The Future of Learning: Harnessing Generative AI for Enhanced Engineering Technology Education

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Abstract:

Integrating Generative AI into engineering education can be a valuable way to prepare students for the future and equip them with skills relevant to emerging technologies. This study explores how Generative AI can revolutionize the traditional pedagogical approach by enabling the development of interactive lab experiences, simulations, and practical exercises to integrate and create a greater understanding of AI capabilities. These innovations create authentic learning environments, equipping students with hands-on experience and honing their problem-solving skills.

This study also scrutinizes the ethical implications and challenges tied to the incorporation of Generative AI in education. It emphasizes the need for unbiased AI algorithms and responsible usage while calling for comprehensive training and support for instructors in harnessing this innovative technology.

In conclusion, this study intends to demonstrate that harnessing Generative AI in engineering technology education has the potential to revolutionize the way students learn in addition to preparing students to leverage these technologies for innovative engineering solutions and equip them with valuable skills that are increasingly in demand in various engineering domains.

Introduction:

Engineering and Engineering Technology education stand at the precipice of a profound transformation driven by the integration of generative Artificial Intelligence (Generative AI) [1]. Incorporating generative AI into engineering technology education can enhance the learning experience, foster creativity and prepare students for the increasingly AI-driven field of engineering. It allows students to focus on problem-solving, innovation and the application of engineering principles, while AI handles routine tasks and provides valuable insights and guidance [2]. However, its crucial to strike a balance and ensure that students also develop a deep understanding of the fundamental concepts and skills that underlie the technology they are using. This paper attempts to provide an overview of an ongoing study that explores the transformative potential and application of Generative AI in engineering technology education in order to enhance student writing outcomes.

Background:

Generative AI refers to a class of artificial intelligence algorithms and models that are designed to generate new, original content. Dating back to the mid-20th century, Generative AI models have increased in complexity over several decades of development, reaching a level of sophistication that can be difficult to distinguish from human generated content. Unlike traditional AI systems that rely on explicit programming and rules, generative AI leverages machine learning techniques to generate text, images or other media by using generative models

that analyze large sets of data. These large sets of data, frequently drawn from online content, are examined for patterns and common structures that are then used to generate new data with similar characteristics. One key aspect of generative AI is its ability to create unique content that was not explicitly programmed into the system.

In 2017, Siemens applied generative design tools to optimize the shape of gas turbine blades and achieved a 10% increase in turbine efficiency, resulting in reduced fuel consumption and carbon emissions. The use of generative design for complex and high-performance components has become increasingly common in industry and emphasizes the importance of enhancing AI knowledge in the education of engineering technologists.

The objective of this paper is to demonstrate that harnessing Generative AI in engineering technology education has the potential to revolutionize the way students learn in addition to preparing students to leverage these technologies for innovative engineering solutions and equip them with valuable skills that are increasingly in demand in various engineering domains.

Challenges:

Engineering Technology students often face several unique challenges when writing academic papers. First, the highly technical nature of their subjects requires precise language and the ability to convey complex concepts clearly and succinctly, which can be daunting for those who may not have a strong background in technical writing. Additionally, balancing the rigorous demands of mathematical and scientific content with the need for coherent, well-structured prose can pose a significant hurdle. Many students struggle with integrating quantitative data and qualitative analysis in a way that is both analytically sound and accessible to readers unfamiliar with the topic.

Furthermore, the concept of neurodiversity introduces a spectrum of cognitive styles that can significantly influence a student's writing abilities. Conditions such as dyslexia, dysgraphia, dyspraxia, attention deficit hyperactivity disorder (ADHD), and challenges related to executive functioning are among the factors that can create substantial barriers for students. These barriers are particularly pronounced in students with average to above-average intelligence, where there exists a stark contrast between their understanding of complex technical material and their ability to articulate this knowledge through writing. These challenges often result in written assignments that fail to truly represent the student's level of comprehension and analytical abilities, thereby not reflecting their true potential or depth of understanding. Recognizing and addressing the diverse needs of neurodiverse students is crucial in creating supportive educational environments.

Lastly, the issue of English language proficiency stands as a significant barrier for international students, often hindering their ability to articulate complex technical concepts and ideas effectively in writing. This challenge is not merely about grappling with the intricacies of a second language but also about engaging deeply with technical jargon and the precise expression required in engineering disciplines. For these students, the task of navigating through dense technical material, synthesizing information, and then presenting it in a coherent and academically rigorous manner can be daunting. Effective writing, in this context, becomes

crucial, not just as a means of academic assessment but as a vital tool for future professional success. This balanced approach to learning advocates for a comprehensive educational experience, where technical acumen and communicative prowess are equally prioritized, thereby enabling students to convey complex technical ideas with clarity and confidence.

