

Engineering Education in the Era of ChatGPT: Promise and Pitfalls of Generative AI for Education

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Abstract—Engineering education is constantly evolving to keep up with the latest technological developments and meet the changing needs of the engineering industry. One promising development in this field is the use of generative artificial intelligence technology, such as the ChatGPT conversational agent. ChatGPT has the potential to offer personalized and effective learning experiences by providing students with customized feedback and explanations, as well as creating realistic virtual simulations for hands-on learning. However, it is important to also consider the limitations of this technology. ChatGPT and other generative AI systems are only as good as their training data and may perpetuate biases or even generate and spread misinformation. Additionally, the use of generative AI in education raises ethical concerns such as the potential for unethical or dishonest use by students and the potential unemployment of humans who are made redundant by technology. While the current state of generative AI technology represented by ChatGPT is impressive but flawed, it is only a preview of what is to come. It is important for engineering educators to understand the implications of this technology and study how to adapt the engineering education ecosystem to ensure that the next generation of engineers can take advantage of the benefits offered by generative AI while minimizing any negative consequences.

Index Terms—Generative AI, ChatGPT, Engineering Education.

I. INTRODUCTION

ChatGPT is a natural language processing (NLP) model that was developed by OpenAI.¹ It is based on the GPT (Generative Pre-trained Transformer) architecture, which was originally developed for language generation tasks such as machine translation and summarization. Compared to traditional AI useful for discriminative predictions, ChatGPT is a generative AI that is designed to be able to generate new content or ideas and express it in real-time conversations. ChatGPT is a text-to-text generative AI compared to other generative AI models that are text-to-image (such as OpenAI's DALL-E). A key feature of ChatGPT is its ability to maintain a conversational style with a consistent persona or identity throughout a conversation, which allows it to engage in more realistic natural dialogues, rather than simply responding with unrelated or unrelated responses. Towards this end, ChatGPT was trained on a large dataset of conversational text, including chat logs, forums, and social media posts, and is able to generate human-like responses to the prompts and questions.

A. Applications of ChatGPT

ChatGPT has been used in a variety of applications, including generating chatbot responses, generating ideas for stories and content, and even creating music. In the context of education, ChatGPT can use both learners and teachers. For instance, an educator can use it to create content including (but not limited to) course outlines, presentations, coding, quizzes, grading, scientific papers, etc. Students can use it for help in solving questions, writing essays, and getting formative feedback on their work [1], [2]. ChatGPT has caused significant excitement in the field, as well as some consternation [3] [4]. It's important to take stock of the situation in a balanced manner and prognosticate the future of education in the presence of tools such as ChatGPT, which will continue to improve and become more impressive. More specifically, it is important to consider the potential applications of ChatGPT along with the significant risks involved so that the tool is used for social good and not for social harm [5] [6], [7]. There exist a number of beneficial educational applications of ChatGPT both for learners and educators. For instance, some technical educational applications such as the ability to solve mathematical questions; theoretical/conceptual questions; and even generate code (see Figure 1). Some experts are even calling the change wrought upon by the rise of AI as so significant that it will completely overhaul current programming practices [8]. Such tools will also find wide in assisting writers in creative writing through outlining or providing leads to be further pursued and refined (see Figure 2 for an illustration).

B. Technology and Education

Technology often disrupts traditional practices, requiring people to adapt and consider the potential benefits and drawbacks of new technologies [9]. In the past, researchers have questioned how Google would impact education; whether it is making us wiser or more shallow [10]; and if at all we need a teacher in these times [11]. In the early 2010s, Massive Open Online Courses (MOOCs) gained widespread attention [12], but their performance did not live up to expectations and their focus and business models underwent shifts as a result [13]. Going even further back to Plato, there were similar admonitions about atrophying tendencies of technology (at that time the written word compared to the spoken word), which will result in ‘forgetfulness in the learners’ souls, because

¹<https://openai.com/blog/chatgpt/>

CODE GENERATION

Give me code for the Dijkstra algorithm in Python

```
from collections import defaultdict
import heapq

def dijkstra(graph, source):
    # Initialize distances and predecessor for each vertex
    distances = defaultdict(lambda: float('inf'))
    predecessor = defaultdict(lambda: None)
    distances[source] = 0

    # Initialize priority queue with all vertices and their distances from the source
    priority_queue = [(0, source)]
    while priority_queue:
        # Extract vertex with minimum distance from the queue
        distance, vertex = heapq.heappop(priority_queue)

        # Update distances and predecessors for all neighbors of the vertex
        for neighbor, weight in graph[vertex]:
            if distances[neighbor] > distance + weight:
                distances[neighbor] = distance + weight
                predecessor[neighbor] = vertex
                heapq.heappush(priority_queue, (distances[neighbor], neighbor))

    return distances, predecessor
```

CONCEPTUAL QUESTIONS

What are algorithmic solutions for solving congestion

Congestion occurs when a network becomes overloaded, resulting in reduced capacity and slower performance. There are several algorithmic solutions for solving congestion in networks, including:

