Examining Students' Beliefs on the Use of ChatGPT in Engineering

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Abstract

An Open Artificial Intelligence language model called Chat Generative Pre-Trained Transformer (ChatGPT) was developed by engineers. This kind of AI system produces text responses that resemble those of a human being in response to a variety of prompts and inquiries. A few benefits of ChatGPT are its round-the-clock assistance, prompt question answering, ability to locate research-related material, ability to write code, etc. Despite these benefits, ChatGPT may provide inaccurate or irrelevant results due to its limited contextual understanding of a given topic. Feedback that is unfair or erroneous may result from bias in the data that was used to train the program. Regrettably, ChatGPT may be susceptible to security flaws that could result in data breaches and the disclosure of students' private information.

In a parallel study, a survey instrument is designed and developed to assess engineering students' perceptions on the use of ChatGPT. This study aims at answering the following research question, 'How do students housed in engineering programs perceive the use of ChatGPT'? To answer this research question, a survey instrument was designed with a few open-ended questions, and the survey instrument also collected participants' demographic information. The open-ended questions included in the survey are (1) Describe the different words (as many as you can) that come to your mind when you think about ChatGPT? (2) How do you see ChatGPT evolving in the future and what impact do you think it will have on education? (3) What ethical considerations should be considered when using ChatGPT in an educational setting? and (4) Can ChatGPT promote critical thinking and problem-solving skills in students? Why?

The responses were coded using NVivo to examine the perceptions of engineering students using ChatGPT. A total of 269 responses were included in the analysis. The responses revealed diverse viewpoints on the future of ChatGPT in education, examining its potential impact on teaching and learning. While advancements are anticipated, ethical concerns like privacy, academic integrity and equitable access surfaced as significant issues. Opinions on ChatGPT's role in boosting critical thinking and problem-solving varied, with some optimistic about its potential and others wary of its limitations in fostering true intellectual growth. Overall, the findings highlight the intricate interplay between technological innovation, ethical considerations, and educational outcomes in the context of integrating AI in education.

Keywords: ChatGPT, concerns with ChatGPT, ethical considerations

Introduction

A language model called Chat Generative Pre-Trained Transformer (ChatGPT) was developed by engineers at Open Artificial Intelligence (OpenAI). This kind of artificial intelligence (AI) system produces text responses to a variety of prompts and queries that resemble those of a human. Through the use of a large dataset of text data to train an algorithm, ChatGPT was created using a technique known as machine learning (Azaria, 2022). The algorithm for ChatGPT was developed using text data that was gathered from books, articles, and other written language sources on the internet. The algorithm has been able to train and learn linguistic patterns and develop the capacity to produce responses that resemble those of a human thanks to this process, natural language processing (NLP), and deep learning (Jiao et al., 2023).

Originally, ChatGPT was intended for use by researchers, developers, and organizations creating services and apps that needed natural language processing (NLP) capabilities. According to George and George (2023), ChatGPT is a tool that anyone can use to communicate or find information in a natural language. It can do a lot of things, like make suggestions, respond to inquiries, write texts in response, and more. Because ChatGPT employs NLP and deep learning, the quality of responses will differ depending on the caliber of the data used to train the language model in the particular language in question (Shen et al., 2023). There are currently only a few languages available for OpenAI, including English, Spanish, French, German, Italian, Dutch, Japanese, Chinese, and Korean (Jiao et al., 2023).

ChatGPT has demonstrated its versatility in a multitude of educational and scholarly contexts. As is well known, one benefit of ChatGPT is that it offers students round-the-clock assistance and pertinent feedback to aid in understanding particular content (Al Afnan, 2023). Additionally, it can lessen workloads by automating some processes for teachers and students, like grading assignments and giving feedback to students (Baidoo-Anu & Owusu Ansah, 2023). ChatGPT can help academics and researchers find pertinent research papers, studies, and articles based on particular keywords and topics in addition to offering services to analyze large amounts of data to generate comprehensive responses not always apparent through conventional methods (Halaweh, 2023). Despite these benefits, ChatGPT may provide inaccurate or irrelevant results due to its limited contextual understanding of a given topic. Additionally, it may be biased due to the data that was supplied to train the program, which makes it easy for feedback to be perceived as unfair or erroneous (Borji, 2023). Regrettably, ChatGPT may lead to security risks that compromise data security and expose students' private information (Nair, Sadhukhan, & Mukhopadhyay, 2023). As with any other online resource, ChatGPT is becoming more and more popular, but relying too much on it may cause students' critical thinking and autonomous problem-solving abilities to suffer in an academic setting (Shen et al., 2023).

Everyone is talking about ChatGPT, and research on the subject is also picking up steam. Recently released research articles (George & George, 2023; Kung et al., 2023; Lund & Wang, 2023; Shenet al., 2023; van Dis et al., 2023) essentially describe the ChatGPT's workings, impact on academia, performance, and use in writing research-related work. This research study will examine ChatGPT's application in engineering from the viewpoint of the students.

Literature Review

Recent years have seen a surge in research on Chat Generative Pre-Trained Transformer (ChatGPT), which is indicative of the increased interest in natural language processing (NLP) and artificial intelligence (AI) technologies. Engineers at Open Artificial Intelligence (OpenAI) first created ChatGPT, and since then, it has attracted interest from a wide range of academic fields. Research has been done on its uses, drawbacks, and implications for different fields. The goal of this review of the literature is to investigate ChatGPT research, both generally and particularly in the engineering domain. In addition, it seeks to analyze and assess how students perceive this transformative tool by interpreting the approaches employed, especially the use of survey instruments.

