

## **Integrating ChatGPT in an Introductory Engineering Undergraduate Course as a Tool for Feedback**

### **Dr. Anthony Cortez, Point Loma Nazarene University**

Dr. Cortez is currently an Assistant Professor in the department of Physics and Engineering at Point Loma Nazarene University. He received his BS in Physics from University of California San Diego (UCSD). He went on to complete his MS and Ph.D. in Mechanical Engineering from University of California Riverside (UCR). His research interests include technology as a tool in the classroom, high temperature superconductivity, superconducting detectors, nanofabrication, and space THz technology.

### **Dr. Paul Daniel Schmelzenbach, Point Loma Nazarene University**

Dr. Paul Schmelzenbach is currently a Professor of Physics and Engineering at Point Loma Nazarene University. He received his BS in Physics and a BS in Chemistry from Northwest Nazarene University in 1998. He then went on to complete his MS and Ph.D. in Nuclear Physics from Oregon State University in 2003. His research interests include gamma-ray spectroscopy, analysis of large data sets, computational physics, and physics and engineering education.

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## **Abstract**

Recently, OpenAI released ChatGPT, which has sparked opposing opinions within academia regarding its role in the classroom and for assignments. Some may consider the use of AI, such as ChatGPT, to be cheating whereas others embrace the possibility for a deeper and more comprehensive learning among students. To gain a better understanding of the potential use of ChatGPT as a tool for students, a series of assignments were given to an Introduction to Engineering undergraduate course that implemented the use of the AI chatbot as a resource. In this study, students were first given an exam that required them to write MATLAB code to create a plot with specific characteristics, using only the documentation within MATLAB as their resource. After receiving their graded exam, the students were given a laboratory assignment in which they interacted with ChatGPT-3.5 to obtain feedback on their MATLAB exam. Qualitative data on the students' experiences with the use of ChatGPT as a tool in studying were collected and analyzed. The results revealed that while students found the capabilities of ChatGPT intriguing, they remained skeptical in the output and reasoning given in regard to their MATLAB assignment.

## **1 Introduction**

In November of 2022, OpenAI introduced ChatGPT, a natural language processing model, to the world. Two months later, it gained 100 million users, making it the fastest growing consumer app in history [1]. The name stems from the model's dependence on the Generative Pre-trained Transformer (GPT) architecture to produce real-time conversation in the form of text. Launching ChatGPT brings the user to a page with OpenAI's logo centered with text immediately beneath stating: "How can I help you today?" followed by a 2x2 array of prompts to send and a designated bubble to input user-specified text at the bottom. The display invites a sense of familiarity with the web page of Google. A first-time user may type prompts similar to a Google search question, but will soon learn that the capabilities of ChatGPT are much more than that of a search engine. The rapid response and ability to generate text can easily give the impression of a human conversation.

A few examples of the applications of ChatGPT include the ability to generate a story with or without constraints, create lyrics appropriate to a specified music genre, and generate a detailed plan on how to achieve specific goals. With respect to education, some of the more notable applications of ChatGPT include the ability to write an essay specific to the prompt, generate

operational code, and create lesson plans [2]. These capabilities raise the concern of student cheating amongst educators [3]. Prohibiting the use of ChatGPT in the classroom will not alleviate this concern since students can submit work written by ChatGPT undetected by the instructor. There exist tools to detect the possibility of ChatGPT generated text, however the results are not definitive and can produce false positives [4]. In a new era of ChatGPT where it is difficult to detect its use, higher education institutions must consider future assessment of student work [5]. One study that investigated the ethical ramifications on student use of AI in an engineering course revealed the potential benefits of utilizing AI as a form of collaboration [6]. Some of the listed benefits include: the ability for a student to discuss a topic with a very knowledgeable machine partner, a means for efficient research of a particular topic, and the possibility to operate as a programming assistant due to the well-commented code generated.

The integration of technology and innovative approaches in education has the potential to enhance the way engineering students learn. Today's students benefit from technological advancements that allow them a variety of resources to aid in their academics. While advancements in technology, such as ChatGPT, have the potential to be useful study tools, their effectiveness is limited by the users' ability to ask the right type of question. The significance of successful prompting of large language models and the student's ability to think critically in generating the question is discussed in reference [2]. Therefore, it is essential to consider how students are using these tools and how they might be utilized to enhance learning in engineering disciplines. This paper investigates the integration of ChatGPT-3.5 as a form of feedback in an Introductory Engineering course to gain insight on student experiences.