1. Routing algorithms: These algorithms aim to route traffic around congested areas or to balance the load among different routes. Some examples include Dijkstra's algorithm, Bellman-Ford algorithm, and Link-State Routing Protocol.
2. Flow control algorithms: These algorithms aim to regulate the flow of traffic in order to prevent congestion. Examples include window-based flow control (such as TCP), rate-based flow control (such as the leaky bucket algorithm), and priority-based flow control (such as strict priority queuing).
3. Resource allocation algorithms: These algorithms aim to allocate resources (such as bandwidth or processing power) to different tasks or users in a way that minimizes congestion. Examples include max-min fairness, proportional fairness, and weighted fair queuing.
4. Traffic engineering algorithms: These algorithms aim to optimize the use of network resources in order to reduce congestion. Examples include QoS routing, traffic grooming, and multicast tree construction.
5. Congestion pricing algorithms: These algorithms aim to incentivize users to reduce their demand for network resources by charging them for congestion. Examples include tolls for using certain roads or time-of-day pricing for using the internet.

MATH QUESTIONS

Find the derivative of the function $f(x) = 3x^2 + 2x - 1$. Describe your working

To find the derivative of the function $f(x) = 3x^2 + 2x - 1$, we need to use the rules of differentiation. The derivative of a function is a measure of how the function is changing at a particular point.

The derivative of a constant term (such as -1 in this case) is always 0 , so we can ignore that part of the function. The derivative of a term with a coefficient of 1 (such as $2x$ in this case) is just the coefficient times the variable (in this case, x), so the derivative of $2x$ is 2 .

The derivative of a term with a coefficient other than 1 (such as $3x^2$ in this case) is the coefficient times the derivative of the term with the coefficient of 1 (in this case, 3 times x), so the derivative of $3x^2$ is $3x$.

Now that we have found the derivative of each term in the function, we can add them up to get the derivative of the whole function:

$$f'(x) = 3x + 2 = 6x + 2$$

This is the final answer. The derivative of the function $f(x) = 3x^2 + 2x - 1$ is $f'(x) = 6x + 2$.

Fig. 1: Technical Educational Applications of ChatGPT.

ESSAY OUTLINING AND POINTERS

I want to write an essay on the ethics of ChatGPT. Can you provide an outline for that?

Sure! Here is an outline that you could use as a starting point for writing an essay on the ethics of ChatGPT:

- I. Introduction
 - Introduce the topic of ChatGPT and its role in the field of natural language processing
 - Explain the purpose of the essay and the ethical issues that you will be exploring
- II. Background on ChatGPT
 - Provide an overview of the development and capabilities of ChatGPT
 - Discuss the potential benefits and limitations of using ChatGPT for conversation and dialogue
- III. Ethical concerns
 - Discuss the potential ethical concerns related to the use of ChatGPT, such as:
 - Bias in the training data
 - Misuse of the model, such as for creating fake news or impersonating other people
 - The impact on employment, such as the potential for ChatGPT to replace human customer service or support roles
- IV. Possible solutions
 - Discuss potential ways to address the ethical concerns raised, such as:
 - Ensuring that the training data is diverse and representative
 - Developing guidelines and policies for the responsible use of ChatGPT
 - Considering the potential impact on employment and developing strategies to address any negative consequences

IMAGINATIVE DIALOGUES

Can you write a very short dialogue between Thamus and Theuth in the style of Plato's dialogue Phaedrus about the benefits and drawbacks of ChatGPT?

Thamus: Thamus, my old friend, I have heard much about this new technology called ChatGPT. What is your opinion of it?

Theuth: Ah, ChatGPT. It is a most remarkable tool, Thamus. It has the ability to understand and generate human-like text, and can assist with tasks such as translation and writing.

Thamus: And what of the drawbacks, Theuth? Is there not a risk that this tool could be misused or that it could replace the need for human intelligence and creativity?

Theuth: Yes, Thamus, there is always a risk when introducing new technology. But I believe that the benefits of ChatGPT far outweigh the drawbacks. It has the potential to revolutionize the way we communicate and access information, making it easier for us to understand one another and learn from one another.

Thamus: I see your point, Theuth. It seems that ChatGPT holds great promise, but we must be mindful of its potential consequences.

Theuth: Indeed, Thamus. Let us embrace this new technology, but let us also be wise and cautious in its use.

STORY WRITING AND PERSUASIVE WRITING

Can you tell me a nice story of how too much use of a technology can actually be detrimental

Sure, here is a story about the negative consequences of overusing a technology:

There was once a small village nestled in the mountains, where the people lived a simple and self-sufficient life. They grew their own food, raised animals, and spent their days working and playing in the great outdoors.

One day, a group of traveling merchants arrived in the village, bringing with them a new technology that promised to revolutionize the way the villagers lived. It was a machine that could do the work of many people, and the merchants convinced the villagers to buy it, promising that it would make their lives easier and more efficient.

At first, the villagers were excited about the new technology. They used it to plow their fields, churn their butter, and even make their meals. But as time passed, they found that they were relying on the machine more and more, and they began to neglect their own skills and abilities. They stopped gardening, stopped caring for their animals, and stopped doing many of the tasks that had once been a part of their daily lives.

As the villagers became more and more dependent on the machine, they started to lose their sense of community and connection with each other. They spent more time indoors, sitting in front of screens and interacting with the machine, and less time outdoors, working and playing together.