Numerous studies have been conducted on ChatGPT, including examinations of its functionality, architecture, and social implications. The technical aspects of ChatGPT were frequently the focus of early research, which also mentioned the effectiveness of its language generation algorithms

and its underlying mechanisms. For example, ChatGPT's training data and model architecture were clarified by Azaria (2022), who offered insights into the machine learning procedures that support ChatGPT's operation. Further studies that went beyond technical details looked at ChatGPT's useful applications in a variety of fields. Research has demonstrated that it can enhance customer service, support content creation tasks, and facilitate human-computer interaction. In their study on ChatGPT's application in customer service environments, Kung et al. (2023) brought up clinical decision-making in particular and emphasized how it can improve user satisfaction and communication processes. In addition, studies looking into the social implications of ChatGPT have brought up ethical and sociocultural issues. Bias, fairness, and privacy concerns in ChatGPT-generated content have been examined closely by academics. To address algorithmic disparities and mitigate strategies to deal with such issues, Borji (2023) investigated the possibility of biases in ChatGPT responses.

ChatGPT has shown promise as a tool for improving learning outcomes and promoting open access to knowledge in the field of engineering education. Research has looked at how useful it is for helping students with their homework, offering support in real time, and automating some tasks. In a thorough examination of ChatGPT's educational uses, Lund and Wang (2023) found that it has the ability to help students with concept clarification and problem-solving. To improve student learning outcomes, the study investigated how crucial it is to incorporate ChatGPT into instructional strategies. Additionally, studies looking into how engineering students feel about ChatGPT are becoming more popular. Survey tools have been employed by researchers to assess students' opinions and worries about ChatGPT's incorporation into the classroom. To investigate students' experiences using ChatGPT in a range of coursework, AlAfnan (2023) created a survey-based methodology. Several factors were evaluated in the study, such as accessibility, value as a teaching tool, and privacy and dependability concerns. Comparably, Halaweh (2023) polled students to find out how they felt about ChatGPT's assistance with research questions and coding assignments in engineering courses. The research concentrated on the opinions that students had, both favorable and unfavorable, regarding ChatGPT.

To sum up, studies conducted on ChatGPT cover a wide range of subjects, from sociocultural ramifications to technical complexities. Survey-based research has made it possible to implement technological interventions in engineering education that are intended to improve learning outcomes by offering detailed insights into students' perceptions of the subject. Further investigation into ChatGPT's transformative potential and its implications for engineering education will become clearer as the field develops. This research study aims to create a survey instrument that encompasses aspects like the effectiveness of the learning tool, reliability, convenience of use, and issues with ChatGPT. The survey instrument is expected to provide significant insights into the viewpoints of students and contribute to the current discussion on the incorporation of artificial intelligence technologies in engineering education.

The study delves into the multifaceted perspectives surrounding the integration of ChatGPT, an advanced language model, in educational settings. As artificial intelligence becomes increasingly prevalent in education, understanding diverse viewpoints and potential implications is crucial. The investigation explores intersections of academic integrity, critical thinking, learning strategies, and the broader human impact on education, as articulated by respondents engaging with ChatGPT.

Methods

This study is a part of a larger study (Sajawal & Kittur, 2024). In summer 2023, the survey instrument was designed, developed, and administered. The instrument included three parts (1) Likert scale questions, (2) demographic questions, and (3) free response questions. Detailed description of the survey instrument can be found in (Sajawal & Kittur, 2024), and factors influencing engineering students' perceptions on using ChatGPT are explained in (Sajawal & Kittur, 2024). In this study, the focus is on analyzing the free response questions with an objective to investigate the research question, 'How do students housed in engineering programs perceive the use of ChatGPT?'

The participant responses to all the questions were coded in NVivo. Following the coding of each response, specific themes emerged, recurring throughout the dataset (Saldaña, 2021; Kittur & Tuti, 2024). These themes were meticulously categorized and, where applicable, merged to identify key patterns and trends within the data. The initial coding revealed themes related to academic integrity, critical thinking, learning strategies, and the broader human impact on education. Organizing and merging these themes facilitated the creation of a comprehensive understanding of various dimensions present in the responses. This approach streamlined analysis, offering a nuanced perspective on the interconnectedness of ideas. The resulting thematic framework serves as a foundation for further exploration and interpretation of the collected data.

Results

After cleaning the survey data, a total of 269 students' responses to the free response questions were considered for analysis. Table 1 provides the demographic information of the participants. More than 85 percent of the respondents were undergraduate engineering students and approximately 60 percent of the overall participants were male. The participants' self-reported race/ethnicity included White, Asian, Hispanic or LatinX, Black or African American, American Indian or Alaska Native, and Native Hawaiian or Other Pacific Islander. The respondents were from twelve different engineering majors.

Findings

In this section, we present the findings for each of the four questions. For every question, the analysis is presented with a brief description of themes and the participants' excerpts are also provided as evidence to support the explanation.

Q1. Describe the different words (as many as you can) that come to your mind when you think about ChatGPT?