## **2 Methods**

### **A. Course structure**

ChatGPT was introduced and integrated into a first-year introductory engineering course to explore the possible benefits of providing students with AI-generated feedback. This course is an introduction to engineering as a career, including problem solving, engineering disciplines, design, teamwork, and communication. It also serves as an introduction to multiple tools and techniques used by engineers, including data analysis, numerical methods, error analysis, and the use of computers for solving problems in physics and engineering. The course is structured in chronological order according to the following learning outcomes:

- 1. Understand the basics of the engineering profession, including problem solving, design, teamwork, and creativity.*
- 2. Develop skills in communicating complex and technical ideas.*
- 3. Understand key ideas of how to use Excel as a tool to solve problems and communicate data in science and engineering.*
- 4. Become proficient at using MATLAB, including writing .m files and correcting or modifying existing code.*
- 5. Learn fundamental skills for group collaboration, as well as lab and project*

*execution/documentation/demonstrations.*

6. *Address the role that artificial intelligence has in engineering.*

7. *Understand how to utilize a microcontroller to solve certain engineering problems.*

Therefore, ChatGPT was not introduced into the course until two-thirds of the way through the semester. The purpose for introducing AI to the latter part of the semester was to allow sufficient time for students to first establish a foundation in problem-solving skills and develop familiarity with software such as MATLAB. For example, in addressing learning outcome 4, three weeks of the semester were dedicated to learning and exploring the capabilities of MATLAB. In this time, students engaged with this material through traditional lecture format, step-by-step tutorials, active-learning assignments in class, reinforced their learning through homework assignments, and completed labs that required critical thinking and problem solving. An in-person exam was given following this three week period for assessment.

## **B. Exam question**

The in-person exam required students to accomplish an objective in MATLAB by following a series of specifications. The text below is the problem given to the students.

*Create overlying lines with a randomized slope and intercept following the specifications below:*

- (a) Use rand() in combination with the appropriate math to create a random decimal value between -5 and 5 and store it in the variable m.*
- (b) Store a random integer between 0 and 4 and store it in the variable b*
- (c) Create a range of 20 different values stored in x between -10 and 10.*
- (d) Create the array y of the line (using the standard formula of  $y = mx + b$ )*
- (e) Make a plot of x and y displayed with the color green if the slope is positive (greater than 0) and red if it is negative.*
- (f) Repeat (a)-(e), overlaying each of the plots on top of each other as long as the random slope is less than 4. (Once it is larger than 4, stop)*
- (g) Create a title that displays the number of lines that were drawn. (So each time you run it, it automatically shows you the new value. You may need to create a variable to keep track of this.)*
- (h) Label the x and y axis with time and signal.*

Following the listed specifications will produce the plot shown in Figure 1.

## **C. Introducing ChatGPT**

The version used in this study is ChatGPT-3.5. Although ChatGPT-4 was available at the time, the decision to use the 3.5 version provides a baseline in student experiences and does not exclude students who are unable to pay the premium required by ChatGPT-4.

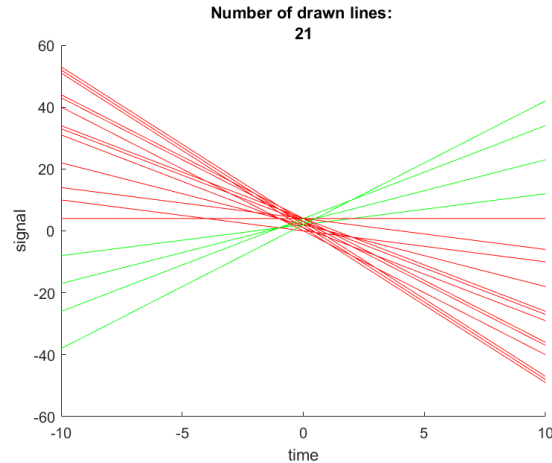


Figure 1: This is the plot created in MATLAB following the specifications of the exam question.

