

Incorporating AI in Engineering Assignments as a Reliable Self-Directed Learning Tool: A Pilot Implementation Overview

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Abstract

An important characteristic of engineering education is its ability to evolve with the changes through time. Whether the changes are technological advancements, improvements in application methodologies or theoretical developments, engineering faculty, and engineering programs and curriculums update their teaching materials, course offerings as well as content delivery methods to incorporate such changes so they can teach their students the most up-to-date approaches. One of the most recent developments, now slowly becoming a permanent component of daily life, is AI (Artificial Intelligence) and related tools. This study aims to provide an overview of the integration process of an AI-based chatbot such as ChatGPT into engineering education through in-class exercises and homework assignments to enhance self-directed learning and tackle challenges associated with its use such as reliability and plagiarism concerns. As a part of the study, authors will share the development of the pre and post experience surveys, the pilot assignment approach along with the evaluation rubrics. The study lays the foundation for future efforts in seamlessly integrating AI into engineering curricula, equipping engineers with both technical expertise and self-directed learning capabilities.

Keywords: ChatGPT, Gemini, Llama, Self-Directed Learning, Engineering Education, Artificial Intelligence

Introduction

It is widely known and accepted; the process of learning never stops for engineers. And as engineering educators our goal is always to instill self-directed learning skills in our students, that way, after graduation, after the formal education ends, the learning never ends. While Gemini describes self-directed learning concept as “*Self-directed learning is taking charge of your learning journey by setting goals, finding resources, choosing methods, and evaluating your progress.*”, ChatGPT describes in this way: “*Self-directed learning is an educational approach in which individuals take responsibility for their own learning process, setting goals, making choices, and assessing progress based on personal interests and motivations.*” Both of the definitions highlight the importance of the self-direction part of self-directed learning, where the student has to take charge and responsibility of learning. The criticality of self-directed learning skill gains more importance especially after graduation where students are expected to continue to learn and to keep up with the changes and advancements in their field, while taking advantage of the new tools that may become available to them. One of the new technologies that is now available to students is an AI-based chatbot ChatGPT[1,2] which was initially released in 2018[3]. Students

from K12 to higher ed already started utilizing ChatGPT as a part of their learning process. One of the challenges faculty often sees is when AI chatbot such as ChatGPT is used, the generated answer may not always be reliable, relevant, or accurate. To overcome this challenge, in this study, our goal is to incorporate an AI based system, specifically ChatGPT, to engineering courses and make ChatGPT (and AI-based tools) a part of the coursework and learning process. Another goal of the paper is to provide students information regarding the use of AI-based chatbots and the concepts of academic integrity and plagiarism. The approaches highlighted in this paper aim to direct students away from copy and paste the Chatbot's answer to read, analyze, edit and use it as a support tool. Onal [4] incorporated the use of ChatGPT into selected Industrial Engineering courses and recommended the use of ChatGPT "*as a supplement, not a replacement*". Richards [5] explored the place of AI in engineering education and pointed out that educators should also consider what AI will be able to do in the near future. Calabro et.al [6] examined the use of ChatGPT to explore potential uses of the chatbot in teaching and assessing first year engineering design courses. Jack and Rowe [7] examined the incorporation of ChatGPT in digital design and highlighted the importance of clearly defining the problem for AI and concluded that use of AI tools "*decrease the time required to perform tedious tasks like writing reports and algorithms*". Uhlig et al [8] highlighted that, students will use ChatGPT during their academic studies and concluded that the "*use of AI tools should be encouraged as a form of collaboration*". Subramanian and Vidalis [9] discussed the incorporation and impact of AI-based tools, specifically ChatGPT, in engineering education and highlighted the importance of using AI-based tools to supplement the learning process and not use it as a substitute to replace one's own skills and abilities. Jawad et al [10] incorporated the use of ChatGPT in the engineering program selection for students.

To goal of this study is to provide an approach of implementing an AI-based tool, specifically ChatGPT, into engineering education to promote self-directed learning. This paper will provide an overview of the pre-implementation process, the implementation of the ChatGPT into the coursework, and post-implementation process. Along with the process details, the evaluation rubric and the surveys that will be used will be shared.

Methodology

ChatGPT is an AI-based chatbot and can generate answers to questions that are presented. Use of an AI-based chatbot in an educational setting has its own unique set of challenges both for faculty and students. From faculty's perspective, it can easily be categorized as a tool students can use for plagiarism. From students' perspective it can be trusted to generate meaningful and relevant answers. In addition, both students and faculty deal with the unknown as this is a new technology, there is hesitation and worry that comes with it as well.