The extensive responses received regarding words associated with ChatGPT indicate a broad spectrum of perceptions and opinions. The diverse range of responses showed varying experiences, expectations, and concerns relating to ChatGPT and its applications. Some responses have highlighted positive attributes, advocating for its ability to innovate, streamline tasks, and boost productivity, using words like "efficient", "useful", "helpful", and "versatile".

Table 1. Demographic information of the participants

Category	Undergraduate students		Graduate students	
	N	%	*N*	%
Total (*N*=269)	233	100	36	100
Gender				
Male	137	58.79	22	61.11
Female	79	33.91	12	33.33
Others	16	6.87	2	5.56
Race/Ethnicity				
White	158	67.81	18	50.0
Asian	44	18.88	14	38.89
Hispanic or LatinX	34	14.59	3	8.33
Black or African American	13	5.58	2	5.56
American Indian or Alaska Native	16	6.87	2	5.56
Native Hawaiian or Other Pacific Islander	2	0.86	-	-
Academic Department				
Computer Science	31	13.30	8	22.22
Mechanical Engineering	44	18.88	11	30.56
Electrical and Computer Engineering	22	9.44	2	5.56
Biomedical Engineering	49	21.03	8	33.22
Aeronautical Engineering	35	15.02	1	2.78
Civil Engineering	8	3.43	4	11.11
Industrial and Systems Engineering	6	2.58	2	5.56
Chemical Engineering	6	2.58	-	-
Aerospace Engineering	9	3.86	-	-
Environmental Engineering	15	6.44	-	-
Architectural Engineering	6	2.58	-	-
Engineering Physics	1	0.43	-	-
Engineering Undecided	1	0.43	-	-
Class Standing				
First year	59	25.32	18	50.0
Second year	72	30.90	6	16.67
Third year	50	21.46	4	11.11
Fourth year and beyond	52	22.32	8	22.22

Others, wary of potential limitations or ethical concerns, express apprehension with words like “biased”, “limited", "cheating”, “misleading”, “inaccurate information”, and “harmful”, reflecting apprehensions about potential limitations, biases, or ethical implications associated with AI language models like ChatGPT. These contrasting views highlight the complexity of the conversation surrounding ChatGPT, emphasizing the need for careful consideration of its capabilities, limitations, and ethical implications in different contexts. A visual representation of the participants’ perceptions is shown in Fig 1.

Fig 1. Visual representation of students' perceptions of ChatGPT

Q2. How do you see ChatGPT evolving in the future and what impact do you think it will have on education?

In analyzing the responses to this question, we employed NVIVO to auto-code the responses. Through this process, a diverse array of themes reflecting various perspectives on ChatGPT's future evolution and its potential educational impact. The question itself bifurcates into two distinct aspects: one regarding future developments and the other pertaining to its educational ramifications. To streamline our analysis, we initially auto coded the responses and then amalgamated common themes, deriving new overarching themes from their convergence. For instance, we consolidated model-related discussions into a broader category termed "model advancements." Similarly, we merged discussions about learning and skills into a unified theme denoted as "enhanced learning strategies." Moreover, we combined themes concerning tools and teaching methodologies to form the concept of "innovative teaching tools." Additionally, discussions about emerging systems and tools were merged to conceptualize "integration with emerging technologies." Lastly, the intersections of learning and models gave rise to the theme of "continuous learning and adaptation." All these themes represented the first half of Q2, i.e., evolution of ChatGPT in the future.

Similarly, we applied a similar approach to analyze the second half of Q2 i.e., impact of ChatGPT on education. Academic integrity themes were redefined as "improved academic integrity," while discussions on critical thinking were categorized as "critical thinking enhancements." Moreover, themes related to resources and learning were combined to form "resourceful learning approaches." Additionally, discussions on the human impact, impact themes, and education themes were merged to create the overarching theme of "human impact on education."

Through this thematic synthesis, we aimed to capture the multifaceted perspectives and insights shared by the participants. This methodological approach facilitated a more comprehensive understanding of the potential trajectories of ChatGPT's development and its implications for education.

A. Themes related to evolution of ChatGPT in the future

A1. Model Advancements

This theme focuses on the continuous improvement and sophistication of ChatGPT's underlying language model. Anticipating advancements in language understanding and response generation, it underscores the potential transformative impact on learning outcomes.

> *"ChatGPT, in its current state is merely a language model. That means that all it is fundamentally doing is judging the probability of the next word it types, based on a pretrained model. As time goes on, we will see it reach AGI, at which point it will in essence be able to act like a human and maybe even pass the turing test. It's odd because its impact is entirely dependent on how the academic community handles it! Those who embrace it will see universally higher scores as well as higher levels of understanding, however that is only if the said students use ChatGPT to learn and create solving strategies. Not to cheat."*

The user outlines the current functionality of ChatGPT as a language model and anticipates its future development towards AGI. The theme draws attention to the pivotal role of the academic community in determining the impact of ChatGPT on education. It underscores the potential for improved learning outcomes and understanding if students use ChatGPT as a tool for learning and developing problem-solving strategies rather than resorting to unethical practices such as cheating.

> *"I believe over time it will replace many jobs such as journalism, story writing, coding, and others that primarily use language to complete tasks. However, for engineering specifically, I see it as an important aid in helping to determine root cause analysis for complex system where NDI is required or to cut costs on proof of concepts by being able to simulate things more accurately. But this is still at least four to six years away from being even remotely reliable for engineering information. Currently it's really only good for basic tasks or writing code, which writing code for a project using ChatGPT does save a tremendous amount of time, freeing time that would other be spent painfully coding to be put into other important tasks."*

The user envisions a transformative effect on various job roles due to the advancement of ChatGPT. While expressing concerns about potential job displacement in areas like journalism and story writing, they identify engineering as a sector where ChatGPT could serve as a valuable aid. The theme highlights the dual perspective of job automation and the positive role ChatGPT might play in engineering tasks, acknowledging its current limitations but foreseeing future advancements in reliability.

