Board 48: Perceptions of ChatGPT on Engineering Education: A 2022-2023 Exploratory Literature Review

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Abstract – This exploratory literature review delves into the perceptions and implications of ChatGPT within engineering education, based on publications from December 2022 to October 2023. It aims to uncover how this generative AI, known for its natural language processing prowess, influences pedagogical practices and learning outcomes in the engineering field. The research question addressed in this literature review is "What are the perceptions related to implications ChatGPT may have on the future of engineering education?". This question investigates the anticipated impacts of ChatGPT on the future of engineering education, extending to its potential applications, limitations, and broader educational implications.

The review adopts a exploratory approach, utilizing a qualitative methodology to sift through relevant literature, guided by keywords related to ChatGPT and engineering education. Key findings suggest that ChatGPT can significantly bolster constructivist learning by supporting problem-solving, hands-on learning, and experiential activities. The review also sheds light on how ChatGPT has been integrated into engineering education, assessing its effectiveness through various pedagogical frameworks and evaluation methodologies, including formative and summative assessments. The study also contemplates the ethical considerations and challenges associated with integrating ChatGPT into educational settings, particularly concerning academic integrity and the ethical use of AI. By juxtaposing different perspectives and methodologies, the review encapsulates a holistic view of ChatGPT's pedagogical potential and its limitations.

This exploratory literature review not only expands our understanding of the pedagogical implications of ChatGPT in engineering education, but also lays the groundwork for future research. It underscores the importance of leveraging the technological advances and benefits of AI in education, advocating a nuanced approach to integrating ChatGPT into the educational landscape. The results of this review hope to provide valuable insights into assessment methods, help educators evaluate the effectiveness of ChatGPT in engineering education, and pave the way for future research in this rapidly evolving field.

Introduction

Artificial Intelligence (AI) has been advancing swiftly, with one of its remarkable achievements being the development of ChatGPT by the company OpenAI. ChatGPT is a generative language model, a type of AI that has the capability to generate human-like text based on a given prompt or context. It works by analyzing large datasets of text and learning how to formulate responses and generate new content that is coherent and contextually relevant, based on the input it receives. Released on November 30, 2022, ChatGPT represents a significant advancement in Natural Language Processing (NLP). NLP is a specialized field in AI that focuses on enabling machines to understand, interpret, and even replicate human language in a way that is both meaningful and accurate [1]. This technology enables ChatGPT to perform a

variety of tasks, such as answering questions, writing essays, or even composing poetry, all by interpreting and responding to the prompts given by users.

In the context of engineering education, the adaptation to evolving technology and pedagogical methods is vital for keeping pace with the latest technological advancements and meeting the evolving needs and demands of the engineering industry and the present world. With the release of ChatGPT, many questions have arisen regarding the impact this technology could have on education. Its ability to perform complex tasks in the field of education, such as writing essays, summarizing and explaining content, giving effective feedback, among others, has generated mixed feelings among educators, as this AI model breakthrough seems to revolutionize the traditional education system [2][3].

The research question of this literature review is “What are the perceptions related to the implications ChatGPT may have on the future of engineering education?”. This exploratory review examines articles related to current research, opinions, and published literature on ChatGPT and the impact of these technologies on engineering education. Due to the scarcity of this particular topic, we have also integrated references related to ChatGPT and education in general. The existing literature was examined in a systematic way, searching multiple combinations of the keywords "ChatGPT / AI” and “engineering education / higher education / education", in academic databases, journals, and conference proceedings. The search was restricted to articles published from December 2022 to October 2023 and cited reference searching.

Implications of AI for Engineering Education

AI has been increasingly integrated into educational settings, with applications ranging from personalized tutoring to automating administrative tasks. Research has shown that AI can help improve learning outcomes, provide instant feedback, and enhance student engagement. Institutions and educators are exploring ways to harness the potential of AI to address these needs [4].

ChatGPT's conversational capabilities make it a promising tool for education. Some educational institutions and platforms have already started experimenting with ChatGPT as a virtual tutor or assistant [5]. It can provide students with on-demand explanations, answer questions, and even assist with problem-solving in various subjects, including engineering.