Our study offers a multi-faceted multi-level approach:

Level 1, Preliminary Assessment:

- Conduct a pre-experience survey to evaluate students' familiarity and attitudes toward AI-based tools, particularly ChatGPT.
- Utilize a 6-question survey employing a 5-point Likert scale to capture nuanced responses.

- Analyze collected data to understand potential hurdles and tailor assignments accordingly.

Level 2, Incorporating ChatGPT into Assignments:

- Design assignments where students actively use ChatGPT as a tool to generate content related to provided keywords.
- Facilitate a controlled environment for students to interact with ChatGPT within the context of engineering topics.
- Ensure that assignments are challenging and open ended enough to encourage critical thinking.

Level 3, Evaluation Framework:

- Provide students with an evaluation rubric encompassing criteria such as accuracy, relevancy, and reliability of information generated by ChatGPT.
- Task students with assessing the merit of ChatGPT's output, offering a structured approach to critique the AI-generated content.
- Encourage students to analyze the overall flow of the generated essay.

Level 4, Skill Development and Improvement:

- Prompt students to edit the ChatGPT-generated essay to enhance its reliability, accuracy, and relevancy.
- Emphasize the importance of students actively participating in the refinement process to foster a deeper understanding of course concepts.
- Evaluate the edited version against the original.

Level 5, Post-Experience Assessment:

- Administer a post-experience survey similar to the pre-experience survey to detect changes in students' attitudes and perceptions towards AI-based tools.
- Implement a 5-point Likert scale to quantify shifts in student attitudes, facilitating the identification of positive or negative changes.
- Leverage survey results to refine existing assignments and create new activities based on the evolving student perceptions.

Pre and Post Experience Survey Design

Understanding students' attitudes towards the AI-based tools like ChatGPT allows us to identify the areas they may see as a potential struggle point as well as to create assignments to help students use such tools without hesitation. To understand students' attitudes and prior experiences with AI-based tools, a 6-question pre-experience survey is designed as shown in Figure 1. The survey uses a 5-point Likert scale, and the collected data is used to fine tune the assignments based on students' prior experience and knowledge of the AI systems. Prior to starting the AI-based examples and assignments, students first will be given the pre-experience survey.

Upon completion of the AI-based examples and assignments, a post-experience survey will be conducted. The aim of the post-experience survey is to measure if there is a change in students' perceptions of AI and also to see if there is a change in students' attitudes towards AI. Similar to

the pre-experience survey, the post-experience survey also uses a 5-point Likert scale. The post-experience survey is shown in Figure 2. The post-experience survey contains some of the same questions from the pre-experience survey. The identical questions help the authors identify and measure the change in students' attitudes and perception towards AI-based tools upon completion of the AI-based classroom activities. The change in students' attitudes, that is either a positive or a negative change, will help authors to redesign the existing assignments and activities, and create new ones.

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 1. AI-Based Tools Pre-Experience Survey

Development of the AI-Based Learning Activity and Evaluation Rubric

The AI-based activity students will complete requires students to utilize an AI tool, such as ChatGPT. The assignment steps are as follows:

Step 1: Students will be provided with 10-12 keywords related to the course content and related to the topics they are learning in the course.

**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 |
|----------------|-------|---------|----------|-------------------|

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

| | | | | |
|----------------|-------|---------|----------|-------------------|
| Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|----------------|-------|---------|----------|-------------------|

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

| | | | | |
|----------------|-------|---------|----------|-------------------|
| Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|----------------|-------|---------|----------|-------------------|

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 |
|----------------|-------|---------|----------|-------------------|

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

| | | | | |
|----------------|-------|---------|----------|-------------------|
| Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|----------------|-------|---------|----------|-------------------|

Figure 2. AI-Based Tools Post-Experience Survey

Step 2: Students will be asked to input any 6 of these keywords into ChatGPT to ask ChatGPT to create a short essay (200 words).

Step 3: Students will use the evaluation rubric to “grade” ChatGPT’s essay. Students will evaluate the relevancy, reliability, and accuracy of the information as well as the overall flow of the essay.

Step 4: Students will edit ChatGPT’s essay to remove any irrelevant parts, irregularities, and inaccuracies, and create an updated version.

Step 5: Students will submit the original essay created by ChatGPT, the updated essay with corrections, and the evaluation rubric.

Step 1: Students will be provided with 10-12 Keywords.

Provided Keywords: Design, Manufacturing, Assembly, Production, Challenges, Reliability, Quality, Robotics, Sustainability, Automation, Precision

Step 2: Students will select 6 Keywords.