As a group, students were first introduced to ChatGPT through a lab assignment designed for open exploration of its capabilities. The lab consisted of three parts: initial feedback and exploration, comparing chatbot and human interactions, and a final survey on student experiences. This preliminary assignment allowed students to form an initial opinion about ChatGPT, which we then discussed as a class. Students shared a wide range of examples from generating fictional stories to summarizing key concepts for a physics problem. While there were many examples demonstrating the impressive capabilities of ChatGPT, such as achieving a satisfactory score on the US Fundamentals of Engineering Exam [7], ChatGPT can also generate misleading or incorrect information [8]. Therefore, the remainder of the lecture time was dedicated to demonstrating some examples of limitations and inaccuracies.

A follow-up lab using ChatGPT was given to the students. The purpose of this lab was to explore the potential use of ChatGPT as an academic tool. This lab was organized into three parts. The first part required the student to review their graded MATLAB exam and attempt to make corrections on their own using documentation or online resources other than chatbots. The second part had students use ChatGPT to produce the MATLAB code that achieves the exam question specifications. The students analyzed the similarities and differences in their code and compared it to ChatGPT's response. The third part had students use the AI chatbot for feedback on their code in comparison with the generated code. A final survey was given to the students to gather feedback on their experience.

### 3 Results

The initial feedback on students' experience with ChatGPT is shown in Figure 2. One-quarter of the class indicated they had no prior experience with ChatGPT, but are aware of its existence. The three-quarters of the class who indicated they had prior experience were asked to provide an example of the context in which they used ChatGPT. One-third of the responses were either ambiguous or did not specify their use. The highest percentage of use by students were for studying schoolwork and hobbies. Some examples of schoolwork consisted of producing example problems for the student to solve and as an aid in writing by producing synonyms and concise

language. The lowest percentage of use was writing a report on ChatGPT for a school assignment.

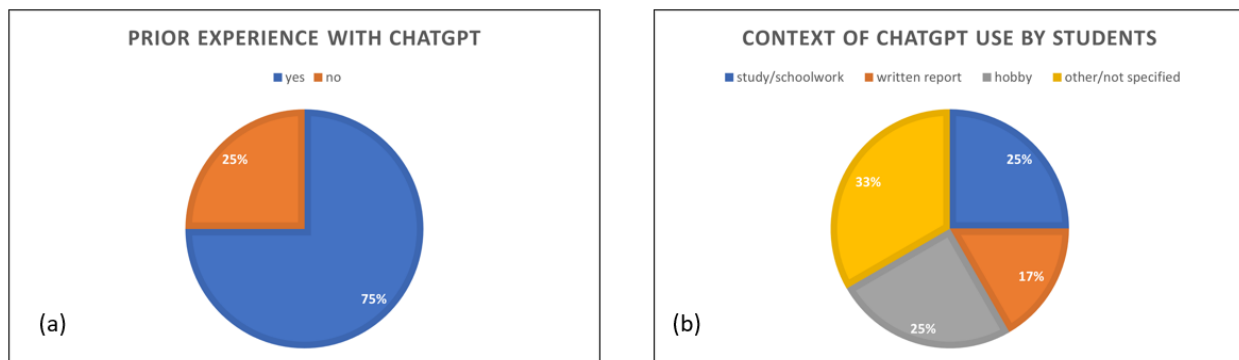


Figure 2: (a) Percentage of students in the class who have prior experience with ChatGPT compared to those who did not. (b) Distribution of ChatGPT use among the students with prior experience.

The following text is the example that was presented in class to illustrate the false or incorrect information that ChatGPT can produce. Prompts by the author are in boldface and ChatGPT's response is italicized. Immediately following each of ChatGPT's responses is brief commentary by the authors.