In addition to the applications of ChatGPT in education already mentioned, we find applications of ChatGPT specifically related to areas of engineering and computation, such as the capability for explaining complex concepts or subjects, creation of code, fixing errors in existing code, mathematical problem solving, the ideation and planning of laboratory experiences, among others [6]. On the other hand, the importance in engineering of creativity, critical thinking, and the ability to solve complex problems, presents an opportunity to maximize the potential of this tool and explore new ways to use it.

Impact on Assignments

The emergence of ChatGPT introduces several profound implications for engineering education, reshaping traditional teaching methods and prompting a reevaluation of assessment strategies. Traditional assignments that have always been done in engineering education, such as standardized tests and multi-answer exams, may begin to evolve into forms of assessment more aligned with experiential learning. Developing and focusing more on exercises and hands-on learning instances, such as labs, oral presentations, field trips with reports and discussions, and research with less emphasis on grading and more focus on relative performance. This shift toward exercise-centered learning is intended to foster more meaningful learning experiences, allowing students to engage deeply with the material [7].

Ethical Considerations

Regarding the implications related to the guidelines and ethical use of ChatGPT, there have also been multiple debates about whether its use is ethical or not. One of the major concerns has been the possibility of students using it dishonestly when submitting various types of assignments, creating negative consequences for their learning [6]. To avoid ambiguities in this regard, it is vital that each educational institution and faculty establish clear guidelines distinguishing acceptable and unacceptable use of ChatGPT in courses. This information should be included in the curriculum of all courses, not only with the goal of preventing ethical conflicts but also to reduce students' uncertainty on the matter. These guidelines ensure that the technology is used as an educational tool that supports learning rather than circumventing it. It is crucial to differentiate between scenarios where ChatGPT assistance is allowed and those where independent problem-solving without external support is expected [7]. On the other hand, students should be consciously educated about the implications and repercussions of what is considered plagiarism and its impact on their learning process, as this is one of the most effective ways to prevent plagiarism [8].

Pedagogical Considerations

To effectively utilize ChatGPT, students must have a foundational understanding of the subject matter. This prior knowledge is crucial for critically evaluating and contextualizing ChatGPT's responses, thereby enhancing their learning experience. This is particularly true in fields like engineering, where knowledge builds upon previous concepts, and critical thinking, along with the ability to apply and interpret results in various contexts, is vital. Educators should emphasize teaching students how to craft precise and relevant questions. The use of engineering prompts, in this regard, becomes increasingly significant [1]. Such skills are essential for obtaining accurate and beneficial responses from ChatGPT, enabling students to fully leverage the technology's capabilities.

Although ChatGPT offers access to vast information resources and could come to be seen as a replacement for certain skills, traditional human skills, such as critical thinking,

communication, and problem solving remain indispensable, even now more than ever. ChatGPT itself could even help to enhance them [9]. These skills enable students not only to analyze the information provided by ChatGPT but also to leverage it to develop innovative solutions to complex engineering problems.

Other Considerations

Beyond education, the integration of artificial intelligence, exemplified by ChatGPT, holds significant promise in engineering research. Analogous to the historical integration of calculators, AI can enhance the learning experiences of future engineers. Correctly leveraged, AI empowers engineers with powerful tools for research, design, and innovation [10]. The importance of integrating artificial intelligence into engineering research as was done with the calculator in its time, cannot be overstated. When used strategically, AI can not only enhances the learning of future engineers but also revolutionizes the field by facilitating unprecedented levels of innovation and efficiency

Ultimately, integrating ChatGPT into engineering education requires a thoughtful reevaluation of pedagogical approaches, assessment methods, and ethical considerations. It is also important to consider the necessary change of mentality of the institutions, faculty, and students to be able to use these tools to their full potential. Institutions must be able to adapt in time so as not to fall behind related to these technological advances.

