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Revolutionizing Engineering Education: The Impact of AI Tools on Student Learning

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Exploring Student Perceptions: The Impact of AI Tools on Engineering Education

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Abstract

The rapid advancement of artificial intelligence (AI) has led to the integration of chatbots like ChatGPT or Chat AI into various sectors, including education. This study investigates the impact of many AI tools in engineering education, focusing on their potential to enhance learning outcomes and improve student engagement. The integration of AI tools has the potential to significantly impact student learning, bridging the gap between theoretical knowledge and practical application. This paper explores the impact of AI tools on student learning in engineering education, particularly in civil engineering. AI tools offer numerous benefits in engineering education, providing students with interactive and immersive learning experiences. These tools enable students to apply their theoretical knowledge in real-world scenarios, enhancing their understanding and problem-solving skills. A survey was distributed to engineering students in civil engineering courses to gather feedback on the effectiveness of using AI tools, allowing for continuous improvement and customization to meet individual student needs. Through the data collected from the student survey, educators can gain insights into the specific areas where AI tools have positively impacted student learning. This information can guide curriculum development, ensuring that the incorporation of AI tools aligns with the desired learning outcomes. Furthermore, the student survey will provide vital feedback on areas where improvements are needed, allowing educators to address any challenges the students face in utilizing AI tools effectively.

Introduction

Artificial intelligence (AI) has rapidly emerged as a transformative force across various sectors, and its potential impact on education, particularly engineering education, is gaining significant traction. This technology holds immense promise for enhancing learning experiences, personalizing instruction, and preparing students for the demands of the modern engineering workforce.

AI is a branch of computer science focused on replicating human intelligence in machines. This encompasses areas like visual perception, speech recognition, decision-making, learning, reasoning, and language translation. AI is increasingly embedded in various devices, from smartphones and smartwatches to automobiles, influencing how we interact with technology (Mukhamediev, et. al., 2022). AI-powered chatbots, such as ChatGPT, use Natural Language Processing to construe what users command and machine learning to convey accurate responses by familiarizing and grouping past interactions automatically. (Rodos, June 2020). Some examples of AI used daily include voice assistants like Siri and Alexa. AI also customizes the daily feeds when one uses social media accounts and assists in our everyday lives.

On November 30, 2022, the Chat Generative Pre-Trained Transformer (ChatGPT) occurred. ChatGPT is an extensive language model-based chatbot that OpenAI developed. Therefore, the use of chatbots is still considered new. They are already being utilized in education, providing students

with immediate access to information and support. Additionally, AI-powered tools can assist educators in tasks such as speech recognition for students with disabilities, improving lesson delivery, and providing feedback on student writing (Johri, 2020).

The introduction of AI in engineering education has the potential to revolutionize the learning process. Here are some keyways AI can be leveraged:

- **Enhanced Learning Experiences:** AI-powered applications can create interactive simulations and virtual environments that provide students with hands-on learning experiences. This allows them to apply theoretical knowledge in real-world scenarios, fostering a deeper understanding of engineering principles and problem-solving skills.
- **Personalized Learning:** AI algorithms can analyze individual student data, including strengths, weaknesses, and learning styles. This enables the creation of personalized learning paths and tailored course content, maximizing student engagement and improving learning outcomes.
- **Bridging the Gap Between Academia and Industry:** AI tools and technologies are becoming increasingly commonplace in engineering. Integrating AI into the curriculum equips students with the necessary skills and knowledge to thrive in this technology-driven environment. This includes understanding AI algorithms, data analysis, machine learning, and automation.

While AI offers significant benefits, concerns regarding job displacement due to automation remain. However, studies like the one conducted by MIT suggest that AI is unlikely to replace most jobs cost-effectively. MIT researchers "found only 23% of workers, measured in dollar wages, could be effectively supplanted. In other cases, because AI-assisted visual recognition is expensive to install and operate, humans did the job more economically." The study found that "the cost-benefit ratio of computer vision is most favorable in segments like retail, transportation, and warehousing," including for major retailers such as Walmart. MIT study finds that humans are cheaper than AI for most jobs.