**Prompt: Identify the key information necessary to solve this problem: Vector  $\vec{A}$  is along the  $\hat{k}$  direction and  $\vec{B}$  is along the  $\hat{j}$  direction. (a) What direction is the resultant vector of  $\vec{A} \times \vec{B}$ ? (b) Compute the resultant vector of  $\vec{C} \times \vec{D}$ , where  $\vec{C} = 5\hat{j}$  and  $\vec{D} = -60\hat{i} + 40\hat{j} + 20\hat{k}$ .**

*ChatGPT: (a) To determine the direction of the resultant vector of  $\vec{A} \times \vec{B}$ , the key information needed is the magnitudes and directions of vectors  $\vec{A}$  and  $\vec{B}$ . (b) To compute the resultant vector of  $\vec{C} \times \vec{D}$ , the key information needed is the magnitudes and directions of vectors  $\vec{C}$  and  $\vec{D}$ . In this case,  $\vec{C}$  is given as  $5\hat{j}$  and  $\vec{D}$  is given as  $-60\hat{i} + 40\hat{j} + 20\hat{k}$ , so no further information is needed to compute the resultant vector.*

This response incorrectly suggests that both magnitude and direction are needed to determine the direction of the resultant vector in part (a), however only the direction of the two vectors is needed. This error is subtle and therefore can be difficult for a student who does not have a strong foundation on the topic to validate the accuracy of the statement. The concern would then be that a student who puts full trust into ChatGPT as a study aid for new topics could potentially lead to receiving misinformation.

**Prompt: In (a) why do I need to know the magnitudes?**

*ChatGPT: I apologize for my previous response, you are correct that in part (a) only the directions of vectors  $\vec{A}$  and  $\vec{B}$  are required to determine the direction of the resultant vector of  $\vec{A} \times \vec{B}$ . Magnitudes are not required for this calculation.*

*To determine the direction of the resultant vector of  $\vec{A} \times \vec{B}$ , one needs to know the orientation of the coordinate system with respect to the vectors  $\vec{A}$  and  $\vec{B}$ . Specifically, one needs to know the angle between the  $\hat{k}$  and  $\hat{j}$  directions, which are the directions of  $\vec{A}$  and  $\vec{B}$ , respectively. With this*

information, one can apply the right-hand rule to find the direction of the cross product  $\vec{A} \times \vec{B}$ .

This response demonstrates ChatGPT's willingness to accept fault and illustrates the possibility for it to generate incorrect statements. It is also interesting to note that fault was admitted without the prompt directly stating that the original response was incorrect. Rather, the chatbot inferred the intent of the prompted question, thus imitating human-like behavior.

**Prompt: What is the answer for part (a)?**

*For part (a), we are given that vector  $\vec{A}$  is along the  $\hat{k}$  direction and vector  $\vec{B}$  is along the  $\hat{j}$  direction. The cross product  $\vec{A} \times \vec{B}$  is given by:*

$$\vec{A} \times \vec{B} = |A||B| \sin \theta \, n$$

*where  $|A|$  and  $|B|$  are the magnitudes of vectors  $\vec{A}$  and  $\vec{B}$ ,  $\theta$  is the angle between them, and  $n$  is a unit vector perpendicular to both  $\vec{A}$  and  $\vec{B}$ .*

*Since  $\vec{A}$  is along the  $\hat{k}$  direction and  $\vec{B}$  is along the  $\hat{j}$  direction, the angle between them is 90 degrees. Therefore,  $\sin \theta = 1$ , and we have:*

$$\vec{A} \times \vec{B} = |A||B| \, n$$

*The direction of  $n$  can be found using the right-hand rule, which gives us the direction of the cross product. Since  $\vec{A}$  is along the  $\hat{k}$  direction and  $\vec{B}$  is along the  $\hat{j}$  direction, their cross product will be in the direction of the third basis vector, which is  $\hat{i}$ . Therefore, the direction of the resultant vector of  $\vec{A} \times \vec{B}$  is along the  $\hat{i}$  direction.*

*So the answer to part (a) is: The resultant vector of  $\vec{A} \times \vec{B}$  is in the  $\hat{i}$  direction.*

This response claims that the resultant vector is in the  $\hat{i}$  direction, however one would find that using the right-hand rule would lead to the resultant vector in the negative  $\hat{i}$  direction. The reasoning given in this statement is well stated and would align to what a student might have read in a textbook or recalled hearing from lecture, however the concern is that the final answer is wrong. It is possible that this could lead a student to doubt their response had they arrived at the negative  $\hat{i}$  direction on their own, but received a conflicting response from ChatGPT. Therefore, it is imperative that students who rely on using ChatGPT for studying recognize that it does not always provide accurate information.