One day, the machine broke down, and the villagers realized that they had lost the knowledge and skills they needed to repair it. They were completely reliant on the machine, and without it, they were lost. They had to rely on the merchants to fix it, and they had to pay a high price for the repair.

The villagers learned a valuable lesson that day: that too much reliance on a single technology can be detrimental, and that it is important to maintain their own skills and abilities, and to nurture their sense of community and connection with each other.

I hope you enjoyed this story! It is a cautionary tale about the dangers of overusing a technology and losing sight of the value of human skills and connections.

Fig. 2: Creative Writing Oriented Educational Applications of ChatGPT.

they will not use their memories.”² Plato’s work about such tools imparting “not truth but only the semblance of truth” and that those who adopt it will appear to omniscient and will generally know nothing.” The concerns may even be leveled on modern technology such as ChatGPT. As we describe in this paper, generative AI technology such as ChatGPT has a lot of potential and also significant risks (such as job displacement particularly for low-skilled workers [14]). The engineering

²What would Plato say about ChatGPT? Zeynep Tufekci, New York Times, <https://www.nytimes.com/2022/12/15/opinion/chatgpt-education-ai-technology.html>

education community has to proactively tackle this issue so that the community can benefit from this tool and any potential downsides are mitigated through the development of clear guidelines on acceptable and non-acceptable use of such tools.

C. Contribution & Organization of This Paper

There have been a number of studies that have explored the use of artificial intelligence (AI) in education [15], including the use of chatbots [16] and other NLP tools [17]. ChatGPT, having been released recently, is a relatively new tool in this space and there is limited research on its specific application

in engineering education. There is an increasing trickle of publications exploring the potential use and abuse of ChatGPT for education [3], [4]. To the best of our knowledge, our work is one of the first works to explore the use of generative AI and ChatGPT techniques for engineering education. The rest of the paper is organized as follows. We take a peek into the future of education through an interesting technique in Section II. We focus on coming up with the right questions to tease useful information out of ChatGPT. The responses of ChatGPT are coherent and useful and therefore are presented as is. We provide our analysis and reflections in Section III. Finally, the paper is concluded in Section IV.

II. A GLIMPSE INTO THE FUTURE OF EDUCATION (Ask ChatGPT a Question!)

The style of this section is unusual as this has been written in partnership with ChatGPT. The questions posed below are provided by the author but the responses to the questions in each subsection are the unedited answers provided by ChatGPT (using the API at <https://openai.com/blog/chatgpt/>) to the question posed by the author. The response of ChatGPT is shown in gray color. The subsection epigraphs are also ChatGPT-generated using the prompt, “Give me an epigraph for a subsection titled (Subsection Heading Here)?”. ChatGPT December 15 2022 release version is used in this work. We note that the Chat-GPT-generated text is structurally, grammatically, and even semantically correct to a large extent.

A. AI for Intelligence Augmentation (IA)

“The ultimate goal of AI is not to create machines that are intelligent, but to create machines that make us more intelligent.”—Ray Kurzweil.

Question: *“How can students optimally use ChatGPT in their schooling for intelligent augmentation rather than for plagiarism?”*

ChatGPT: ChatGPT is an NLP model developed by OpenAI that is capable of generating human-like text. It is not intended to be used as a tool for plagiarism, but rather as a tool for intelligent augmentation.

Here are a few ways students can make optimally use ChatGPT in their schooling:

- 1) Writing assistance: ChatGPT can help students generate ideas and structure for their writing assignments. It can provide suggestions for how to organize an essay, generate possible topic sentences, or provide alternative ways to express an idea.
- 2) Language learning: ChatGPT can be used to help students practice their language skills. For example, students can input a sentence in their native language and have ChatGPT translate it into the target language.
- 3) Research assistance: ChatGPT can help students identify relevant sources and generate a list of potential research topics. It can also provide summaries of articles and

research papers, helping students to quickly understand the main points.

It's important to note that ChatGPT is a tool, and like any tool, it's important to use it responsibly. Students should not rely solely on ChatGPT or any other artificial intelligence (AI) tool to complete their assignments. Instead, they should use it as a supplement to their own research and writing efforts.

B. Asking the Right Questions

“The questions we ask shape the answers we get. Asking the right questions is the first step in finding the right answers”—Daniel Kahneman.

Question: *“In the era of ChatGPT, would asking good questions become a more important skill than answering questions?”*

ChatGPT: Asking good questions is an important skill in any era, and it becomes even more important in the era of ChatGPT and other artificial intelligence (AI) tools. These tools are designed to assist and augment human knowledge and understanding, but they are not intended to replace the critical thinking and problem-solving skills of humans.

Asking good questions allows us to clarify our understanding of a subject, identify gaps in our knowledge, and seek out new information. It helps us to think more deeply about a topic and to approach problems from different angles. In the era of ChatGPT and other AI tools, it may be tempting to rely on these tools to answer our questions for us. However, it's important to remember that these tools are only as good as the data and algorithms that they are based on. Asking good questions and engaging in critical thinking and problem-solving remains an essential skill for learning and growth.

