its role as a collaborative aid rather than a solution provider.

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Appendix A

Below, we outline some of the common generative AI tools, their categories, notable examples, and specific functionalities.

Category	Example	Functionality	Category	Example	Functionality
Text Generation	ChatGPT (OpenAI)	Generates human-like text for conversations, content creation, and Q&A.	**Code Generation**	GitHub Copilot (OpenAI)	Suggests code snippets and aids in software development.
	GPT-4 (OpenAI)	Advanced natural language tasks like summarization and creative writing.		Codex (OpenAI)	Powers GitHub Copilot; generates algorithms and debugs code.
	T5 (Google)	Transforms and translates text, performs summarization.		TabNine	Provides AI-powered autocompletion for developers.
Image Generation	DALL-E (OpenAI)	Creates detailed images from textual descriptions.	**Video Game Assets**	Scenario GG	Generates custom game assets like textures and 3D models.
	Stable Diffusion	Generates visually intricate images from prompts.		GANs for Gaming	Creates in-game assets, characters, and environments.
	MidJourney	AI art generator for creative and artistic visuals.	**Creative Writing**	Jasper AI	Produces marketing copy, blog posts, and email content.
	DeepArt	Applies artistic styles to photographs.		Writesonic	Creates search engine optimization content for businesses.
Video Generation	Synthesia	Creates video presentations with AI-powered virtual avatars.		Copy.ai	Automates ad and product description writing.
	Runway ML	AI-powered video editing and generation tools.	**Speech and Voice**	Descript	Voice cloning and audio editing for podcasts and videos.
	Pictory AI	Converts text content into engaging video summaries.		Respeecher	High-quality speech synthesis and voice replication.

Category	Example	Functionality	Category	Example	Functionality
Music Generation	MuseNet (OpenAI)	Creates multi-instrumental music in various styles.		Replica Studios	AI voice actors for animations and video games.
	AIVA	Composes soundtracks for films, video games, and ads.	**Miscellaneous**	DeepDream (Google)	Creates surreal visuals by enhancing image details.
	Amper Music	Generates royalty-free music for quick use.		DeepFake Technology	Creates realistic fake videos by altering faces or voices.
				NVIDIA Omniverse	Simulates 3D environments for design, engineering, and collaboration.

Appendix B

Snapshot of CAPCHAT webpage.
http://ec2-52-38-184-67.us-west-2.compute.amazonaws.com/CapstoneAI.html