

Integrating AI in Engineering Education: A Five-Phase Framework for Responsible ChatGPT Use

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Abstract

One of the challenges as the new technological advancements become part of everyday lives are to be able to incorporate and responsibly use them. The use of generative AI tools such as ChatGPT, started to become more common, especially in educational settings. One of the challenges is to understand how can we support students to be responsible generative AI users while highlighting the importance of original work and creativity. Another challenge is also how can faculty decide on the appropriate amount of AI usage in student assignments: what is acceptable and what will fall under plagiarism. To address these challenges and to encourage students to be creative while still be responsible using AI-based platforms, a series of examples and exercises are designed to be incorporated in the engineering and engineering technology courses. The goal of these examples is to teach students how can they use AI-based tools, such as ChatGPT, to improve their work, however also to teach them to not to solely rely on outcomes from ChatGPT. The examples also will provide students opportunity to be able to identify the relevance and reliability of the information they may get from AI-based tools. In this paper, the authors will share sample examples and implementation procedures for the examples along with assessment tools faculty can use to assess the examples.

Introduction:

The integration of Artificial Intelligence (AI) in education has been a growing trend in recent years, with early applications focusing on providing more efficient and effective ways to support the learning process, such as automated grading and personalized learning [1]. As the incorporation of AI into education progressed, it also became a widely debated topic given the concerns of originality and plagiarism [2]. As the access to AI platforms such as ChatGPT is free and easily accessible and it is not possible to deny AI's potential use by students to complete their coursework. While these concerns are valid, it is crucial for educators to guide students in the responsible and acceptable use of AI platforms, providing them with opportunities and guidance to explore and leverage this new technology. The potential of ChatGPT in the classroom has been analyzed in various studies [3-5], highlighting its applications as a writing assistant, study tool, and personal tutor [6]. However, there are also concerns that the overreliance on ChatGPT may adversely affect students' critical thinking and problem-solving skills [7]. As AI becomes more prevalent in higher education, it is essential for educators, curriculum designers, and policymakers to understand the implications of integrating these tools into the educational context.

According to research [7], ChatGPT has the ability to respond immediately to queries, supporting personalized learning and enhancing the overall learning experience. Students have highlighted the tool's potential to assist with programming tasks, providing immediate feedback and support.

Additionally, ChatGPT can be used to generate study materials, practice questions, and even personalized feedback, potentially improving the efficiency and effectiveness of the learning process [6]. While the potential benefits of ChatGPT in education are evident, there are also significant concerns that must be addressed. Some students have expressed concern that the use of ChatGPT could stifle their creativity, motivation, and critical thinking skills [7]. There are also worries that the integration of AI in education could fundamentally challenge traditional university experiences and feedback mechanisms, potentially depriving students of the practical wisdom gained through these experiences [1]. These concerns reflect a general fear and confusion surrounding the implications of ChatGPT in education, researchers have highlighted the need to understand how students may use ChatGPT, as many will use it regardless of its adoption by the instructor. To address the transformative effects of ChatGPT on the learning environment, it is crucial to educate both teachers and students about the capabilities and limitations of the tool. Academic regulations and evaluation practices used in educational institutions need to be updated to accommodate the use of ChatGPT and other AI tools.

Educators should play a crucial role in the development and implementation of AI platforms in education, providing feedback and guidance on the design and use of AI systems. Students should also be educated about the use of AI platforms in education and allowed to provide feedback on the effectiveness of AI in supporting their learning. By adopting a collaborative and informed approach, we can ensure that the integration of AI in education enhances the learning experience, fosters critical thinking, and prepares students for the challenges and opportunities of the digital age. Integration of ChatGPT has the potential to enhance the learning experience, including in programming, there is a need to carefully balance its use to ensure that students' critical thinking and problem-solving skills are not adversely affected.

The goal of this study is to develop a framework that is customizable to meet the needs of different courses and disciplines. The use of framework also allows the faculty members to design and incorporate AI experiences that will fit their coursework and support their students' learning process.