C. ChatGPT Technology: Boon or Bain?

Question: *“What are the potential pitfalls in schools and education regarding the student use and abuse of ChatGPT?”*

ChatGPT: There are several potential pitfalls in schools and education regarding the student use and abuse of ChatGPT and other artificial intelligence (AI) tools:

- 1) Plagiarism: One potential pitfall is that students may use ChatGPT or other AI tools to generate text or ideas that they present as their own, leading to plagiarism. It's important for students to understand the importance of properly citing sources and to use these tools responsibly.
- 2) Overreliance: Another potential pitfall is that students may become overly reliant on ChatGPT or other AI tools, leading to a lack of critical thinking and problem-solving skills. It's important for students to use these tools as a supplement to their own efforts, rather than relying solely on them.
- 3) Misinformation: ChatGPT and other AI tools are only as good as the data and algorithms that they are based

on. If the data is inaccurate or the algorithms are flawed, the output of these tools may be misleading or incorrect. It's important for students to verify the accuracy of the information they receive from these tools and to use multiple sources when researching a topic.

- 4) Privacy concerns: Finally, there are privacy concerns surrounding the use of ChatGPT and other AI tools in schools. It's important for schools to have clear policies in place regarding the use of these tools and to ensure that student data is properly protected.

D. The Future of Education

Question: *"With tools like ChatGPT blooming, what is the right education for young learners in schools and colleges for responsible productive and effective usage?"*

ChatGPT: With the increasing prevalence of tools like ChatGPT, it is important for schools and colleges to provide education on responsible and productive use of technology to young learners. This can involve teaching students about the ethical considerations involved in using technology, such as avoiding plagiarism and properly citing sources. It can also involve teaching students how to use technology effectively and productively, such as learning how to use chatbots and language models to generate ideas and inspiration for their own original work.

In addition to providing education on responsible and effective use of technology, it is also important for schools and colleges to provide a well-rounded education that includes critical thinking skills, problem-solving skills, and the ability to communicate effectively. These skills will be important for students to use technology responsibly and effectively, as well as to succeed in their careers and personal lives.

Ultimately, the right education for young learners in schools and colleges will depend on the specific needs and goals of the students and the institution. It is important for educators to consider the role that technology can play in education, and to provide the necessary guidance and resources to ensure that students are able to use it responsibly and effectively.

E. How University Education Will Adapt?

Question: *"How will university education, particularly, teaching, and assessment, change as a result of the rise of generative and conversational AI tools such as GPT?"*

ChatGPT: The rise of generative and conversational artificial intelligence (AI) tools such as GPT (Generative Pre-training Transformer) is likely to have a significant impact on university education, particularly in terms of teaching and assessment. Some potential changes include:

- 1) Increased use of AI-assisted grading: AI tools such as GPT may be used to grade assignments and exams, allowing for more efficient and objective grading.
- 2) Personalized learning: AI tools may be used to tailor course content and assignments to the individual needs

and learning styles of students, leading to more personalized and effective learning experiences.

- 3) Increased use of online and distance learning: AI tools may enable universities to offer more online and distance learning options, making education more accessible to students who are unable to physically attend class.
- 4) Changes to the role of instructors: The increased use of AI tools may change the role of instructors, leading to a shift from traditional lecturing to more interactive and collaborative learning experiences. It's important to note that the impact of AI on university education will depend on how these tools are implemented and used. It's essential for universities to carefully consider the potential benefits and drawbacks of incorporating AI into their teaching and assessment practices.

F. On Detecting Plagiarism

"To steal ideas from one person is plagiarism. To steal from many is research." - Steven Wright.

Question: *"What is the difference between acceptable use of ChatGPT and plain plagiarism and how can someone distinguish between these?"*

ChatGPT: The difference between acceptable use of ChatGPT and plain plagiarism is that acceptable use involves using the tool as a means of generating ideas or inspiration for your own original work, while plagiarism involves copying and presenting someone else's work or ideas as your own without proper attribution.

To distinguish between these, it is important to understand the proper use of ChatGPT and to always give credit to the source of any ideas or content that you use in your work. If you are using ChatGPT to generate ideas or inspiration for your own original work, it is generally acceptable to do so as long as you properly cite the source and give credit to the model. However, if you are simply copying and pasting text generated by ChatGPT and presenting it as your own original work, this would be considered plagiarism.

To avoid committing plagiarism, it is important to understand and follow proper citation guidelines and to always give credit to the sources of any ideas or content that you use in your work. It is also a good idea to double-check your work using a plagiarism detection tool to ensure that you have properly cited all sources and that you are not presenting someone else's work as your own.

G. Fate of Traditional Curriculum and Assessment

Question: *"Will traditional home works become obsolete with ChatGPT? How will and should teachers adapt?"*

ChatGPT: It's unlikely that traditional homework assignments will become obsolete with the use of ChatGPT or other artificial intelligence (AI) tools. While these tools can be useful for generating ideas and assisting with research, they

are not intended to replace the critical thinking and problem-solving skills that are developed through traditional homework assignments.

Instead, teachers can use ChatGPT and other AI tools as a supplement to traditional homework assignments, helping students to generate ideas, structure their work, and improve their language skills. For example, a teacher could assign a traditional research paper, but allow students to use ChatGPT to generate ideas for their topic or to help them structure their essay.