By leveraging the strengths of this technology while preserving the integrity of teaching, institutions can prepare students to effectively navigate the dynamic and AI-augmented landscape of engineering. Moreover, as AI continues to shape the future of engineering, its responsible integration into engineering education will become increasingly important and necessary to keep pace with this ever-changing world. Strategies, such as banning the use of artificial intelligence for students who will inhabit a world in which this type of technology will be of significant importance, lacks sound reasoning [11].

Possible Applications on Engineering Education

ChatGPT and related generative AI offer significant advantages for advancing teaching and learning in engineering. These advantages include personalized tutoring through comprehensive explanations that are adaptable to different levels of understanding. In addition, ChatGPT's ability to accurately grade essays, reducing the workload of teachers, and its proficiency in language translation, making educational materials accessible in all languages, further underscore its potential. Interactive learning experiences facilitated by ChatGPT's conversational capabilities enhance language proficiency and learner support. Finally, ChatGPT can contribute to adaptive learning systems that adapt teaching methods based on learner progress, as demonstrated in the teaching of programming [3].

ChatGPT's role in tutoring and grading assessments is multifaceted and holds great potential in enhancing educational experiences. It can serve as a virtual intelligent tutoring service, offering students personalized responses and feedback, making it a valuable tool for language editing, language practice, solving technical and non-technical questions, and providing research assistance [1]. The high quality of theoretical answers generated by ChatGPT positions it as an effective personal tutor for students seeking study support [7]. While ChatGPT may occasionally falter in solving calculation questions, it excels in guiding students through the correct problem-solving steps, rendering its instructional capabilities highly dependable. Overall, ChatGPT's contributions to tutoring and assessment grading are marked by its adaptability and capacity to provide tailored support across various educational domains.

Educators can use ChatGPT-generated reports to provide constructive feedback to students, improving formative and summative assessments and pointing out areas where learners face challenges. AI-based grading systems can contribute to unbiased assessments and have proven effective in grading short answers in online learning environments, which could improve students' test scores. ChatGPT's advanced features enable educators to create innovative teaching techniques, build comprehensive lesson plans, and engage learners in dynamic classroom activities [3]. As AI technology evolves, its integration into education is expected to become even more sophisticated and effective, ultimately enhancing the learning experience and allowing teachers to focus on personalized training and tutoring, fostering the skills and capabilities needed for the future.

Challenges and Concerns

Despite its potential benefits, the integration of ChatGPT into engineering education raises challenges and concerns. Privacy and data security issues must be carefully considered, especially when dealing with sensitive student data [12]. There are also concerns about potential bias in the AI's responses and the risk of overreliance on technology, which may diminish the role of educators [13].

To maximize the benefits of ChatGPT in engineering education, pedagogical considerations are crucial. Educators should explore how to effectively integrate ChatGPT into their teaching strategies, emphasizing its role as a supplementary tool rather than a replacement for human interaction [14]. Furthermore, the development of students' critical thinking and problem-solving skills remains essential.

Future Trends and Recommendations

Looking ahead, the future of engineering education may see increased adoption of ChatGPT and similar AI technologies. Educators and institutions should invest in training and support for faculty to effectively leverage these tools [15]. Ethical guidelines and regulations should be established to ensure responsible AI use in education.

ChatGPT and AI technologies hold promise for the future of engineering education. They can provide valuable support to both students and educators, offering instant access to knowledge and personalized learning experiences. However, addressing challenges related to privacy, bias, and pedagogical considerations is crucial to ensure that these technologies are integrated responsibly and effectively.

The number of publications that have emerged throughout the year 2023 on different projects and research questions related to this technology has been truly astounding. The impact of this technology on different aspects of education and the educational system has also started to take more and more relevance, reevaluating capabilities, possible applications and ethical considerations, specifically applied to different educational contexts.

However, most of these publications are focusing more on the tool and its different aspects than on the change of mentality that people and organizations need to take advantage of emerging tools like this one. We need to begin questioning why things are still being done in the same way and how this disruption (one more of many others to come) can really help us to evidence the obsolescence and deficiencies of the current educational system and the need to adopt a mentality according to the changing times we are living as humanity. Special consideration should be given to researching methodologies to maximize the potential of these new tools to have a more meaningful learning and teaching process and how to help people in this technological transition.

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