The lab requiring students to use ChatGPT as feedback for their MATLAB exam culminated with the following survey questions:

- (a) *How was your experience with using ChatGPT as a tool to revisit the MATLAB Exam question? (Extremely Helpful/Helpful/Somewhat Helpful/Less Helpful/Not Helpful) Explain why you feel this way.*
- (b) *What were the most valuable insights or features you discovered while using ChatGPT to generate its own solution?*

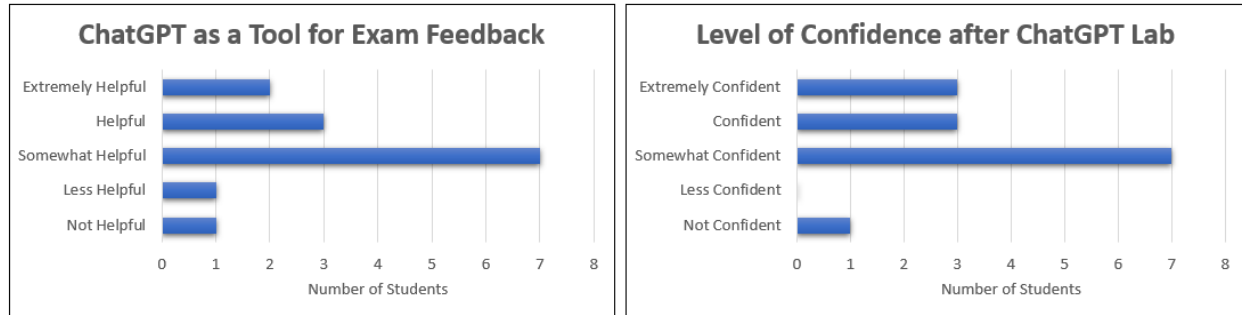


Figure 3: (Left) Student responses on their experience using ChatGPT as a tool to revisit the MATLAB Exam question. (Right) Student responses on rating their level of confidence on the MATLAB problem if asked to solve again by themselves following the ChatGPT lab.

(c) *How would you rate your level of confidence on this problem if you were asked to solve it again by yourself? (Extremely Confident/Confident/Somewhat Confident/Less Confident/Not Confident) Explain why you feel this way?*

The student responses to survey question (a) and (c) are shown in Figure 3. The responses of two students were not included due to ambiguous answers. Half of the responses indicated that they found ChatGPT “somewhat helpful” as a tool to revisit their exam question. Of the remaining students, 36% indicated the use of ChatGPT was “helpful” or “extremely helpful” while 14% found it to be “less” or “not helpful”. This suggests that there is some potential in using ChatGPT as a tool for feedback, but the process must be adjusted such that the majority of students find it more than “somewhat helpful”.

The most common response to survey question (b) was the students’ ability to gain a new perspective on how to solve the same problem. This allows students to explore functions not discussed in class or learn new approaches in solving a problem. The next most common response was the speed at which ChatGPT produced the code. In a digital age where we desire information immediately, it is understandable that the speed of ChatGPT responses would attract many users.

Comparing the student rankings of ChatGPT as a tool for feedback and their level of confidence after the lab reveals interesting results. For example, the one student who responded “less helpful” also responded as “extremely confident” in solving the problem independently after the lab. A plausible explanation for this is because the student already had a strong understanding of the material indicated by their original exam score. Figure 4 shows the response of students to (a) and (c) in groups of their exam score. All students, except one, who earned a grade of B or greater on their exam indicated a positive response towards ranking the helpfulness of ChatGPT. It is interesting to note that this is the only group that contained a response of “extreme” confidence or helpfulness. A plausible explanation for this is that a student’s experience with ChatGPT is improved when discussing a subject in which the student is knowledgeable. The student who responded “not confident” also responded “not helpful”. A student who uses ChatGPT to assist in a topic they are not knowledgeable in could potentially have increased difficulty in appropriately prompting the chatbot.