Methodology

This paper will provide an overview of a framework that can be adapted into different courses to implement AI platforms (such as ChatGPT). In addition to the framework, pre-experience and post-experience surveys are shared that can be included to measure students' readiness and perception of incorporation of ChatGPT into their courses and if incorporation of ChatGPT-based classroom activities would change that initial perception.

Framework Development and Implementation

In an effort to provide an opportunity for students to explore the use of AI when they are completing their assignments, a framework is developed. The framework is based on measuring students' understanding and attitude towards the use of AI platforms in the educational setting, and provides them a structured and guided approach.

The framework consists five phases that can be completed in a sequential order as shown in Figure 1. One of the advantages of the phased approach is that, if needed a phase can be skipped or not included in the experience, if the course professor thinks that will be a more appropriate approach for their course and their students.

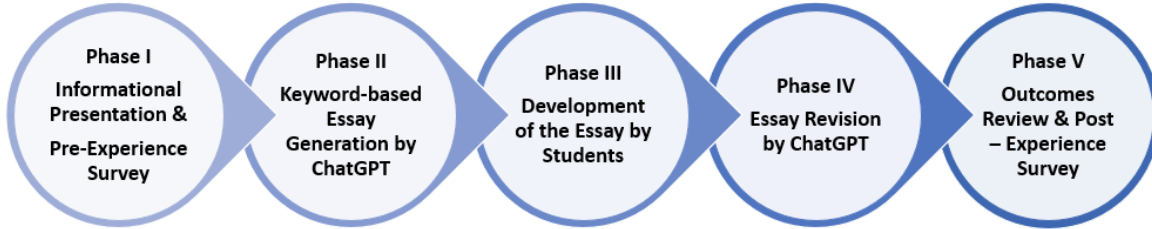


Figure 1. AI Framework to Support Engineering and Engineering Technology Courses

- **Phase I - Informational Presentation and Pre-Experience Survey:** Phase I starts with an informational presentation followed by a pre-experience survey. The informational presentation discusses AI platforms, responsible use approaches and policies, if available, goes over school’s AI and plagiarism policies and answer any student questions and concerns. The pre-experience survey aims to measure students’ attitudes and concerns towards incorporation of AI in educational setting and completing assignments with and AI platform such as ChatGPT. The pre-experience survey that will be used for this phase is a 5-point Likert scale survey and previously developed by authors [1] as shown in Figure 2.

ARTIFICIAL INTELLIGENCE (AI) -BASED TOOLS				
PRE-EXPERIENCE SURVEY				
Question 1: How would you rate your familiarity with Artificial Intelligence (AI) based tools? (Such as ChatGPT)				
Very Familiar	Familiar	Moderately Familiar	Slightly Familiar	Not Familiar
Question 2: AI-based tools can be used as a part of formal education process.				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Question 3: AI and AI-based tools will be more commonly used in the future.				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Question 4: I am worried about the negative implications of AI and AI-based tools.				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Question 5: I am interested in learning how to use AI-based tools as a part of my coursework.				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Question 6: I am happy that new technological advancements are a part of my learning process.				
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Figure 2. Pre-Experience Survey [1]

- **Phase II - Keyword-based Essay Generation by ChatGPT:** In Phase II, students are provided with 10-12 keywords that are relevant to their major of study/course, and each student is asked to pick 6 keywords and input them in ChatGPT and ask ChatGPT to write a 100-word essay. The selection of keywords is major specific and can easily be adapted to different fields of study. Once ChatGPT creates the essay, students are then asked to review the essay for accuracy, quality, reliability of the information and comprehensiveness of the content provided. Students are encouraged to look for “filler sentences” that “look” good on paper but may not provide much depth to the content as shown in Figure 3.