Ethical Considerations:

The integration of generative artificial intelligence (AI) in engineering technology education raises several ethical considerations that necessitate careful examination [3]. One primary concern lies in transparency and accountability. As students utilize generative AI tools, it becomes crucial to understand the underlying algorithms and mechanisms driving these systems. Lack of transparency may result in unintended biases or reliance on flawed models, potentially compromising educational integrity. Figure 1 shows a few critical challenges we currently face in promoting generative AI in education.

Another ethical consideration is the potential for plagiarism. Generative AI tools can generate content with remarkable fluency, and if not used ethically, students may be tempted to pass off machine-generated work as their own. This challenges the fundamental principles of academic honesty and intellectual property.

Addressing these ethical implications requires a thoughtful approach, involving clear guidelines, comprehensive education on responsible AI use, and ongoing dialogue between educators, students, and policymakers. As generative AI continues to evolve, a proactive ethical framework is essential to ensure that its integration in engineering technology education aligns with principles of fairness, transparency, and equity.

Figure 1: Critical challenges of incorporating Generative AI in Education.

Methodology:

The study used in this article is conducted in the "Introduction to Engineering and Engineering Technology" course. Generative AI techniques were strategically employed to explore opportunities to enhance both the depth and quality of student work. By leveraging generative AI tools, students will be able to significantly and quickly supplement their research efforts. The method of implementing research problems in course work has previously been proven to enhance student learning and immersive experience for students [4]. These tools not only have the potential to aid in data analysis and interpretation but also contribute to the creative aspects of writing in order to improve student outcomes.

Specifically, the project goal was to instruct the students in the use of generative AI applications to streamline the synthesis of complex information, allowing for a more comprehensive exploration of the topic. The technology's ability to generate coherent and contextually relevant content proved invaluable in articulating student developed concepts with precision. Moreover, generative AI assisted in brainstorming innovative perspectives, contributing to a richer narrative and a more nuanced understanding of the subject matter. Integrating generative AI into the research process not only expedites information synthesis but also empowers students to elevate the overall quality of their papers by fostering a synthesis of human creativity and machine-assisted efficiency.

The assignment was described as thus:

> "Through the course of our lives, we have already been witnesses to innovations being developed that have had a major impact on how we live. You are going to research and evaluate one (1) technological innovation that has been developed or become popular within your lifetime and discuss it in terms of the positive and negative impacts on society. You will use Microsoft Word to create a written report detailing your chosen innovation."

The goal of the assignment aims to leverage generative AI tools to facilitate the research, analysis, and generation of content related to the chosen innovation. Students were guided in their research with a specific sequence of processes designed to ensure a structured approach to writing and ensure a proper appreciation for the ethical use of those tools. Each step of the sequence was followed by an assignment of student reflection upon the process to guarantee student understanding of the acceptable use of generative AI.

Title: Generative AI Exploration: Innovation Within Your Lifetime

Objective: To use Generative AI tools in the research, ideation, and writing process for a paper focusing on an innovation that has occurred within your lifetime.

Submission Guidelines:
Submit a well-structured paper following the provided instructions.
Papers must be written in Times New Roman 12 point font.
Papers must be DOUBLE-SPACED.
Papers must include the correct heading and a Title (see examples).
Include evidence of AI-generated content where applicable.

Cite relevant sources to support your analysis.
Use a recognized citation style (e.g., APA, MLA).

Evaluation Criteria - Your assignment will be evaluated based on the following criteria:

- Depth of research and analysis on the chosen innovation
- Creativity and innovation demonstrated in the paper
- Integration of AI-generated content
- Ethical considerations discussed
- Clarity, organization, and overall quality of the paper.

Project Assignment #1

Selection of Innovation:

a. Choose an innovation that has occurred in an area of technology within your lifetime (e.g., Technology, Medicine, Communication, Transportation).
b. Clearly define the scope and significance of the chosen innovation.
Purpose: This step is crucial for focusing the assignment on a specific innovation within the student's lifetime. It helps in defining the scope and significance of the innovation, setting the foundation for a well-targeted and informative paper.

Project Assignment #2

Background Research:

a. Conduct background research on the selected innovation, exploring its origins, development, and impact.
b. Utilize reputable sources, academic articles, and case studies to gather information.
Purpose: To encourage students to conduct thorough research on the chosen innovation. This step ensures a solid understanding of the innovation's origins, development, and impact, laying the groundwork for an informed and well-supported paper.