A2. Enhanced Learning Strategies

This theme pertains to the impact of ChatGPT on learning strategies, envisioning a future where the tools play a role in enhancing personalized and effective learning approaches. It explores the potential for ChatGPT to provide tailored support and strategies for individualized learning experiences.

> *"ChatGPT is likely to evolve with improved contextual understanding, personalized learning, and enhanced multimodal capabilities. It may expand access to quality*

education, act as a teacher's assistant, aid language learning, support research, and raise ethical considerations when using in an academic setting."

The user discusses the potential evolution of ChatGPT, emphasizing key improvements such as better contextual understanding and multimodal capabilities. The theme projects a positive impact on education, envisioning ChatGPT as a versatile tool supporting various aspects of the learning process. The excerpt ends on an open note regarding ethical use, leaving the final thought to be delved into by the reader.

"ChatGPT has the potential to transform education by providing personalized, accessible, and interactive learning experiences. It can empower students, expand their access to knowledge, and support educators in facilitating engaging and effective instruction. Plagiarism-free and grammatically correct writing will completely change the student's mindset to analyze the literature, and it may also affect the education system."

The user envisions ChatGPT as a transformative force in education, emphasizing its ability to personalize learning experiences and support both students and educators. The theme underscores the potential impact on students' mindset, promoting analytical thinking and potentially influencing the broader education system.

A3. Innovative Teaching Tools

This theme focuses on the role of ChatGPT as a tool for educators, providing innovative resources for lesson planning, content creation, and instructional methods. It looks at how ChatGPT may contribute to redefining traditional teaching tools in the educational landscape.

"I see ChatGPT developing in to a new research standard similar to how Google has replaced books. As well as being a base line for further AI platforms. Likewise I think it will have a similar effect on education, with it being something looked down on at first but later excepted in specific spaces."

This quote suggests that the speaker envisions ChatGPT evolving into a standard tool for conducting research, comparable to how Google has replaced traditional books as a primary source of information. The idea is that ChatGPT could serve as a foundational element for future AI platforms. Additionally, the quote suggests that while there might be initial skepticism or resistance in educational settings, ChatGPT could eventually gain acceptance, finding its place in specific areas of education.

"I think it will be extremely beneficial to education in the long run because of it's uses in general guidance and teaching capabilities. In the short term it is ALSO being used as a crutch for poor writing skills and to save time from researching accurate data."

This quote expresses a nuanced perspective on ChatGPT's impact on education. The speaker acknowledges the potential long-term benefits of ChatGPT in providing general guidance and enhancing teaching capabilities. However, there is also a recognition of its short-term use as a crutch, particularly for individuals with poor writing skills, and as a time-saving tool for quickly accessing information. The quote implies that while there are positive aspects, there are concerns about its potential misuse or dependency in certain areas of education.

A4. Integration with Emerging Technologies

This theme explores the potential collaboration of ChatGPT with emerging technologies for autonomous tasks and much more. The aim is to make ChatGPT more versatile and interactive, catering to diverse learning styles and content formats.

> *"I think it will integrate with emerging technologies like Siri, and both might be used in conjunction with each other. It might serve as a building block to create more sophisticated AI. This integration could make ChatGPT more versatile and interactive, catering to diverse learning styles and content formats."*

This statement anticipates the integration of ChatGPT with emerging technologies like Siri, envisioning a collaborative relationship between the two. The speaker suggests that such integration could lead to the development of more sophisticated AI models. The emphasis is on versatility and interactivity, anticipating a future where ChatGPT becomes more adaptable to various learning styles and content formats through its collaboration with other technologies.

> *"I imagine AI will turn into a daily assistance of sorts like Siri but infinitely more useful. I think that AI will make humans useless in society as we know it and the role of education as we know it will change forever. This integration with emerging technologies could reshape the landscape of education and learning"*

This statement envisions AI, including ChatGPT, evolving into a daily assistant like Siri but with enhanced utility. The speaker suggests that AI could potentially render certain human roles obsolete, leading to a transformation in societal dynamics. The integration with emerging technologies, as implied, can bring about significant changes in education, hinting at a transformative shift in the way we perceive and engage with the educational process.

A5. Continuous Learning and Adaptation

This theme delves into the concept of ChatGPT as a dynamic system that continuously learns from the user interactions and adapts to evolving educational needs. It emphasizes the ongoing refinement of the model through continuous training and user feedback.

> *"As ChatGPT's data set continues to grow, its answers are becoming more and more accurate. At one point it will actually become a reliable source of information. And eventually it will be able to solve complex programming problems ready to run with minimal debugging. It will be even more tempting for students to use, but also most likely more regulated. The integration with emerging technologies will bring about new possibilities and applications."*

This statement emphasizes the continuous improvement in ChatGPT's accuracy as its dataset expands, foreseeing a future where it becomes a reliable source of information. The expectation is that the model's capabilities will extend to solving complex programming problems with minimal debugging required, potentially making it a valuable tool for technical tasks. However, the speaker also acknowledges the likelihood of increased regulation to address potential challenges associated with its use. Additionally, the mention of integration with emerging technologies hints at a broader impact on various applications beyond its current capabilities.