Today, educators seek technology to improve teaching and learning. However, the rapid advancement in everyday technology is questionable if it can help in engineering education. Educators currently use AI-type services in their daily lives, such as voice assistance, grammar correcting tools, and live navigation tools. Educators today are exploring AI tools for capabilities in speech recognition for students with disabilities and multilingual learners, improving lessons and writing (U.S. Department of Education, May 2023).

Engineering education equips future engineers with the necessary skills and knowledge to address complex technological challenges. The introduction of AI took place in 1956. The use of AI in engineering education has gained significant attention in recent years. (Anyoha, 2017) One of the key advantages of incorporating AI into engineering education is the ability to enhance learning experiences. AI-powered applications can create interactive simulations and virtual environments that allow students to engage in hands-on learning experiences. It aids in developing theoretical knowledge and enables students to apply concepts in real-world scenarios. By experiencing different scenarios and challenges, students can better understand engineering principles and develop problem-solving skills.

Additionally, AI can provide personalized and adaptive learning experiences. Learning platforms powered by AI algorithms can analyze individual students' strengths, weaknesses, and learning styles. It enables the system to create customized learning paths and deliver content tailored to each student's needs. Personalized learning increases student engagement and improves learning

outcomes by focusing on areas where students may require additional support.

Moreover, integrating AI in engineering education can bridge the gap between academia and industry demands. AI-powered tools and technologies are becoming increasingly prevalent in engineering, and students must be well-prepared to leverage these advancements. By incorporating AI into the curriculum, educational institutions can ensure that students graduate with the necessary skills to excel in a technology-driven workplace. It includes knowledge of AI algorithms, data analysis, machine learning, and automation. The next step was to analyze the responses from all the students to understand how far ahead or behind they were in using AI tools in engineering education.

Methodology

This paper explores students' points of view regarding integrating AI in engineering education.
A questionnaire on the use of AI in engineering education was handed out to a sample of civil engineering and technology students from various classes. The survey included questions about their knowledge, frequency, benefits, challenges, and suggestions for future use of AI tools in engineering education.

The questionnaires were distributed to 107 junior and senior students in seven civil engineering courses during the fall semester of 2023. Half of the courses took the survey online, via Canvas Course, and the other half as a handout. The questionnaire was anonymous and was distributed to various civil engineering courses, such as Construction Management Materials, Transportation Operations, Planning and Scheduling, and Project Information Modeling. In addition, the students who took the questionnaires also had different concentrations in civil engineering and technology, such as structural engineering, construction management, environmental engineering, or transportation. This questionnaire was imperative to understand students' current perceptions and experiences in the field. It also shows how AI has impacted their academic studies.

This survey aimed to gather valuable insights regarding integrating AI in engineering education from students' perspectives. By understanding their attitudes, preferences, and challenges. The students' feedback from the survey can help educators and policymakers make informed decisions about implementing and improving AI technologies in the classroom.

The survey addressed the following ten questions:

1. Have you used AI-powered tools like ChatGPT for learning in your engineering studies?
2. How frequently do you use AI tools for academic purposes?
3. What advantages do you think AI tools offer in engineering education?
4. How has using AI tools influenced your understanding of engineering concepts and problem-solving skills?
5. Do you believe AI impacted your ability to grasp complex engineering topics?
6. Have you experienced personalized learning through AI tools? Please explain.
7. What challenges have you encountered while using AI tools for engineering education?
8. Do AI tools encourage active participation and critical thinking in your engineering studies?
9. What improvements or additional features would you like to see in AI tools for engineering education?
10. How do you envision the role of AI tools evolving in engineering education in the future?

The first two questions were multiple-choice. The rest of the questions were open-ended. It

allowed students to freely respond and give insight into what they thought about using AI in engineering education.

Findings and Discussion

Question 1
Students today use technology in engineering education. Some of these technologies are software programs, applications, and the Internet. Figure 1 shows the percentage of students who frequently use or do not use AI in academia. Surprisingly, the questionnaire results revealed that 70% of the students had not used AI-powered tools in their engineering studies. That finding came as a shock, knowing how tech-savvy students are regarding new applications.

Question 2
The survey's first question was consistent with how often the students used AI, as seen in Figure-1. Only 4% of the 134 students who participated in the survey said they use AI chatbots weekly to help them understand topics and problems. Most of them use it weekly, monthly, rarely, or never.