Project Assignment #3

Generative AI Ideation:

a. Use Generative AI tools to brainstorm and generate ideas related to your chosen innovation.
b. Evaluate the AI-generated suggestions for unique perspectives and insights.
Purpose: This step introduces the use of Generative AI for brainstorming and idea generation. It allows students to explore novel perspectives and insights that they might not have considered. The purpose is to enhance creativity and broaden the scope of the paper.

Comparative Analysis:

a. Compare your own ideas with those generated by AI.
b. Discuss the advantages and limitations of using AI in the ideation process.
Purpose: To stimulate critical thinking, this step involves comparing the student's own ideas with those generated by AI. It encourages students to evaluate the advantages and limitations of incorporating AI into the ideation process, fostering a deeper understanding of AI's role in creativity.

Project Assignment #4

AI-Powered Outline:

a. Utilize Generative AI to create an outline for your paper, organizing key points and arguments.
b. Modify and refine the outline as needed to align with your writing goals.
Purpose: Using Generative AI to create an outline aids in organizing thoughts, key points, and arguments systematically. The purpose is to leverage AI's assistance in structuring the paper effectively and ensuring a logical flow of information.

Project Assignment #5

Collaborative Writing:

a. Explore collaborative writing tools that incorporate Generative AI.
b. Co-write sections of your paper, integrating AI-generated content to enhance clarity and coherence.
Purpose: This step introduces collaborative writing tools that integrate Generative AI. It encourages students to work collectively and leverage AI-generated content to enhance the clarity and coherence of their paper. It highlights the collaborative potential of AI in the writing process.

Project Assignment #6

Style and Tone Experimentation:

a. Experiment with different writing styles and tones using Generative AI.
Purpose: Experimenting with writing styles and tones using Generative AI helps students explore different ways to express their ideas. The purpose is to enhance the overall quality of the paper by integrating AI-generated suggestions while maintaining the student's unique voice.

Project Assignment #7

Reflection:

a. Reflect on your experience using Generative AI for writing about innovation.
b. Discuss how AI-generated suggestions can be integrated to enhance the overall quality of your paper.
c. Discuss the impact of AI on your creative process, efficiency, and the final quality of the paper.
Purpose: This step requires students to reflect on their experience using Generative AI throughout the writing process. It encourages a thoughtful analysis of the impact of AI on creativity, efficiency, and the overall quality of the paper, promoting self-awareness and critical reflection.

Ethical Considerations:

a. Reflect on the ethical implications of using AI in the research and writing process.
b. Discuss potential concerns related to bias, transparency, and attribution.
Purpose: To instill a sense of responsibility, this final step prompts students to reflect on the ethical implications of using AI. It encourages discussion on potential concerns related to bias, transparency, and proper attribution, fostering ethical awareness in AI utilization.

Table 1: Writing Assignments

Assessment:

The research assignment on "An Innovation Within My Lifetime" focused on utilizing generative AI to enhance student writing and has yielded transformative outcomes. Through the integration of generative AI tools, students experienced notable improvements in various facets of their writing skills. Additionally, a survey of students expressed increased confidence in their writing ability as a result of the use of GenAI to assist in organizing and structuring their writing to address their audience. The technology assisted in generating well-structured outlines, refining thesis statements, and suggesting coherent ideas, thereby streamlining the writing process. The project results indicate a more efficient and collaborative approach to assignments, allowing students to engage with complex topics and articulate their thoughts more effectively. The use of generative AI not only expedited the drafting phase but also encouraged students to delve deeper into research and critical analysis by suggesting areas of discussion that they themselves had not considered. Additionally, the feedback loop between students and the AI system contributed to a continuous learning process, fostering a culture of refinement and improvement in writing

capabilities. As a result, the research assignment showcased the potential of generative AI to serve as a valuable educational tool, empowering students to elevate the quality of their writing and embrace a more dynamic and effective approach to academic expression.