Selected Keywords: Design, Precision, Robotics, Automation, Challenges, Reliability

You

write a 200 word essay using the keywords: Design, Precision, Robotics, Automation, Challenges, Reliability



ChatGPT

In the contemporary realm of industrialization, the symbiosis of design, precision, robotics, and automation has redefined the landscape of manufacturing. Design, serving as the initial architectural vision, is not merely an aesthetic endeavor but a crucial determinant of functionality and efficiency. Precision, the fine calibration of each component, is the linchpin ensuring that the end product meets exacting standards.

Robotics and automation have emerged as pivotal players in this intricate dance. Robotics, with its programmed dexterity, contributes to unparalleled precision in the manufacturing process. Automation, seamlessly integrated with robotics, streamlines workflows and reduces manual intervention, thereby enhancing efficiency. However, this amalgamation is not without its challenges.

The primary hurdle lies in orchestrating a flawless collaboration between design and the automated systems. Ensuring that the robotics adhere to the envisioned design parameters while maintaining reliability is an intricate task. Challenges include programming complexities, adaptability to diverse tasks, and the need for continuous fine-tuning. Reliability is the cornerstone of this intricate nexus; any lapse could reverberate through the entire production

Step 3: Students use the evaluation rubric to evaluate ChatGPT's essay.

| | Below Expectations | Meets Expectations | Above Expectations |
|-----------------------------------|--|--|--|
| Organization (___/25 Points) | Content is not presented in a meaningful order and has vague statements. | Content presented in a clear order with some vague statements. | Content presented in a clear order and doesn't have any vague statements |
| Relevancy (___/ 25 Points) | Content is generic, not relevant to engineering. | Content is mostly related to engineering with some generic statements. | Content is related to engineering with no generic statements. |
| Text Structure (___/25 Points) | Content has mostly long, hard to follow sentences without clear direction. | Content has some long, hard to follow sentences. Some of the sentences doesn't have a clear direction. | Content is easy to follow. The direction of the content is clear. |
| Accuracy (___/25 Points) | Content has major inaccuracies, uses incorrect information/data. | Content has some inaccuracies, uses limited data or omits important information. | Content is accurate, no important information is omitted. |

Step 4: Students will edit ChatGPT's essay to remove any irrelevant parts, irregularities, inaccuracies,...

In the contemporary realm of industrialization, the symbiosis of **design, precision, robotics, and automation has redefined the landscape of manufacturing**. Design, serving as the initial architectural vision, is not merely an aesthetic endeavor but a crucial determinant of functionality and efficiency. Precision, the fine calibration of each component, is the linchpin ensuring that the **end-product** meets exacting **engineering standards**.

Robotics and automation have emerged as pivotal players in **mass production. this intricate dance**. Robotics, with its programmed dexterity, contributes to unparalleled precision in the manufacturing process. Automation, seamlessly integrated with robotics, streamlines workflows and reduces manual intervention, thereby enhancing efficiency. However, this amalgamation is not without its challenges.

The primary hurdle lies in orchestrating a **flawless collaboration between design and the automated systems**. **Ensuring that the robotics adhere to the envisioned design parameters while maintaining reliability is an intricate task**. Challenges include programming complexities, adaptability to diverse tasks, and the need for continuous fine-tuning. **Reliability is the cornerstone of this intricate nexus; any lapse could reverberate through the entire production chain**.

In overcoming these challenges lies the **promise of a manufacturing future where design, precision, robotics, and automation coalesce seamlessly**, propelling industries toward unprecedented levels of efficiency and quality.

Step 5: Students will submit the original essay created by ChatGPT, the edited version, and the evaluation rubric.

Conclusion

Incorporation of AI, specifically ChatGPT, into engineering education presents a promising avenue for fostering self-directed learning skills among students. We demonstrated a pilot implementation including pre and post-experience surveys, assignments, and evaluation rubrics. The study recognizes the challenges and concerns associated with the use of AI in educational settings, such as the potential for plagiarism and the need to ensure the reliability of generated content. Through the structured methodology, students are not only introduced to AI but are actively engaged in the learning process. The pre and post-experience surveys serve as valuable instruments for quantifying students' perceptions and they allow educators to tailor assignments based on these responses.

The designed AI-based learning activity is aimed to encourage critical thinking and collaboration between students and AI. By editing and refining the output generated by ChatGPT, students not only enhance their understanding of course content but also develop essential skills in evaluating and improving AI-generated responses.

As highlighted by previous studies mentioned in this overview, the incorporation of AI, when approached as a supplement rather than a replacement, proves beneficial. The insights gained from this pilot implementation contribute to the ongoing discourse on the role of AI in engineering education, emphasizing the importance of responsible and collaborative use. This pilot study lays the groundwork for future endeavors in seamlessly integrating AI tools like ChatGPT into engineering curricula, fostering engineers equipped with both technical expertise and self-directed learning capabilities.

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