It's important for teachers to understand the benefits and limitations of these tools and to use them in a responsible and thoughtful way. By doing so, they can help students make the most of these tools while also maintaining the value of traditional homework assignments.

H. New Skills for Teachers

Question: “*What becomes important for teachers as tools such as ChatGPT become readily accessible to students?*”

ChatGPT: As tools like ChatGPT and other artificial intelligence (AI) tools become more readily accessible to students, it's important for teachers to understand how to effectively incorporate these tools into their teaching practices. Some key considerations for teachers include:

- 1) Ensuring that students understand how to use these tools responsibly: It's important for teachers to educate students about the proper use of AI tools, including how to avoid plagiarism and how to verify the accuracy of the information generated by these tools.
- 2) Encouraging critical thinking and problem-solving: While AI tools can be useful for generating ideas and assisting with research, it's important for teachers to encourage students to engage in critical thinking and problem-solving. These skills are essential for learning and growth, and should not be replaced by reliance on AI tools.
- 3) Fostering creativity and innovation: AI tools can help students to generate new ideas and approaches to problems. Teachers should encourage students to use these tools as a way to stimulate their own creativity and innovation.
- 4) Incorporating AI tools into lesson plans: Teachers can incorporate AI tools into their lesson plans in a way that enhances the learning experience. For example, they could use AI tools to generate discussion prompts, provide personalized feedback, or create interactive learning materials.

By understanding the benefits and limitations of AI tools and incorporating them into their teaching practices in a responsible and thoughtful way, teachers can help students make the most of these tools and enhance their learning experiences.

I. Applications For Teachers and For Students

Question: “Can you talk about the uses of ChatGPT separately for teachers and for students?”

ChatGPT:

Certainly. ChatGPT, a variant of the GPT (Generative Pre-trained Transformer) language model, has the potential to be used in a number of different ways by both teachers and students in the education context. Here are some possible uses of ChatGPT for teachers and students:

For Teachers:

- 1) Facilitating personalized and adaptive learning experiences: ChatGPT can be used by teachers to create personalized and adaptive learning experiences for their students. For example, ChatGPT could be used to provide students with tailored feedback and recommendations based on their individual learning needs and progress.
- 2) Enhancing student engagement and retention: ChatGPT has the potential to increase student engagement and retention by providing students with engaging and interactive learning experiences. For example, ChatGPT could be used to create interactive quizzes or games that help students learn and practice important concepts.
- 3) Supporting student learning outside of traditional classroom hours: ChatGPT can be used to support student learning outside of traditional classroom hours, for example by providing students with on-demand access to educational resources and support.
- 4) Enhancing teacher efficiency: ChatGPT has the potential to enhance teacher efficiency by automating certain tasks, such as grading assignments or providing feedback to students.

For Students:

- 1) Enhancing learning and retention: ChatGPT can be used by students to enhance their learning and retention by providing them with personalized and adaptive learning experiences. For example, ChatGPT could be used to create interactive quizzes or games that help students learn and practice important concepts.
- 2) Providing on-demand access to educational resources and support: ChatGPT can be used by students to access educational resources and support on-demand, for example by answering questions or providing explanations on difficult concepts.
- 3) Enhancing communication with teachers: ChatGPT can be used by students to communicate with teachers and other students in real-time, for example by asking questions or seeking feedback on assignments.

Overall, ChatGPT has the potential to be a useful tool for both teachers and students in the education context, providing a range of benefits including personalized and adaptive learning experiences, increased student engagement and retention, and enhanced teacher efficiency.

J. ChatGPT-Created Comparison Table

Question: “Create a 5 x 3 grid format table to describe the high-impact applications of ChatGPT for engineering and computing education. Show the use cases in rows AND provide short text in two columns (educators/teachers and learners/students). The table should contain brief clarifying text.”

ChatGPT: ChatGPT provided a tabular output, which is exactly presented below as an image in Figure 3.

Use Case	Educators/Teachers	Learners/Students
Interactive lesson planning	ChatGPT can assist educators in planning and structuring interactive lessons by suggesting relevant content and activities. This can save time and help ensure that lessons are engaging and effective.	Students can use ChatGPT to ask questions and receive personalized help with their coursework, allowing them to progress at their own pace and learn more effectively.
Collaborative problem-solving	ChatGPT can facilitate group problem-solving sessions by suggesting questions and ideas for discussion. This can help students learn how to work together to solve complex problems and improve their critical thinking skills.	Students can use ChatGPT to collaborate with their peers and work together to solve problems and complete assignments. This can help them develop their teamwork and communication skills.
Personalized feedback	ChatGPT can provide personalized feedback to students based on their specific needs and goals. This can help students understand where they need to improve and how to achieve their academic goals.	Students can use ChatGPT to receive feedback on their work and track their progress over time, allowing them to identify areas for improvement and take steps to achieve their academic goals.
Virtual tutoring and mentorship	ChatGPT can assist educators in providing virtual tutoring and mentorship to students, allowing them to receive personalized support from anywhere. This can be particularly useful for students who are unable to access in-person support.	Students can use ChatGPT to receive virtual tutoring and mentorship, allowing them to get help with specific concepts or problems and receive guidance on their academic and career goals.
Adaptive learning and personalized content	Educators can use ChatGPT to create adaptive learning environments that adjust to each student's needs and preferences. This can help students learn more effectively and at their own pace.	Students can use ChatGPT to receive personalized content and recommendations based on their interests and learning style, allowing them to learn more effectively and efficiently.