The following rubric was established to evaluate student outcomes:

Content and Originality (30 points)	
Exceptional (25-30): The paper presents a highly original exploration of an innovation, demonstrating deep understanding and insightful analysis.	
Good (19-24): The paper discusses the innovation with original insights and satisfactory analysis.	
Adequate (13-18): The paper covers the innovation with basic analysis and minimal original insights.	
Needs Improvement (0-12): The paper lacks originality or significant content related to the innovation.	
Research and Evidence (20 points)	
Exceptional (17-20): The team conducts comprehensive research, integrating multiple high-quality sources effectively.	
Good (13-16): Research is thorough, with most sources being relevant and credible.	
Adequate (9-12): Research is present but lacks variety or depth, with some sources of questionable credibility.	
Needs Improvement (0-8): Minimal or no research is evident, with poor or no use of sources.	
Team Collaboration and Integration (20 points)	
Exceptional (17-20): The paper demonstrates seamless integration of ideas and writing styles, indicating excellent team collaboration.	
Good (13-16): The paper shows good integration of team members' contributions, with minor inconsistencies.	
Adequate (9-12): The paper shows some integration of contributions, but the differences in writing style or perspective are noticeable.	
Needs Improvement (0-8): The paper lacks integration, with disjointed sections clearly indicating poor collaboration.	
Organization and Clarity (15 points)	
Exceptional (13-15): The paper is exceptionally well-organized, with clear and logical progression of ideas.	
Good (10-12): The paper is well-organized, with minor lapses in clarity or flow.	
Adequate (6-9): The paper's organization is adequate, but some sections may be unclear or poorly connected.	
Needs Improvement (0-5): The paper is poorly organized, lacking clear structure or coherence.	
Writing Quality (Grammar, Punctuation, and Style) (15 points)	
Exceptional (13-15): The writing is flawless, demonstrating professional-level grammar, punctuation, and style.	
Good (10-12): The writing is good, with few errors that do not detract from readability.	
Adequate (6-9): The writing is adequate, but errors distract from the content.	
Needs Improvement (0-5): The writing is poor, with frequent errors that significantly detract from the readability and professionalism of the paper.	

Table 2: Assignment Grading Rubric

At the beginning of the assignment, students were given a self-assessment survey to evaluate their writing confidence for technical majors. Students were asked to rate several criteria on a scale of 1-5 with a score of 5 as Extremely Confident and 1 as Not Confident at All with the averages show in the table below. At the end of the assignment, students were given the self-assessment survey again. These surveys aimed to not only assess improvement in students' self-reported confidence levels but also to encourage reflection on their writing skills, understanding of AI capabilities, and ethical considerations when using AI as a writing aid.

Question	Pre-Assessment	Post-Assessment
How confident are you in your overall writing abilities for Engineering Technology courses?	3.36	3.82
How familiar are you with Generative AI technologies for writing assistance?	2.64	4.00
Rate your confidence in structuring technical reports effectively.	3.36	4.09
Rate your confidence in your ability to write clear and concise technical descriptions.	3.36	3.91
How confident are you in your ability to cite sources correctly in engineering technology papers?	4.00	4.09
How well do you understand the ethical guidelines related to using Generative AI for academic writing?	2.91	3.91
Rate your confidence in your ability to use Generative AI to improve the clarity and conciseness of your writing.	3.18	4.36

Table 3: Self-Assessment Survey Results

	Paper #1	Paper #2	Paper #3	Paper #4	Paper #5	Paper #6	Paper #7	Paper #8
Content and Originality	26	26	26	28	28	28	24	27
Research and Evidence	17	14	19	18	19	20	16	18
Team Collaboration	16	18	18	19	19	19	14	18
Organization and Clarity	13	14	14	14	15	15	12	13
Writing Quality	12	13	12	13	14	14	10	12
Final Grade	**84**	**85**	**89**	**92**	**95**	**96**	**76**	**88**

Table 4: Project Paper Results

Conclusion:

In conclusion, the exploration and integration of generative AI into engineering technology education offer a transformative pathway for the field. By leveraging the capabilities of generative AI, educators and students can navigate the complex landscape of modern engineering challenges with enhanced creativity, efficiency, and insight. Student survey results indicate that at the conclusion of this assignment there was a greater level of confidence in their ability to write effectively while observing ethical considerations. This study not only

underscores the potential of generative AI to revolutionize educational methodologies but also highlights the importance of ethical considerations and the need for a balanced approach to technology integration. Additionally, the use of Generative AI can mitigate or remove barriers to student learning presented by learning disabilities or language barriers in order to accurately evaluate student learning.

As we move forward, it is imperative that the educational community remains vigilant in addressing the ethical implications of AI use, ensuring transparency, fairness, and inclusivity. The future of engineering technology education, enriched by generative AI, promises a dynamic and innovative learning environment where students are prepared to excel in a rapidly evolving technological world. Embracing this future requires a commitment to continuous learning, ethical consideration, and an openness to the vast possibilities that generative AI presents for enhancing the educational experience and preparing students for the challenges and opportunities of the 21st century.

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