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THE REVOLUTION OF ARTIFICIAL INTELLIGENCE IN THE CLASSROOM: AN EXPERIENCE IN ENGINEERING

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Abstract

This study explores the educational revolution driven by the integration of generative Artificial Intelligence (AI) in the classroom, highlighting its vast didactic potential. Specifically, it describes the development and implementation of "TutorAI," an innovative AI-powered tool designed to transform the learning experience in the Electrical Engineering course. TutorAI has been integrated into the virtual classroom and operates as an intelligent virtual assistant, leveraging Chipp technology to interact with students and provide personalized learning support. TutorAI has been meticulously trained using comprehensive course materials, enabling it to address students' specific needs effectively. This AI assistant not only delivers clear and concise explanations of theoretical concepts but also provides practical examples and step-by-step problem-solving guidance, facilitating a deeper understanding and application of complex knowledge. The implementation of TutorAI has proven to be a valuable resource, particularly in the practical components of the course. Its availability 24/7 allows students to access support and guidance at any time and from any location. Additionally, its ability to adapt to each student's individual learning pace ensures a personalized and effective educational experience. Preliminary results indicate a positive impact on students' academic performance and motivation. By providing immediate and personalized feedback, TutorAI helps students identify areas for improvement and reinforces their understanding of key concepts. This study underscores the potential of AI-driven tools to enhance engineering education and optimize student learning outcomes.

Keywords: *Artificial intelligence (AI), virtual learning assistants, engineering education, personalized learning, educational technology.*

1. Introduction

The integration of generative AI is rapidly transforming traditional teaching and learning. This study focuses on the development and implementation of "TutorAI," an AI-powered tool to enhance learning in Electrical Engineering. The complexity of engineering disciplines necessitates personalized support, which intelligent virtual assistants can provide through on-demand assistance and adaptive learning. This paper presents the design, objectives, implementation, and outcomes of integrating TutorAI into the curriculum, exploring AI's broader impact on STEM education (Liu et al., 2025).

2. Design

TutorAI is an intelligent virtual assistant using generative AI and natural language processing. It was designed for the specific needs of an Electrical Engineering course, using Chipp technology for interaction within the Virtual Classroom (Moodle). The design of TutorAI draws upon principles of effective chatbot interaction, emphasizing clarity, responsiveness, and pedagogical soundness (Følstad & Brandtzæg, 2017). The development process involved meticulous training of TutorAI using comprehensive course materials, including lecture notes, textbooks, problem sets, and supplementary resources. This extensive training dataset allows TutorAI to address a wide range of student queries effectively. Key design features include:

- Contextual Understanding: TutorAI is engineered to understand the specific context of student questions, drawing upon the relevant course material to provide accurate and targeted responses.
- Explanatory Capabilities: Beyond simply providing answers, TutorAI offers clear and concise explanations of theoretical concepts, breaking down complex ideas into digestible segments.

- Practical Application Support: Recognizing the importance of practical application in engineering, TutorAI provides practical examples and step-by-step guidance for problem-solving, bridging the gap between theory and practice.
- 24/7 Availability: A crucial design element is TutorAI's continuous availability, offering students support and guidance at any time and from any location, overcoming the limitations of traditional office hours and enhancing accessibility.
- Personalized Learning: TutorAI is designed to adapt to each student's individual learning pace, identifying areas of difficulty and providing tailored support to ensure a more effective and personalized educational experience. This aligns with the growing interest in leveraging AI for personalized learning pathways in higher education (Popenici & Kerr, 2017).

3. Objectives

The primary objectives of this study were:

1. Develop and implement an AI-powered virtual learning assistant (TutorAI) for an Electrical Engineering course.
2. Evaluate the impact of TutorAI on students' academic performance in the course, including a detailed analysis of assessment metrics.
3. Assess the influence of TutorAI on student motivation and engagement with the learning material through surveys and interaction data.
4. Investigate the effectiveness of TutorAI in providing personalized learning support and addressing individual student needs, analyzing how students utilized the tool for different learning challenges.
5. Explore the potential of AI-driven tools to enhance engineering education and optimize overall student learning outcomes, while also considering potential limitations and challenges, as discussed in broader literature on AI in higher education (Zawacki-Richter et al., 2019).