Fig. 3: ChatGPT-generated table of ChatGPT applications in computing and engineering education.

III. REFLECTIONS AND MUSINGS

A. ChatGPT as a Virtual Intelligent Tutor

ChatGPT, or an NLP model like it, can potentially be used to provide a virtual intelligent tutoring service, in which a student can ask questions and receive personalized responses and feedback. This personalized feedback-enabled iterative learning leads to significant learning gains, as demonstrated by the “Two Sigma Effect,” which posits an average performance gain of two standard deviations over those who receive traditional instruction. This effect is often attributed to the ability of intelligent tutoring systems to provide quick and frequent feedback, allowing students to iteratively improve their understanding and skills. This approach aligns with the concept of mastery learning, in which students work at

their own pace, focusing on building a strong foundation of knowledge before moving on to more advanced material. Virtual tutors become especially useful when physical human teachers are inaccessible or scarce [18], [19]. In the literature, it has been reported that the failure to engage oneself in learning and the failure to realize that learning is a social activity are major learning impediments [20], [21]. ChatGPT can also be very useful for engaging the students due to its conversational style that simulates the feedback and social presence one could get from a human tutor. It’s important to note, however, that while a virtual intelligent tutoring system may be able to provide some assistance, it is not a replacement for a human instructor and may not be able to provide the same level of personalized support. Examples of virtual tutoring and personalized learning ChatGPT use scenarios are depicted in Figures 4, 5, and 6.

VIRTUAL TUTORING & PERSONALIZED LEARNING

JU My teacher asked me, "What is the maximum number of host addresses that can be assigned in a subnet with a subnet mask of 255.255.255.240?". My reply was 8 but my teacher said that this is wrong. Why is it wrong?

The maximum number of host addresses that can be assigned in a subnet with a subnet mask of 255.255.255.240 is not 8. The subnet mask 255.255.255.240 allows for 4 bits to be used for host addresses, and each bit can represent 2 values (0 or 1). Therefore, the total number of host addresses that can be assigned in this subnet is $2^4 = 16$.

It's important to note that the subnet mask is used to determine the number of host addresses that can be assigned in a subnet. The subnet mask consists of a series of 1s and 0s, and the number of 1s indicates the number of bits that are reserved for the network portion of the IP address. The number of 0s indicates the number of bits that are available for host addresses. By counting the number of 0s in the subnet mask and using the formula 2^n (where n is the number of 0s), you can determine the maximum number of host addresses that can be assigned in a subnet.

Fig. 4: Virtual Tutoring and Personalized Learning Oriented Applications of ChatGPT.

PRACTICE AND TEST PREPARATION

JU Make me a test with two MCQs on IP addressing, subnet masking, and VLSM.

Test on IP addressing, subnet masking, and VLSM

1. What is the maximum number of host addresses that can be assigned in a subnet with a subnet mask of 255.255.255.240?

A) 4
B) 8
C) 16
D) 32

2. What is the decimal equivalent of the binary subnet mask 11111111.11111111.11111111.10000000?

A) 128
B) 192
C) 224
D) 240

Fig. 5: Practice and Test Preparation Oriented Applications of ChatGPT.

LANGUAGE LEARNING, EDITING, AND WRITING

The screenshot shows a ChatGPT interface. The user asks ChatGPT to edit a sentence about automated thinking and writing tools. ChatGPT provides a revised version that is clearer and more concise. It also explains the changes made.

Edit the following for me: "An important consideration regarding the use of automated thinking and writing tools is that how will it impact the livelihoods of those who are in the business of writing." and provide feedback if it was good writing or if it contained any mistakes or issues.

Here is a revised version of the sentence:

"One important consideration when using automated thinking and writing tools is how they will affect the livelihoods of those who make their living as writers."

This revised version is clearer and more concise than the original sentence. I did not identify any mistakes or issues in the original sentence, but I made a few changes to improve its clarity and flow. Specifically, I replaced the phrase "regarding the use of" with the more concise "when using," and I rephrased the final part of the sentence to be more concise and to use more specific language. Overall, the revised sentence is a well-written and clear expression of the idea that the use of automated tools could have an impact on the livelihoods of writers.

Fig. 6: Language Learning Oriented Applications of ChatGPT.

B. Lack of Reliability & Hallucinative Misinformation

Since ChatGPT is a generative AI model, it is possible for ChatGPT to make up nonsensical or false information (misinformation). This can occur for a variety of reasons, including the limitations of the model, the quality of the data it was trained on, and the specific inputs and prompts provided by the user. For numerous queries we made, we noted factual errors with some incidents, books, articles, and people being made up or confused. ChatGPT provides the following disclaimer on their site prominently: may occasionally generate incorrect information; may occasionally produce harmful instructions or biased content. Sam Altman, CEO of OpenAI, the company behind ChatGPT summarizes in his tweet dated 11 Dec 22, “ChatGPT is incredibly limited, but good enough at some things to create a misleading impression of greatness. it’s a mistake to be relying on it for anything important right now. it’s a preview of progress; we have lots of work to do on robustness and truthfulness.”