> *"Continuous learning and adaptation form the cornerstone of ChatGPT's educational prowess. As it dynamically responds to user interactions, the model undergoes constant*

refinement, ensuring its ability to meet evolving educational needs. This continuous improvement, driven by ongoing training and user feedback, positions ChatGPT as a dynamic and adaptive tool in the educational landscape."

This statement underscores the iterative learning process of ChatGPT, emphasizing its ability to adapt and improve continuously. The model's responsiveness to user interactions and the incorporation of ongoing training and feedback contribute to its dynamic nature. The speaker positions ChatGPT as a tool that evolves to meet the changing educational landscape, suggesting a commitment to staying relevant and effective in addressing diverse learning needs over time.

B. Themes Related to Impact of ChatGPT on Education

B1. Improved Academic Integrity

This theme addresses the impact of ChatGPT in fostering improved academic integrity. By providing reliable and plagiarism-free assistance, ChatGPT can contribute negatively to a learning environment that values and upholds ethical academic practices.

"I could see ChatGPT being used in school for an assignment but schools will need to consider this software in academic integrity policies. The use of ChatGPT in my opinion devalues institutions when students are using it to write code or essays etc."

The quote suggests that ChatGPT's potential use in schools for assignments comes with the caveat that academic integrity policies need to be carefully considered. The user expresses concern that widespread use of ChatGPT, particularly in tasks like coding or essay writing, could potentially devalue educational institutions. This implies a need for clear guidelines and ethical considerations surrounding the integration of AI tools like ChatGPT in educational settings.

"Within the realm of academic integrity, ChatGPT emerges as a double-edged sword. While it holds the potential to foster improved academic integrity by providing reliable and plagiarism-free assistance, there is a concern that its ease of use may contribute negatively to a learning environment that values and upholds ethical academic practices. Striking a balance becomes crucial in harnessing the benefits of assistance while maintaining the integrity of the learning process."

This quote highlights the dual nature of ChatGPT concerning academic integrity. On one hand, the tool is seen as having the potential to enhance academic integrity by offering reliable and plagiarism-free assistance. However, there is a concern raised about the ease of use and its potential negative impact on an academic environment that values ethical practices. The quote emphasizes the need to find a delicate balance that allows leveraging the benefits of assistance while preserving the integrity of the learning process.

B2. Critical Thinking Enhancements

This theme focuses on the positive influence of ChatGPT on enhancing critical thinking skills. While acknowledging the limitations of the model, it explores how ChatGPT can encourage users to think critically and engage in more profound problem-solving approaches.

"I think AI and ChatGPT is at a plateau at the moment. For the time being, I think that any writing assignments will dramatically improve due to its writing ability. This also depends on if AI writing detection will improve, because at the moment it is not fantastic."

The quote suggests a perspective on the current state of AI and ChatGPT, characterizing it as being at a plateau. The focus is on the perceived improvement in writing assignments attributed to the advanced writing capabilities of AI, particularly ChatGPT. The statement also highlights a contingent factor—improvements in AI writing detection technology. There's an acknowledgment that the effectiveness of AI in enhancing writing assignments may be influenced by the concurrent development of tools to detect AI-generated content.

> *"I think it will shift to become an academic tool that will help aid students in their studies and understanding of courses."*

The quote expresses a belief in the transformation of ChatGPT into an academic tool designed to assist students in their studies and comprehension of courses. This perspective suggests a positive outlook on the potential role of ChatGPT in education, emphasizing its capacity to support and enhance the learning experience for students.

B3. Resourceful Learning Approaches

This theme highlights how ChatGPT can positively impact learning strategies by providing resources and support. It emphasizes ChatGPT's role as a valuable tool for learners, offering assistance and ideas to enhance the overall learning experience.

> *"ChatGPT can assist students with homework, providing explanations, solving problems, and suggesting relevant study materials. It can complement traditional teaching methods and provide additional support outside the classroom."*

This quote emphasizes how ChatGPT can be a valuable resource in assisting students with homework. By providing explanations, solving problems, and suggesting study materials, ChatGPT complements traditional teaching methods and offers additional support beyond the classroom. This highlights the resourceful nature of ChatGPT in enhancing learning approaches and supporting students in their academic endeavors.

> *"AI can analyze educational data to provide insights into student performance, helping educators identify areas where students may be struggling and make data-informed decisions to improve teaching methods."*

It highlights how AI, including ChatGPT, can play a role in analyzing educational data to offer insights into student performance. By identifying areas where students may be struggling, educators can make informed decisions to enhance teaching methods. This underscores the potential of AI in providing data-driven insights to improve the overall educational experience.

B4. Human Impact on Education

Focusing on the broader societal impact, this theme explores how ChatGPT can assist teachers, serve as a valuable aid to academic study, and contribute to collaborative learning experiences.

> *"AI can assist teachers by automating administrative tasks, such as grading, freeing up more time for actual instruction and personalized student support."*

The quoted statement underscores the potential role of AI, including ChatGPT, in supporting educators by automating administrative tasks, particularly grading. By relieving teachers of these routine responsibilities, AI can contribute to a more efficient use of their time, allowing them to focus on core aspects of instruction and providing personalized support to students. The idea here

is that AI's automation capabilities can enhance the overall teaching experience, making it more effective and tailored to the needs of individual students.