Question 3
While some students expressed unfamiliarity with AI tools in education, those who had some experience highlighted several perceived benefits:

- **Enhanced Learning Efficiency:** AI tools were seen as facilitating faster access to information, potentially reducing study time.
- **Improved Comprehension:** Students mentioned that AI could help explain complex topics more clearly, leading to better understanding.
- **Problem-Solving Support:** AI tools were perceived as valuable aids in problem-solving tasks.
- **Creative Inspiration:** Students appreciated the potential of AI to generate new ideas and enhance their creativity.
- **Content Creation Assistance:** AI tools were seen as helpful for drafting papers and other written content.
- **Verification and Reference:** Students valued the ability to use AI for checking their work and accessing additional reference materials.

However, students also acknowledged potential drawbacks associated with AI tools:

- **Over-reliance and Reduced Effort:** Concerns were raised about AI potentially fostering laziness and reducing the motivation for independent learning.
- **Accuracy and Reliability:** Students expressed the need to be cautious about the accuracy of information provided by AI tools and the importance of independent verification.
- **Safety Net Mentality:** While AI can be a valuable support system, students recognized the need to maintain critical thinking skills and not rely solely on AI for solutions.

Question 4

Among students who utilized AI tools in their studies, chatbots emerged as the most common application. Students reported using AI for:

- **Enhanced Topic Comprehension:** AI tools were perceived as helpful in understanding complex topics more effectively.
- **Improved Classroom Learning:** Students felt that AI could supplement and potentially enhance traditional classroom learning experiences.
- **Problem-Solving Support:** AI tools were seen as valuable aids in tackling challenging problems.
- **Writing Assistance:** Students appreciated the potential of AI to assist with writing tasks.

However, students also acknowledged limitations in the current capabilities of AI tools:

- **Limited Problem-Solving Scope:** Students felt that AI tools still require significant development to fully address their problem-solving needs in engineering.
- **Design Opportunities:** Students perceived limitations in AI's ability to provide comprehensive design support.
- **Project Feasibility Assessment:** Concerns were raised regarding the effectiveness of AI in accurately assessing the feasibility of engineering projects.
- **Limited Impact on Class Comprehension:** Only 22% of students reported that AI tools significantly influenced their understanding of engineering concepts taught in class. This suggests that traditional classroom lectures remain the primary source of knowledge acquisition for many students.

Question 5

Living up to their promise of convenience and accessibility, AI tools have demonstrably aided a significant portion of students. Around 60% of those who utilized them reported a positive impact on their understanding of complex engineering topics. This aligns with student feedback highlighting the benefits of AI tools in:

- **Verification and Confirmation:** Students appreciated the ability to check answers and equations, ensuring accuracy and solidifying their understanding.
- **Quick Access to Information:** AI tools facilitate rapid retrieval of information, potentially reducing time spent searching for explanations.
- **Enhanced Comprehension:** Students felt that AI tools provided clearer explanations of complex concepts, leading to a deeper grasp of the material.

Questions 6

Personalized learning, which tailors instruction to individual student strengths, skills, needs, and interests, holds immense potential in education (Morin, 2023). However, only 30% of students who utilized AI tools in their engineering studies reported experiencing personalized learning benefits.

While some students appreciated the ability to get specific questions answered and clarify challenging concepts, others felt that AI tools primarily provided generic information rather than personalized learning experiences. This suggests a gap between the potential of AI for personalized learning and its current implementation in engineering education.

Question 7

While technology may offer benefits, students using AI tools in engineering education have encountered several challenges:

- **Limited Problem-Solving Capabilities:** Students identified that AI tools currently fall short in handling complex mathematical and physics problems effectively.
- **Data Accuracy Concerns:** Concerns were raised regarding the potential for outdated or inaccurate data within AI tools, leading to unreliable results.
- **Query Formulation Difficulty:** Students highlighted the challenge of formulating precise questions to obtain accurate and relevant responses from AI tools.
- **Limited Equation Handling:** Students noted limitations in the ability of AI tools to differentiate variables within equations specific to engineering problems.
- **Discrepancy in Problem-Solving Methods:** Students observed that AI tools often utilize different problem-solving methods compared to traditional engineering approaches, requiring them to specify the desired method for accurate solutions.
- **Graphical Representation Limitations:** Students encountered difficulties in generating specific types of graphs using AI tools.
- **Lack of Visual Aids:** The absence of visual aids in some AI responses was identified as a hindrance to understanding complex concepts.