A user must, therefore, be aware that due diligence must be exercised and the information reported by ChatGPT should not be automatically accepted. For instance, while working on the paper, the author asked ChatGPT, “I want to write an article titled, “Engineering Education in the Era of Generative AI and ChatGPT”. Which books and articles I should absolutely read?” ChatGPT gave a couple of pointers including an apparently made-up article by prominent MOOC and edtech proponent and AI scientist, Andrew Ng titled, “The Future of Learning: How Artificial Intelligence and Generative Models Will Shape Education”.³ Sensing a close match, the author tried very hard to locate the article online but without success. ChatGPT was again asked to provide full bibliographic details of this paper to which it replied uncannily with a non-functional URL. This looks like, to the best of our investiga-

³ ChatGPT response included the reference, “Ng, A. (2018). The Future of Learning: How Artificial Intelligence and Generative Models Will Shape Education. Retrieved from <https://www.forbes.com/sites/cognitiveworld/2018/07/16/the-future-of-learning-how-artificial-intelligence-and-generative-models-will-shape-education/?sh=3b3e3a6d65ab>” (this link is invalid and no such article exists on the Internet)

tion, a figment of the generative imagination of ChatGPT as such a paper was not available online. The link does however have a semblance of a valid URL (in Platonic words, the tool often offers “not truth but only the semblance of truth”). Sam Altman, CEO of OpenAI, confirmed that this phenomenon in the current version of ChatGPT is not uncommon in his tweet dated 12 December 2022 that “the danger is that it is confident and wrong a significant fraction of the time.”

It is also to be noted that ChatGPT does not always give you the same answer to a question consistently.⁴ The answer does depend on the context in a chat and in another chat the answer may be completely different. Thus, the framing of the question and the context of the ongoing discussion becomes very important.

C. Differentiating Between Acceptable and Non-Acceptable Use of ChatGPT

“The most important method of education ... always has consisted of that in which the pupil was urged to actual performance.”—Albert Einstein.

There is currently a lack of understanding about all the ways ChatGPT can be used in an education context and what would be perceived as acceptable and what might be considered cheating. While ChatGPT and other NLP models can be useful for inspiration and brainstorming, verbatim copying of text from these sources is not acceptable, as it does not add any value and may be considered deceptive or misleading. It is important for students to disclose their sources and resources, and failure to do so may be considered an academic offense. There are also concerns about the potential impact of ChatGPT and similar tools on the integrity of online exams and assignments [4]. As these tools become more widely available and sophisticated, there is a risk that they may be used to cheat on assessments. It is likely that the definition of plagiarism and the acceptable and non-acceptable use of these tools will evolve as they become more prevalent. Alternative methods of assessment, such as oral exams or projects, may become more popular as a way to mitigate these risks. Traditional assignments may be used more as exercises, with less emphasis on grading, while the real assessment may come in the form of actual performance

D. Importance of Existing Advantage and Prior Knowledge

As Kentaro Toyama notes in his book “Geek Heresy: Rescuing Social Change from the Cult of Technology,” the effectiveness of any resource or tool is limited by an individual’s existing knowledge and background [22]. Toyama terms this the “law of amplification” according to which technology amplifies existing human forces and intentions. A technology like ChatGPT is an exponential technology through which slight advantages can accelerate into colossal ones. This means that a person can only benefit from a resource to the extent that

⁴ Blog post by Logan Cochrane Is ChatGPT Manipulating You? (Or Are You Manipulating It?) <http://logancochrane.com/blog/is-chatgpt-manipulating-you-or-are-you-manipulating-it>

they are able to understand and use it effectively. In the case of ChatGPT and other NLP tools, this highlights the importance of having a strong foundation in relevant skills and knowledge, such as critical thinking, in order to be able to fully take advantage of these resources. For example, a person with a strong background in critical thinking will be better able to filter out inaccuracies and build upon the useful and helpful parts of the answers provided by ChatGPT.

E. Importance of Writing the Right Questions (& Prompts)

In the era of ChatGPT and other NLP models, it is more important than ever for individuals to be able to ask their own questions and seek out information and resources on their own. This requires the ability to think critically and to be resourceful, which involves using various tools and strategies to locate and evaluate information. The ability to ask one's own questions is a key component of critical thinking and can lead to deeper understanding and better retention of information as discussed by Dan Rothstein and Luz Santana in their book, "Make Just One Change: Teach Students to Ask Their Own Questions" [23]. The ones who can question well have a great advantage as getting answers is free and the quality of the answers depends on the quality of the questions. The same phenomenon also is applicable to tools such as DALL-E, where impressive outputs can be obtained through the right choice of prompt (a library of such art with associated prompts can be seen at <https://lexica.art/>). With the quality of the output depending greatly on the question and prompt, prompt engineering⁵ becomes an important science that can improve the effectiveness of the use of such tools. Text-to-text AI are also interesting in that "prompt chaining" could be used such that the output of the single run of the model can be fed back again to the model to execute multi-step reasoning. Such prompt chaining can allow LLMs to carry out much more sophisticated activities than otherwise possible. Numerous startups are working to build services based on prompt chaining.⁶