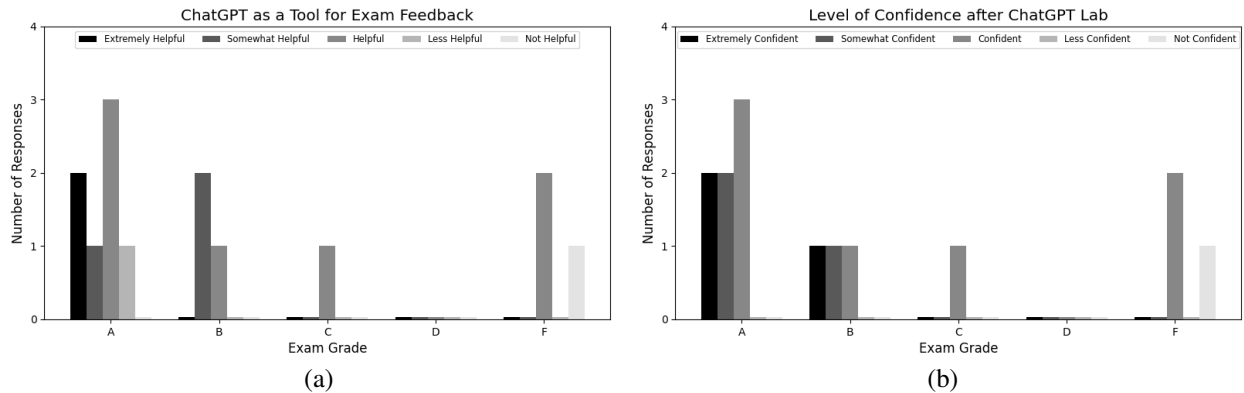


Figure 4: (a) Student responses on their experience using ChatGPT as a tool to revisit the exam question and (b) student ratings on their level of confidence grouped by exam scores.

In addition to the final survey questions, students were allowed to provide any additional comments of their experience. Below are a few selected quotes from students. Permission to use the students' quotes for the purpose of this paper was given to the authors.

*Student 1: "Using ChatGPT was helpful for sure. I already had the code working, so I already understood it, but when I gave the prompt to ChatGPT it gave me a completely different but working solution, and that was really cool to see and understand."*

*Student 2: "The most valuable feature that I discovered for giving feedback was the ability for it to give me different suggestions on my code and what I can do to improve it in ways I had not seen."*

These responses highlight the potential to learn a new point of view on how to approach or solve a similar problem. This demonstrates the ability for a student to expand beyond their current understanding in a given topic. While it is great to learn that students gained a deeper understanding of the material, there are some who did not benefit from ChatGPT as shown in the quote below.

*Student 3: "Simple things that I already understood it did correct for the most part but overall it just made MATLAB more confusing for me"*

Some students identified both positive and negative aspects of the AI. The following student quote provides insight into ChatGPT's effectiveness in acting as a study tool.

*Student 4: "ChatGPT overall is a somewhat helpful tool when it comes to complex prompts such as this. It tends to agree with the user when it does not exactly know the correct answer which can be very dangerous. To be useful, you must have extensive background knowledge to be able to recognize the errors that it makes to correct your code."*

This student recognizes a potential risk of using ChatGPT for topics in which a user lacks a sufficient level of background knowledge. The concern arises with the understanding that ChatGPT can provide incorrect information in a manner that is not immediately evident. Therefore, it is possible for a student to mistakenly develop a false understanding of a given topic.

Hence, Student 4 recommends a threshold level of understanding in the topic to help mitigate and eliminate some risk associated with using ChatGPT as a study tool. The threshold level is dependent on the user's ability to recognize errors in ChatGPT's responses.

## **4 Discussion and Conclusions**

### **A. Student metacognition**

Metacognition involves a person critically analyzing their own understanding. Within engineering education, this reflective practice by the student enhances learning and problem solving. There are numerous classroom structures or techniques we can use to build these skills. ChatGPT provides interesting ways for a student to engage with material, and may further a student's understanding of their own learning processes, problem-solving strategies, and perhaps identify knowledge gaps.