Keywords Provided to Students	Keywords Selected – 1	Keywords Provided to Students	Keywords Selected – 2
Engineering, manufacturing, autonomous, control, process, design, innovation, prototype, fluid mechanics, solid modeling, simulation, analysis	Manufacturing, fluid mechanics, innovation, analysis, simulation, control	Engineering, manufacturing, autonomous, control, process, design, innovation, prototype, fluid mechanics, solid modeling, simulation, analysis	Autonomous, Control, Analysis, Innovation, Design, Process
<p>can you write a 100 word essay using the following keywords: manufacturing, fluid mechanics, innovation, analysis, simulation, control</p> <p>Manufacturing has evolved dramatically through the integration of fluid mechanics and innovative technologies. By utilizing advanced analysis and simulation techniques, engineers can optimize processes and enhance product quality. Innovations in control systems allow for real-time adjustments, ensuring efficiency and precision in production. This synergy between fluid mechanics and manufacturing leads to improved resource management and reduced waste. As industries continue to embrace these advancements, the potential for increased productivity and sustainability grows. Ultimately, the intersection of these fields fosters a new era of manufacturing that prioritizes both innovation and environmental responsibility, driving the industry toward a more efficient future.</p>		<p>Please write a 100 word essay with the following keywords: autonomous, control, analysis, innovation, design and process</p> <p>The rise of autonomous systems has revolutionized design and process across various industries. By leveraging innovative control mechanisms, these systems can analyze data in real-time, allowing for precise adjustments and enhanced efficiency. The integration of advanced algorithms facilitates intelligent decision-making, streamlining workflows and reducing human error. As engineers embrace this paradigm shift, they create designs that not only optimize performance but also adapt to changing conditions. This innovative approach not only improves productivity but also opens new avenues for research and development, paving the way for future advancements in automation and efficiency. The future of technology lies in autonomous innovation.</p>	
<p>Keywords Selected - 1</p> <p>Manufacturing, fluid mechanics, innovation, analysis, simulation, control</p> <p>100 Word Essay Created by ChatGPT</p> <p>Review of ChatGPT Essay</p> <p>Manufacturing has evolved dramatically through the integration of fluid mechanics and innovative technologies. By utilizing advanced analysis and simulation techniques, engineers can optimize processes and enhance product quality. Innovations in control systems allow for real-time adjustments, ensuring efficiency and precision in production. This synergy between fluid mechanics and manufacturing leads to improved resource management and reduced waste. As industries continue to embrace these advancements, the potential for increased productivity and sustainability grows. Ultimately, the intersection of these fields fosters a new era of manufacturing that prioritizes both innovation and environmental responsibility, driving the industry toward a more efficient future.</p> <p>Too generic, what are the innovative technologies?</p> <p>What are some of the examples of such innovations?</p> <p>There is a lot of information on this sentence, but lack of examples and additional content makes it a filler statement.</p> <p>Which fields? Not clear, which fields the text is referring to.</p>		<p>Keywords Selected - 2</p> <p>Autonomous, Control, Analysis, Innovation, Design, Process</p> <p>100 Word Essay Created by ChatGPT</p> <p>Student's Review of ChatGPT Essay</p> <p>The rise of autonomous systems has revolutionized design and process across various industries. By leveraging innovative control mechanisms, these systems can analyze data in real-time, allowing for precise adjustments and enhanced efficiency. The integration of advanced algorithms facilitates intelligent decision-making, streamlining workflows and reducing human error. As engineers embrace this paradigm shift, they create designs that not only optimize performance but also adapt to changing conditions. This innovative approach not only improves productivity but also opens new avenues for research and development, paving the way for future advancements in automation and efficiency. The future of technology lies in autonomous innovation.</p> <p>Not clear, do you mean autonomous systems?</p> <p>Seems like this sentence fits any engineering essay, the general, AI can't provide details.</p> <p>Not clear which paradigm shift. There is no mention earlier in the text to recommend a paradigm shift to integration of advanced algorithms a paradigm shift?</p> <p>No earlier connection to productivity or improvement of productivity mentioned. It's confusing here.</p>	

Figure 3. ChatGPT Essay Development Using the Provided Keywords

- **Phase III - Development of the Essay by Students:** After reviewing the essays generated by AI, students are then asked to use the same keywords that they picked to write their own 100-word essays. They are encouraged to emphasize the important and critical areas in their essays based on their knowledge and experience as shown in Figure 4.