Question 8

While most students may not yet perceive AI tools as promoting active participation and critical thinking, around 25% reported positive experiences in this regard. Students mentioned that AI tools:

- **Stimulate Creative Problem-Solving:** AI tools can encourage students to think outside the box and explore alternative approaches to solving problems.
- **Enhanced Topic Comprehension:** AI-powered explanations can lead to a deeper understanding of complex topics, potentially increasing confidence in-class participation.

This suggests that AI tools have the potential to foster a more active and critical learning environment for engineering students, although further exploration and development are needed to maximize their impact in this area.

Question 9

While the novelty of AI tools in engineering education may limit widespread student experience, those who have used them expressed a strong desire for further development and integration. Their suggestions for improvement and additional features fall into several key categories:

Integration and Accessibility:
- **Classroom Integration:** Students envision seamless integration of AI tools within the classroom environment, potentially for interactive learning experiences.
- **Information Access:** Features like access to AI-powered educational videos or resources were seen as valuable additions.

Problem-Solving and Engineering-Specific Functions:
- **Complex Problem-Solving:** Students emphasized the need for AI tools to tackle more intricate mathematical and physics problems effectively.
- **Engineering-Specific Functionality:** Features tailored to specific engineering disciplines and applications were highly desired.
- **Lab Research Assistance:** Students envision AI tools playing a supportive role in laboratory research activities.

Visualizations and Explanations:
- **Visual Answers:** The ability to generate visual representations of solutions and concepts was highlighted as a critical improvement.
- **Explanatory Capabilities:** Students expressed a need for AI tools to provide clear and comprehensive explanations of complex design concepts and problems.

Additional Features:
- **Exam and Report Support:** Exploring the potential use of AI tools for exam preparation and report generation was mentioned.
- **Design Opportunities:** Students envision AI tools offering design capabilities similar to existing software like AutoCAD and Revit.
- **Enhanced Input Options:** Expanding input methods beyond text-based queries was seen as beneficial.

Question 10

Recognizing the rapid advancements in technology, instructors sought student perspectives on how AI tools might evolve within engineering education. The student responses echoed some of their previous desires and highlighted the following potential future applications:

Enhanced Problem-Solving and Efficiency:
- **Advanced Calculations:** Students envision AI tools capable of handling complex mathematical and physics problems with greater accuracy and speed.
- **Information Access:** Easier access to relevant information through AI-powered videos and resources was seen as a valuable future addition.
- **Software Integration:** The integration of AI tools within existing engineering software like AutoCAD and Revit was identified as a potential game-changer.

Creative Exploration and Design:
- **3D Modeling and Visualization:** Students see AI playing a significant role in generating 3D models and visualizations, enhancing design capabilities.
- **Idea Generation and Optimization:** AI-powered tools that assist with brainstorming and optimizing design solutions were highly anticipated.

Streamlined Processes and Project Management:
- **Report Writing and Scheduling:** Students envision AI tools streamlining report writing and project scheduling tasks, freeing up time for more analytical work.
- **Construction and Operation Optimization:** AI-driven tools that optimize construction processes and improve operational efficiency in engineering projects were mentioned.

Additional Insights:
- **Job Displacement Concerns:** Some students expressed concerns about AI potentially taking over specific engineering jobs in the future.
- **Critical Thinking and Human Expertise:** While acknowledging the potential of AI, students emphasized the continued importance of critical thinking and human expertise in engineering education.

The student survey provided valuable insights into the potential and challenges of integrating AI tools within engineering education. Here's a summary of the key findings:

Benefits and Drawbacks:
- **Advantages:** Students highlighted benefits like faster access to information, improved problem-solving support, enhanced comprehension of complex topics, and assistance with writing tasks.
- **Disadvantages:** Concerns were raised about limited accuracy and potential for over-reliance on AI, leading to reduced critical thinking and verification skills.