The process of initially re-engaging with the test question without the assistance of AI, provided a means to both reflect on their own work, as well as explore more traditional means of correcting or expanding their original code outside the pressure of an exam situation. This also readied students to be able to interact and carefully evaluate responses by the AI. For some students, ChatGPT-3.5's initial response did not satisfy the requirements of the test question. This actually produced a very high level of engagement. By this stage, students had developed expertise of the problem, and had to work toward nudging the AI to get a correct response. Because of their previous knowledge of the problem, students were better able to identify differences and similarities with their code. While engaged in this careful comparison, several students gained new insights, or even new methods. The process of nudging the AI toward the correct answer is reminiscent of improving one's learning by teaching or tutoring. Some of the value to the student learning process in the use of the AI came not only from what it did correctly, but also where it failed.

It is interesting to consider how using ChatGPT-4 or other similar AI programs might change the level of student engagement if it were used in a similar way. The initial prompt, particularly with some additional basic information, tends to provide an answer that satisfies all the problem parameters. Used with more structured prompts, it seems like this would act perhaps more like the AI is the tutor for the student, rather than the other way around.

### **B. Recommendation for instructors who do not plan to integrate ChatGPT in the classroom**

The results of integrating the use of ChatGPT into the classroom in an attempt to aid students in studying by providing exam specific feedback reveal challenges that instructors must consider when designing a course. This is also true for instructors who intend to prohibit student use of ChatGPT.

A course left unchecked to the effects of recent advancements in artificial intelligence remains susceptible to false assessment results of student performance in the class. Consider a class that incorporates traditional graded homework as a form of assessment. The graded homework will provide feedback for the student and instructor on the student's comprehension of the material. This works well when the student is genuinely submitting their own solution to a given problem,

but becomes ineffective if the student submits work obtained from another source. There exists safeguards such as Turnitin [9] which detect forms of plagiarism, however it is much more difficult to make any definitive claim that a student did use ChatGPT to generate text. Therefore it is possible for a student to submit work generated by ChatPT unbeknownst to the instructor and receive full credit on the assignment. However, this grade does not reflect the student's work, thus it cannot serve as a valid assessment of student comprehension. As a result, it is recommended that instructors redesign assessment questions to reduce the potential use of copying and pasting a response generated by ChatGPT. Redesign of questions will depend on the course and particular assignment, but there are some general guidelines that may prove helpful. Instructors should avoid textbook questions, which is true for ChatGPT, but also other existing online solution websites. Certain types of questions that previously tended to require student engagement, such as reflections or novel and individualized questions through online homework systems, can often be answered by ChatGPT. A potential workaround is to ask questions centered on key discussions or demonstrations seen in class. This approach requires students to make connections between what they have learned in class and the specified question, a task that ChatGPT cannot perform accurately since it lacks awareness of the specific demonstrations conducted in class. This is a suggested starting point for question redesign, but further testing by individual instructors is required.

### **C. Recommendations for instructors who plan to integrate ChatGPT in the classroom**

The results from this study revealed that ChatGPT was not inherently useful for all students and in some cases can lead to more confusion. Therefore, we recommended to instructors who wish to integrate ChatGPT into the classroom to provide intentional guidelines that help introduce proper use of the AI within the scope of the class. The methods section of this paper discusses how ChatGPT was introduced to the class in this study. Prior to its use to receive feedback, the students allocated two distinct lesson plans on ChatGPT. The first included a three hour open exploration lab with the intent to form an initial framework of the AI by the student. The second consisted of a one hour lecture demonstrating the potential for it to generate incorrect information. This structure of introducing ChatGPT to the class resulted in responses by students, either in the assignments or informally through conversation, which revealed a healthy level of skepticism in what was generated. However, this method does not effectively inform students of the AI's practical applications as a study tool. We recommend to dedicate another lesson on ChatGPT which includes techniques to both improve the generated response and allow students to practice critical thinking about the AI's output. Through this additional lab, students would develop skills to more effectively prompt the AI by exploring and adjusting prompting language. Through this process, students are incorporating all levels of Bloom's taxonomy: remember, understand, apply, analyze, evaluate, and create [10].

Regardless of the specific methods used, the instructor should explore the capabilities of ChatGPT in the scope of the class to discover which methods work well. Generative AI is already here and is quickly improving, therefore, it is crucial that instructors remain up to date with these advancements to better navigate the role AI might have for students as a study tool.

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