> *"ChatGPT is a useful aide to academic study, but nothing more. It can become a great crutch for some students though."*

The provided quote touches upon the notion that ChatGPT serves as a valuable aid in academic study but emphasizes its limitations, stating that it is nothing more than a helpful tool. The concern raised is that, for some students, ChatGPT might become a crutch, implying a heavy reliance that could potentially hinder the development of independent academic skills. This viewpoint highlights the need for a balanced approach in utilizing ChatGPT as a supplementary resource without compromising the essential aspects of individual learning and critical thinking.

B5. Global Accessibility and Inclusivity

This theme addresses the potential of ChatGPT to positively impact global accessibility and inclusivity in education. By providing scalable and accessible learning tools, ChatGPT can contribute to breaking down geographical and socio-economic barriers to education.

> *"Global Education: ChatGPT can break down language barriers, making education materials and resources more accessible to students around the world. It can also help with cross-cultural understanding and collaboration."*

This quote highlights the potential of ChatGPT to contribute to global education by addressing language barriers and enhancing accessibility to educational materials. By breaking down language barriers, ChatGPT can make learning resources more readily available to students worldwide, regardless of their native language. Additionally, the mention of cross-cultural understanding and collaboration suggests that ChatGPT may play a role in fostering communication and cooperation among students from diverse cultural backgrounds. The collaborative learning experiences facilitated by ChatGPT can transcend linguistic differences, promoting a more inclusive and interconnected global educational landscape.

> *"AI can improve accessibility for students with disabilities. It can provide text-to-speech, speech-to-text, and other assistive technologies to accommodate different learning needs."*

This quote emphasizes the positive impact of AI, specifically ChatGPT, on improving accessibility for students with disabilities. It suggests that AI technologies can play a crucial role in creating a more inclusive educational environment by offering features like text-to-speech and speech-to-text capabilities. These assistive technologies cater to diverse learning needs, making educational resources more accessible and adaptable for students with varying abilities. The quote underscores the potential of AI, such as ChatGPT, to contribute to a more inclusive and accommodating educational experience for all students.

B6. Ethical Use and Responsible AI Practices

This theme underscores the importance of ethical use and responsible AI practices in the context of ChatGPT. It acknowledges the need for measures to ensure proper utilization of the tool, avoiding misuse and maintaining academic integrity.

> *"... However, it's important to note that the integration of AI in education also raises ethical and privacy concerns. Ensuring data security, addressing biases in AI, and*

maintaining a balance between technology and human interaction are challenges that need to be addressed as these technologies continue to evolve."

This quote highlights the ethical considerations associated with integrating AI, including ChatGPT, into education. It points out that while AI offers numerous benefits, there are significant ethical and privacy concerns that need careful attention. The mention of ensuring data security emphasizes the need to protect sensitive information from unauthorized access or misuse.

Addressing biases in AI underlines the importance of preventing any unfair or discriminatory outcomes in educational processes. Maintaining a balance between technology and human interaction emphasizes the need to avoid over-reliance on AI and preserve the essential human elements in education. In essence, the quote calls for a thoughtful and ethical approach to the integration of AI in education, considering the potential risks and challenges associated with privacy, bias, and the overall balance between technological advancements and human values.

"I believe that ChatGPT usage should be included in academic integrity codes to promote its usage in moderation, and have punishments for abuse of the program."

This quote suggests the inclusion of ChatGPT usage guidelines within academic integrity codes. The idea is to establish a framework that encourages the responsible and moderate use of ChatGPT while discouraging any form of abuse. Including ChatGPT in academic integrity codes signifies an acknowledgment of its role in the educational environment. By setting clear expectations and consequences for misuse, institutions aim to maintain the ethical standards and integrity of academic work. This approach recognizes the potential benefits of ChatGPT while emphasizing the importance of responsible utilization to avoid any negative impact on the learning process.

Q3. What ethical considerations should be considered when using ChatGPT in an educational setting?

A diverse array of themes reflecting various perspectives and concerns of ChatGPT's ethical implications in education were identified. These themes encompassed a wide range of topics, including ethical considerations in educational settings, plagiarism concerns in academic responses, and citation considerations. We initially auto-coded the responses and then amalgamated common themes, deriving new overarching themes from their convergence. For instance, we consolidated "ethical," "setting," and "considerations" into a broader category termed "Ethical Considerations in Educational Settings." Similarly, we merged discussions about "research," "knowledge," and "source" into a unified theme denoted as "Citation Considerations." Moreover, we combined themes concerning "assignments" and "plagiarism " to form the concept of "Plagiarism Concerns in Academic Responses."

1. Ethical Considerations in Educational Settings

This theme delves into the ethical considerations surrounding the utilization of ChatGPT within educational environments. It explores the responsible deployment of ChatGPT, ensuring that its integration aligns with ethical standards, maintains academic integrity, and addresses potential issues related to fairness, bias, and misuse.

"*Some ethical considerations that I can think of when using ChatGPT in an educational setting, is how ChatGPT gives you all your answers without looking for them. This can mean that if a student has access to an Internet resource, they will immediately use this*

tool to help them, solve all the problems, rather than looking through textbooks, books, or lectures and etc. Some other ethical considerations, would be that we need to locate ways that students can focus on learning traditionally, instead of using AI as we won't know who is being honest versus who is not."