Areas for Improvement:
- **Advanced Capabilities:** Students expressed a desire for AI tools that can handle more complex problems, offer engineering-specific functionalities, and provide visual aids for better understanding.

- **Integration and Features:** Seamless integration within classroom settings, access to AI-powered educational resources, and features like report writing assistance were highly sought after.

Future Vision:

Students envision AI tools evolving to:

- **Enhance Problem-Solving:** Performing complex calculations, optimizing designs, and tackling challenging engineering situations.
- **Streamline Processes:** Automating report writing, scheduling tasks, and optimizing construction and operational processes.
- **Foster Creativity and Design:** Generating 3D models, assisting with idea generation, and providing design support.

Alignment with "Five Touchpoints":

The survey findings resonate with the "five touchpoints" framework proposed by Baron (2023) for evaluating the role of AI in education:

1. **Trust:** Students acknowledged the need for critical verification and awareness of potential inaccuracies in AI-generated information.
2. **Effort:** While AI tools can provide outlines and initial ideas, students recognized the importance of independent writing and avoiding overreliance.
3. **Writing Skills:** The potential for AI to improve writing skills through idea generation, outlining, and reducing writing blocks was recognized.
4. **Writing Voice:** Students emphasized maintaining their writing style while leveraging AI for assistance.
5. **Commitment:** The importance of personal engagement and critical thinking in academic work was highlighted.

Recommendations for Improved Integration:

- **Enhanced Resources and Training:** Providing students with resources and training opportunities to effectively utilize AI tools in engineering education.
- **Critical Thinking and Verification:** Emphasizing the importance of independent verification and critical thinking alongside AI-generated information.
- **Ethical Considerations:** Raising awareness about potential biases and the evolving nature of AI, promoting responsible use. Developing new frameworks for plagiarism of one's creative work is essential. (Unesco, 2023)

By addressing these areas, educators can leverage AI tools effectively to enhance the learning experience for future engineers while fostering critical thinking skills and ethical considerations.

Conclusion and Future Research

In conclusion, this paper highlights the significance of integrating AI tools in engineering education. It emphasizes the importance of providing adequate training and technical support to instructors while addressing concerns regarding the ethical implications of AI in education. The findings from the case study suggest that AI tools have the potential to revolutionize engineering education and equip students with the skills necessary for future technological advancements.

In conclusion, this survey aimed to shed light on the perspectives and experiences of engineering students regarding the use of AI in their education. By understanding the potential impacts, benefits, challenges, and expectations, one can strive toward a more effective integration of AI in engineering curricula. The survey showed that 60% of the students who took the survey do not use AI tools in their learning. The questionnaire showed that most of the students still do not feel that AI tools, such as Chat GPT, are beneficial for now. They feel that in the future, AI tools will

become better than what they are now. The insights gained from this survey will contribute to the ongoing discourse on AI in education. It will also help shape the future of engineering education, providing students with the necessary knowledge and skills to thrive in a rapidly evolving technological landscape. Lastly, it will help educators understand how AI helps students in their education.
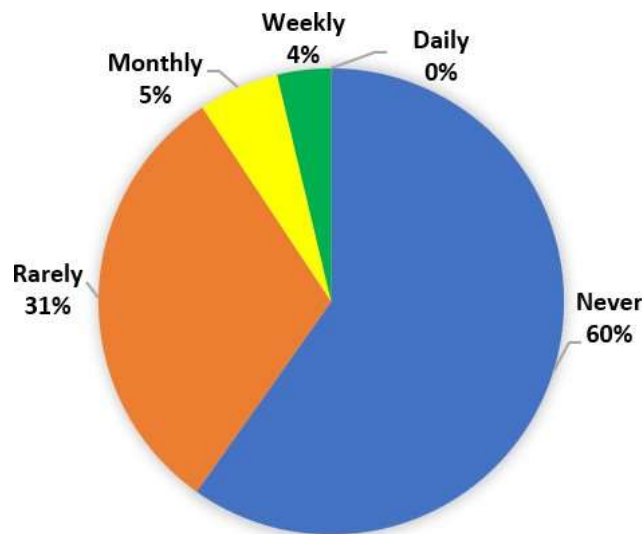

Figure 1: Frequent Use of AI Tools in Academia

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