F. Classical Skills Will Not Become Outdated

Paradoxically, with advancing technology, classical human skills and liberal arts such as critical thinking, communication, and problem-solving become more rather than less important. These skills are essential for being able to effectively use and analyze information and technology, as well as for creating original and innovative solutions to complex problems. In today's world, it is more important than ever to be able to think critically and analyze arguments, spot errors and misinformation, and make fixes when necessary. This is especially true for engineers, who rely on a wide range of tools and techniques to solve complex problems and design innovative solutions. As the tools available to engineers become more sophisticated

and readily accessible, it becomes increasingly important to be able to identify the right tool for the right task and to use it effectively. This requires resourcefulness, which involves using various strategies to locate and evaluate information and resources, as well as the ability to think holistically and consider the big picture [19], [24].

G. "Steal Like An Artist": Value-Adding ChatGPT Use

Austin Kleon, a writer and artist, has written about the idea that all artists "steal" ideas from other sources as a natural part of the creative process. In his book "Steal Like an Artist," Kleon argues that it is not necessary or even possible to be completely original and that it is natural and beneficial for artists to draw inspiration from other sources and incorporate them into their own work [25]. However, it is important to understand that "stealing" in this context does not mean copying the work of others without giving credit or permission. Instead, it means using other sources as inspiration and incorporating those ideas into one's own work in a creative and original way, such as by adapting, mixing, or reinterpreting those ideas. Kleon distinguishes between good theft and bad theft. Good theft involves creating additional value by remixing, transforming, and extending the initial inspiration, while bad theft involves claiming credit without any justification or value creation.

H. Plagiarism Giveaways: Detecting Careless ChatGPT Use

We have already discussed the potential acceptable and non-acceptable use of a tool like ChatGPT. The emergence of ChatGPT, and similar tools, will enable a lot of mindless and careless use for plagiarism and for submitting assignments, homework, and even academic paper. This will probably initiate a Large Language Model (LLM) arms race between plagiarizers (and plagiarizing software) and consumers of the work (and plagiarism-detection software). Already, there are numerous automated writing tools available that is in wide use. Such tools often do leave a fingerprint that can be used to detect their use; even though such fingerprints may be partially or fully erased through subsequent editing. Similarly, plagiarism detection software is getting more sophisticated and there are automated tools that can use techniques such as looking for "tortured phrases" (a style that emerges from replacing valid words with their inappropriate and odd synonyms during paraphrasing) [26]. It is likely that ChatGPT will also leave a trace and a marketplace is emerging of detection tools.⁷. ChatGPT sometimes makes peculiar mistakes by confidently stating factoids that are incorrect or even made up; such peculiar mistakes could be a giveaway sign for detectors. It will be interesting to see how this field evolves as technology advances and community standards around acceptable and non-acceptable use become more established.

⁵Prompt engineering with OpenAI API <https://help.openai.com/en/articles/6654000-best-practices-for-prompt-engineering-with-openai-api>

⁶Rob Toews, The Biggest Opportunity In Generative AI Is Language, Not Images, <https://www.forbes.com/sites/robtoews/2022/11/06/the-biggest-opportunity-in-generative-ai-is-language-not-images>

⁷For example, <https://huggingface.co/openai-detector> and <https://writer.com/ai-content-detector/>

I. The Issue of Equitability

It is also important to think of ways we can ensure equitable access to such technology developed by AI research organizations and corporations [6]. Tufekci also makes the case that we should focus much more on equitability as the use of generative AI technology becomes more prevalent in education and society. This “rich gets richer and poor gets poorer” phenomenon was also seen during the COVID-19 crisis, where it was seen that the advanced more privileged students were able to benefit much more from educational technology compared to backward disadvantaged students. Justin Reich describes this as the EdTech Matthew Effect in his book, “Failure to disrupt: Why technology alone can’t transform education” [27]. The need for equitable access to advanced technology is especially important in engineering, a global field with an oversized economic imprint where innovation is vital and technology plays a huge role in the competitiveness of individuals, companies, and countries.

IV. CONCLUSIONS

ChatGPT and other AI language models have the potential to be helpful and convenient tools for engineering education, both for students and teachers. These models can generate human-like text, engage in conversation, answer questions, write essays, and solve homework tasks. Potential applications include language editing, virtual tutoring, language practice, generating and solving technical and non-technical questions, and research assistance. However, it is important to remember that ChatGPT and other AI language models are not perfect and may make mistakes or provide incorrect information. It is therefore important to use these tools with caution and to consider establishing community guidelines and standards for their fair use. The versatility of ChatGPT also raises questions about its acceptable and non-acceptable use, as it may be able to generate complete answers to assessments used to gauge human learning. It is clear that engineering education and the profession will eventually adopt such tools, and assessment strategies will have to evolve to prevent unethical conduct while still allowing for the productivity that can be achieved with these tools. It is also important to ensure equitable access to advanced technology and sufficient training and education, particularly for marginalized communities, to avoid exacerbating existing inequalities.

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