The individual expresses concern about ChatGPT's capability to provide instant answers, leading to a potential shift away from traditional learning methods. The emphasis is on the need for educational strategies that encourage honesty and genuine learning experiences, highlighting the ethical challenges associated with AI tools in academic settings.

"*I think it depends on the class. If it is a writing-based class where an author's own voice is important, it could be a major ethical issue as it reduces student input to a major degree. If it is a math class or a coding class, it could be a great in between for understanding concepts, but it will be important to consider where the line is drawn between useful help and giving the answer.*"

The user introduces a discipline-dependent ethical dimension, highlighting concerns about the impact of ChatGPT on students' individual expression in writing classes. In contrast, it recognizes the potential value in technical subjects but emphasizes the need for a well-defined boundary between assistance and providing solutions to maintain ethical academic practices.

2. Plagiarism concerns in Academic Responses

This theme focuses on the challenges and concerns related to plagiarism in academic responses facilitated by ChatGPT. It delves into the need for clear guidelines and safeguards to prevent unintended plagiarism, emphasizing the importance of educating users on ethical writing practices.

"*It must be considered whether a student is using it to do thinking for them or using it to generate ideas. For idea generation, like as a brainstorming partner, use of ChatGPT may be acceptable, but any other use should probably be considered cheating. Of course, it may be difficult to distinguish between these uses from the perspective of a grader, so in general it is probably best not to use it.*"

The user raises a critical ethical concern, emphasizing the need to distinguish between acceptable and unacceptable uses of ChatGPT. The focus is on encouraging responsible use for idea generation while acknowledging the difficulty in evaluating students' intent, ultimately leading to a cautious stance on its integration into academic activities.

"*ChatGPT uses the work of tons of people that you aren't even aware of. When you write something with ChatGPT, it isn't you writing it--you use the text of the thousands of writers that ChatGPT used to train its algorithms. I would consider using ChatGPT akin to plagiarism.*"

The user sheds light on a crucial ethical dimension, questioning the authenticity of content generated with ChatGPT. By likening it to plagiarism, the user underscores the need for users to critically assess the originality and authorship of the text produced, prompting a thoughtful reflection on the ethical use of AI-generated content in academic contexts.

3. Citation Considerations

This theme centers on the importance of proper citation practices when utilizing ChatGPT in educational settings. It underscores the need for users to be mindful of crediting sources appropriately, acknowledging the AI's role in using sources, and maintaining academic integrity.

> *"ChatGPT is an AI program that analyses work from other people. Some ethical considerations that should be taken into account is how does one cite work if ChatGPT is used in an academic setting or work? Also, is it really your own work if you use AI as a foundation for any academic work?"*

The student delves into the complexities of citing AI-generated work, pointing out the need to establish proper citation practices. Additionally, the theme touches on the fundamental question of ownership, pondering whether work created with ChatGPT can truly be considered one's own. This emphasizes the ethical dilemmas associated with acknowledging AI contributions and maintaining academic integrity in the context of using AI as a foundational tool.

> *"It needs to be cited as a source, and the information that comes from it needs to be quoted. As it is now, Chat GPT does not create, it only consolidates. The sources it pulls information from also need to be cited, just like using Wikipedia to learn about a subject and citing the relevant sources in your own paper. If a student uses Chat GPT without citing it, and especially without citing the sources it pulls from, that should be treated exactly the same way as plagiarism. The only parts of a paper that don't need to be cited are your original thoughts and words. If you're not creating anything new, which you won't be if you're copying from Chat GPT, you should not get credit for it. It's not your thoughts. I do think it needs to be normalized for students to cite it without fear of punishment though, because if a teacher completely bans any use of it as a resource, it will just lead to plagiarism."*

The user highlights the necessity of citing ChatGPT as a source, drawing parallels with citing other references like Wikipedia. The theme underscores the user's perspective that, just like any external source, ChatGPT should be credited, and the information it provides needs to be quoted and attributed. It also raises a nuanced point about normalizing the citation of AI tools in academic settings to prevent potential plagiarism while using them as resources.

Q4. Can ChatGPT promote critical thinking and problem-solving skills in students? Why or why not?

The analysis of the responses to this question was done differently compared to the analysis of the responses of previous two questions. We leveraged NVivo to discern sentiments within the dataset. By conducting sentiment analysis, we were able to unveil a diverse array of attitudes and viewpoints regarding ChatGPT's ability to impact critical thinking and problem-solving skills among students. Essentially, we highlight the positive and negative sentiments associated with using ChatGPT to promote critical thinking and problem-solving skills. Table 1 provides excerpts from particpants' responses.

Positive sentiments stemmed from the belief that ChatGPT can serve as a valuable educational tool, providing students with access to vast amounts of information and diverse perspectives that can induce critical thinking. Some responses advocated to the argument of ChatGPT being used to catalyze analytical reasoning, exploration, inquiry, and research, thereby augmenting students'

ability to solve problems effectively. Conversely, negative sentiments mainly stemmed from skepticism about AI technologies being effective in promoting genuine critical thinking and problem-solving skills. Most criticism questioned ChatGPT's capacity to comprehend context, understand meaning, and being attuned to the depth and diversity of human thought.