Keywords Selected - 1	Keywords Selected - 2
<p>Manufacturing, fluid mechanics, innovation, analysis, simulation, control</p> <p>100 Word Essay Created by ChatGPT</p> <p>Student's Review of ChatGPT Essay</p> <p>Student's Own Essay</p>	<p>Autonomous, Control, Analysis, Innovation, Design, Process</p> <p>100 Word Essay Created by ChatGPT</p> <p>Student's Review of ChatGPT Essay</p> <p>Student's Own Essay</p>
<p>Manufacturing has evolved dramatically through the integration of fluid mechanics and innovative technologies. By utilizing advanced analysis and simulation techniques, engineers can optimize processes and enhance product quality. Innovations in control systems allow for real-time adjustments, ensuring efficiency and precision in production. This synergy between fluid mechanics and manufacturing leads to improved resource management and reduced waste. As industries continue to embrace these advancements, the potential for increased productivity and sustainability grows. Ultimately, the intersection of these fields fosters a new era of manufacturing that prioritizes both innovation and environmental responsibility, driving the industry toward a more efficient future.</p> <p>The applications of fluid mechanics in manufacturing operations creates the integral components of our daily lives. HVAC systems, pumping systems and industrial manufacturing operations where material in liquid form is expected to be moved and stored are some examples of application of fluid mechanics in engineering and manufacturing operations. As engineering innovations became more and more available, the need to integrate these innovations in manufacturing processes became apparent. One of the approaches was to incorporate use of simulation and analysis tools for fluid mechanics such as CFD (Computational Fluid Dynamics). The use of CFD to analyze fluid mechanics applications helped improve the processes and helped engineers to develop appropriate control features.</p>	<p>The rise of autonomous systems has revolutionized design and process across various industries. By leveraging innovative control mechanisms, these systems can analyze data in real-time, allowing for precise adjustments and enhanced efficiency. The integration of advanced algorithms facilitates intelligent decision-making, streamlining workflows and reducing human error. As engineers embrace this paradigm shift, they create designs that not only optimize performance but also adapt to changing conditions. This innovative approach not only improves productivity but also opens new avenues for research and development, paving the way for future advancements in automation and efficiency. The future of technology lies in autonomous innovation.</p> <p>Autonomy is an integral part of engineering applications with autonomous vehicles or crafts being more and more available. The advantages of autonomous vehicles make them preferred to carry out certain functions, such as driving to create roadmaps, or deliveries or technical support. To be able to develop autonomous systems, engineers rely on robust control systems, processes and in depth analysis of the design processes. To design successful control systems it is important to integrate most up to date innovation components to the design process. Design innovation such as integration of state of the art feedback controls and incorporation of real time response systems ensure the success of autonomous systems.</p>

Figure 4. Students' Review of the ChatGPT Essay

- **Phase IV – Essay Revision by ChatGPT:** After completing their essay, in phase IV students ask ChatGPT to review their essays. This revision request can be a general revision request or can be more specific such as review for grammar, structure, punctuation, or flow. The decision of how they want ChatGPT to review their essays are carried out by students. The original version and the revised by ChatGPT version of the student essays are shown in Figure 5.