4. Methods

This study used a mixed-methods approach, combining quantitative and qualitative data to assess TutorAI's impact.

4.1. Participants

A total of 60 Electrical Engineering students were divided into two groups (n=30 each):

- Control Group: Received standard course instruction.
- TutorAI Group: Received standard instruction plus access to TutorAI.

4.2. Implementation

TutorAI was integrated into the virtual learning environment, allowing the TutorAI group to:

- Ask course-related questions.
- Seek clarifications.
- Receive problem-solving guidance.

4.3. Data collection

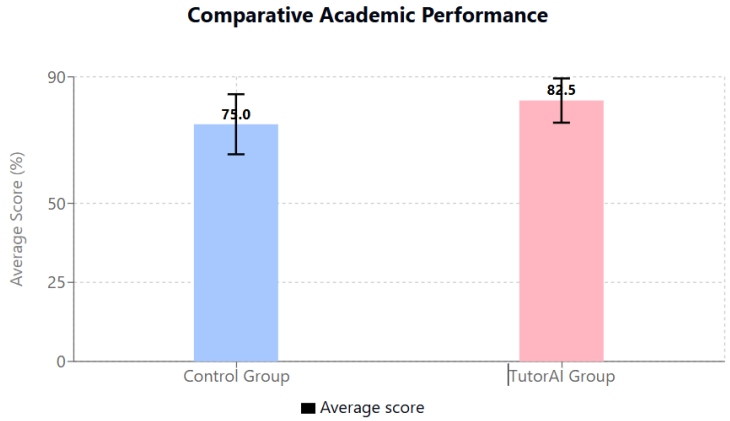
- Quantitative: Grades from assignments, quizzes, and exams were analyzed. Mean scores, standard deviations, and statistical significance (p-value from t-tests) were compared.
- Qualitative: Surveys and questionnaires gathered student feedback on learning experience, engagement, and perceived support.

5. Results and discussion

The quantitative analysis revealed that the TutorAI group had a significantly higher mean score (82.5%) compared to the control group (75.0%) ($p < 0.01$), as shown in Figure 1. The TutorAI group also demonstrated a lower standard deviation (7.0%) compared to the control group (9.5%), indicating more consistent performance. These results align with research on intelligent tutoring systems, suggesting that TutorAI effectively enhanced student learning outcomes.

Qualitative data from surveys indicated higher satisfaction, engagement, and perceived personalized learning in the TutorAI group. Intelligent virtual assistants hold significant potential in addressing these challenges by offering on-demand assistance, adaptive learning pathways, and immediate feedback (Okonkwo & Ade-Ibijola, 2021).

Figure 1. TutorAI Group Outperforms Control Group in Academic Performance ($p < 0.01$).



While these results are promising, it's important to acknowledge limitations. This study represents an initial investigation, and further research with larger samples and in-depth interaction analysis is needed to generalize these findings and fully understand TutorAI's benefits.

6. Conclusions

This study demonstrates the significant potential of generative AI-driven virtual learning assistants like TutorAI to revolutionize engineering education. The integration of TutorAI led to notable improvements in Electrical Engineering students' academic performance, evidenced by higher mean scores and reduced performance variability. This suggests that generative AI can effectively enhance learning outcomes and promote greater consistency among students. Furthermore, student feedback highlighted increased satisfaction and engagement, indicating that TutorAI fosters a more positive and personalized learning environment. The 24/7 availability and adaptive support of AI tools can cater to diverse learning needs and schedules, ultimately empowering students in their learning journey. These findings contribute to the growing body of evidence supporting the transformative power of generative AI in higher education. However, further research is needed to explore the long-term impact, scalability, and ethical implications of generative AI integration in educational settings.

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