Table 1. Positive and negative sentiments about ChatGPT

Positive Sentiments	**Negative Sentiments**
I am of the opinion that ChatGPT can definitely promote critical thinking and problem-solving in students if used wisely.	The unfortunate reality, however, is that many students will abuse this, and therefore rely on the generative model's output too heavily.
Used as a basis for ideas or research, it could trigger critical thinking skills.	For the students who just copy the output of ChatGPT, I think it will damper problem-solving skills.
If used properly, I believe ChatGPT could be a wonderful tool to help students formalize thoughts, brainstorm, or just generally begin on the problem at hand.	However, it can be used similarly in the opposite fashion, asking for only evidence to support the argument that the student wants.
I can see both sides of this question... for the students who are genuinely trying to learn, I think it will promote critical thinking and problem-solving skills immensely.	I think ChatGPT can hinder students' critical thinking and problem-solving skills. When ChatGPT is able to synthesize and analyze information on its own, the student does not necessarily need to do any work.
I believe ChatGPT promotes critical thinking by providing information and allowing us to become more informed to make decisions.	It may be more of a crutch than a step, as students will grow to rely on the software instead of interacting with their peers.

Discussion

This study encompasses four main findings that intersect with crucial aspects of artificial intelligence (AI) integration in engineering education contexts: Enhanced learning strategies, ethical use and responsible AI practices, plagiarism concerns in academic responses, and if ChatGPT has the potential to promote critical thinking and problem-solving skills among students. Each of these findings connects to existing literature on AI ethics, educational technology, and pedagogical approaches, highlighting the multifaceted nature of AI's impact on education.

Firstly, the discussion of ChatGPT's impact on learning strategies highlight its potential evolution with improved contextual understanding and multimodal capabilities, with it serving as a versatile tool supporting personalized and effective learning approaches. The exploration of using AI for enhanced learning strategies aligns with a growing body of research that underscores the potential of AI-driven technologies to personalize learning experiences and optimize instructional delivery (Adiguzel et al. 2023). Studies by Yu et al. (2022) and Bachiri et al. (2023) have demonstrated the efficacy of adaptive learning systems and intelligent tutoring programs in improving student engagement, retention, and academic achievement. By examining the effectiveness of AI-enhanced learning strategies, our findings could help contribute to the ongoing discourse on innovative approaches in the digital age.

The discussion on ethical use and responsible AI practices surrounding ChatGPT emphasizes the need for proper utilization, algorithmic bias, and maintaining academic integrity. It highlights the concerns regarding transparency, data security, and preserving the balance between technology

and human interaction. These concerns have also been extensively documented in the literature (Floridi et al., 2018; Jobin et al., 2019). The study's exploration of students' apprehensions regarding the ethical implications of AI resonates with existing research on the need for transparent, accountable, and socially responsible AI practices in academic contexts.

The discussion on plagiarism concerns academic responses by the usage of ChatGPT highlights the challenges of distinguishing between acceptable and unacceptable uses of the tool. Respondents expressed concerns about the potential for unintended plagiarism and the ethical implications of using AI-generated material. Our findings revealed a call for clear guidelines and safeguarding to promote responsible use and educate people on ethical writing practices, emphasizing the importance of critical assessment and originality in academic work. Literature on academic integrity and digital ethics is emphasized by addressing the importance of plagiarism, cheating, and unethical behavior promoted by AI technologies (Francke et al., 2019; Malik et al.,2023). By delving into the prevalence of plagiarism and exploring strategies for mitigating academic misconduct in AI-driven learning environments, our findings contribute to efforts to uphold academic integrity and ethical standards in education.

Responses on ChatGPT's impact on critical thinking and problem-solving skills reveal divergent views. While some see ChatGPT as a valuable tool for accessing diverse perspectives and fostering analytical reasoning, others responded with doubting the effectiveness due to limitations in contextual understanding and human thought diversity. The potential of ChatGPT and similar AI platforms affecting critical thinking and problem-solving skills among students in an area of increasing interest in educational research (Darwin et al., 2024). By engaging students in interactive dialogues, problem-solving tasks, and reflective exercises, ChatGPT can enhance cognitive engagement, foster metacognitive awareness, and stimulate higher order thinking processes (Spector et al., 2019). In the context of this study, examining these varied viewpoints on how ChatGPT impacts critical thinking and problem-solving skills enriches the ongoing debate about AI in education, ensuring the development of effective teaching and learning methods, as well as ethical considerations for future implementation.

In summary, this study encompasses a comprehensive exploration of key findings at the intersection of AI and engineering education, examining its potential to revolutionize how we learn. It delves deep into critical themes of pedagogical innovation, ethical considerations, academic integrity, and the potential of AI technologies affecting critical thinking and problem-solving among students. By addressing these critical issues, this research can shape policy, practice, and inform for the future of AI-driven learning environments.

Conclusions

This study is a part of a larger study aimed at understanding engineering students' perceptions on the use of ChatGPT in engineering. In this study, free response questions from 269 participants were analyzed using NVivo and the results are presented for each question. The responses revealed diverse viewpoints on the future of ChatGPT in education, examining its potential impact on teaching and learning. While advancements are anticipated, ethical concerns like privacy, academic integrity and equitable access surfaced as significant issues. Opinions on ChatGPT's role in boosting critical thinking and problem-solving varied, with some optimistic about its potential and others wary of its limitations in fostering true intellectual growth. Overall, the findings highlight

the intricate interplay between technological innovation, ethical considerations, and educational outcomes in the context of integrating AI in education.

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