Keywords Selected - 1		Keywords Selected - 2	
Manufacturing, fluid mechanics, innovation, analysis, simulation, control		Autonomous, Control, Analysis, Innovation, Design, Process	
<p>Student's Own Essay</p> <p>The applications of fluid mechanics in manufacturing operations creates the integral components of our daily lives. HVAC systems, pumping systems and industrial manufacturing operations where material in liquid form is expected to be moved and stored are some examples of application of fluid mechanics in engineering and manufacturing operations. As engineering innovations became more and more available, the need to integrate these innovations in manufacturing processes became apparent. One of the approaches was to incorporate use of simulation and analysis tools for fluid mechanics such as CFD (Computational Fluid Dynamics). The use of CFD to analyze fluid mechanics applications helped improve the processes and helped engineers to develop appropriate control features.</p>	<p>ChatGPT Review of Student's Essay (Reviewed for grammar, structure, and flow)</p> <p>The applications of fluid mechanics in manufacturing operations create integral components of our daily lives. Examples include HVAC systems, pumping systems, and industrial processes where liquids are moved and stored. As engineering innovations have become more widely available, the need to integrate these advancements into manufacturing processes has become apparent. One effective approach has been the incorporation of simulation and analysis tools for fluid mechanics, such as Computational Fluid Dynamics (CFD). Utilizing CFD to analyze fluid mechanics applications has improved processes and enabled engineers to develop appropriate control features, significantly enhancing efficiency and product quality.</p>	<p>Student's Own Essay</p> <p>Autonomy is an integral part of engineering applications with autonomous vehicles or crafts being more and more available. The advantages of autonomous vehicles make them preferred to carry out certain functions, such as driving to create roadmaps, or deliveries or technical support. To be able to develop autonomous systems, engineers rely on robust control systems, processes and in-depth analysis of the design processes. To design successful control systems it is important to integrate most up to date innovation components to the design process. Design innovation such as integration of state of the art feedback controls and incorporation of real time response systems ensure the success of autonomous systems.</p>	<p>ChatGPT Review of Student's Essay (Reviewed for grammar, structure, and flow)</p> <p>Autonomy is an integral part of engineering applications, with autonomous vehicles and crafts becoming increasingly available. The advantages of these vehicles make them preferable for various functions, such as creating roadmaps, making deliveries, and providing technical support. To develop successful autonomous systems, engineers rely on robust control systems, established processes, and in-depth analysis of design methodologies. It is crucial to integrate the most up-to-date innovative components into the design process. Innovations such as state-of-the-art feedback controls and real-time response systems are essential for ensuring the success of autonomous systems.</p>

Figure 5. Students' Essay and ChatGPT Review of the Students' Essay

- **Phase V – Outcomes Review and Post-Experience Survey:** In the last phase, a discussion on the overall experience, and level of incorporation and the outcome quality of the essays are carried out followed by a post-experience survey developed by authors [1] and is a 5-point Likert scale survey as shown in Figure Q.

ARTIFICIAL INTELLIGENCE (AI) -BASED TOOLS

POST-EXPERIENCE SURVEY

Question 1: AI-based tools can be used as a part of formal education process.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
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Question 2: AI and AI-based tools will be more commonly used in the future.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
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Question 3: I feel comfortable/confident using AI-based tools as a part of my learning process.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
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Question 4: I plan on continuing to incorporate AI-based tools to further my learning process in the future.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
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Question 5: I am interested in seeing more AI-based applications as a part of my coursework.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
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Figure 6. Post-Experience Survey [2]

Conclusions

This study introduces a novel five-phase framework for incorporating AI tools, particularly ChatGPT, into engineering and technology courses. The framework offers a structured approach to familiarize students with AI platforms while promoting responsible use and critical thinking. It provides several key benefits, including a gradual introduction of AI tools, encouragement of critical engagement with AI-generated content, and flexibility for adaptation across various courses and disciplines. The inclusion of pre- and post-experience surveys allows educators to measure changes in students' attitudes towards AI use in education.

While the pilot implementation shows promise, limitations such as potential variations in effectiveness across different student populations and the need for frequent updates due to rapidly evolving AI technology should be considered. Future research could explore longitudinal studies on the framework's long-term impact, comparative studies across disciplines, and the incorporation of additional AI tools beyond ChatGPT.

In summary, this framework represents a step towards responsibly integrating AI into engineering and technology education. By providing structured experiences with AI tools, educators can better prepare students for an increasingly AI-driven future in both academic and professional settings. As we continue to navigate the challenges and opportunities presented by AI in education, frameworks like this will be crucial in developing students' skills to use these tools effectively and ethically.

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