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# Integrating Generative AI in Higher Education: Challenges, Opportunities, and Innovations in Assessment Practices within Electrical Engineering

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The rapid integration of artificial intelligence (AI) in higher education has been significantly propelled by developments in generative AI tools, which hold considerable promise for transforming teaching and assessment methodologies. This paper explores the distinctive opportunities and challenges associated with the incorporation of generative AI in Electrical Engineering (EE) education, a discipline characterized by its emphasis on precision, experiential learning, and context-specific feedback. By concentrating on EE, the study investigates how AI tools can facilitate dynamic and personalized feedback, promote active learning, and enhance innovative assessment strategies, all while addressing the specific requirements for technical skill acquisition and critical problem-solving inherent in the field. Through the implementation of AI-driven simulations, automated control systems, and data analytics, educators can establish responsive and industry-aligned learning environments that reflect current labour market needs. Nonetheless, effective integration necessitates a thoughtful alignment of AI applications with traditional assessment frameworks, including lab-based and project-based evaluations, to ensure that crucial hands-on skills and critical thinking abilities are preserved. The implications of this research extend beyond EE, offering a comprehensive framework for the adaptation of generative AI across various higher education disciplines. By reconciling AI's technological advancements with educational goals, this study enhances the understanding of AI's role in cultivating both technical proficiency and essential human-centred skills within engineering education.

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## Introduction

The integration of artificial intelligence (AI) in higher education (HE) has rapidly increased over recent years (Chu et al., 2022; Maphosa & Maphosa, 2023), accompanied by a surge of new AI tools designed for educational purposes. Scholars (Chen et al., 2020; Crompton et al., 2020; Crompton & Song, 2021) have highlighted the potential benefits AI offers to both instructors and students. These include adapting instruction to meet the diverse needs of learners (Verdú et al., 2017), providing customized and prompt feedback (Dever et al., 2020), developing more dynamic assessments (Baykasoğlu et al., 2018), and predicting academic success (Çağataylı & Çelebi, 2022). Such studies contribute to a growing body of research informing educators about how artificial intelligence in education can be leveraged in higher education to enhance learning outcomes.

The rise of generative AI tools, such as ChatGPT, has further transformed educational settings by enabling real-time, human-like responses (Dwivedi et al., 2023). These tools facilitate dynamic, interactive learning environments where students can engage in conversations, ask questions, and receive immediate feedback from AI virtual assistants (Emenike & Emenike, 2023). As a result, AI has significant potential for offering personalized guidance, assisting in problem-solving, and providing supplementary resources that cater to individual learning needs (Kooli, 2023).

Despite these promising developments, the practical pathways for the effective integration of AI into higher education remain ambiguous for many researchers (Lodge, 2023). This ambiguity is particularly pronounced in the programming and engineering disciplines, where understanding how generative AI tools can be tailored for specific applications is essential. These fields require precision and customized feedback (Adebanjo et al., 2023; Santos & Ferreira, 2023), underscoring the necessity to explore the distinct opportunities and challenges that AI presents within them. Gaining a deeper insight into the influence of AI across various engineering disciplines will empower educators to adapt curricula and assessment methods, ensuring alignment with both the unique contexts of these fields and the evolving demands of higher education in an AI-driven landscape. Furthermore, this transition calls for a re-evaluation of educators' objectives when assessing students in these technical domains.

This paper aims to investigate the challenges and opportunities associated with integrating generative AI into higher education, with a specific focus on its impact in Electrical Engineering (EE). By examining the unique context of EE, this study seeks to uncover how generative AI can drive innovations in assessment practices, while also highlighting the discipline-specific advantages and challenges that arise. The insights gained can extend beyond EE, offering valuable implications for AI integration across various disciplines, thus contributing to a broader understanding of how generative AI may transform higher education practices overall.

## AI and Its Transformative Role in Electrical Engineering Education

The integration of artificial intelligence (AI) in electrical engineering education is transforming traditional teaching methodologies, fostering more dynamic, efficient, and responsive learning environments. Central to AI's impact is its capacity to simulate and expand human intelligence, allowing machines to perform complex tasks that support both teaching and industrial applications (Chen, 2019; Feng, 2018). In particular, AI-driven automation and control systems have improved the stability and efficiency of electrical engineering processes, making them a valuable focus for students pursuing careers in this field (Ali & Choi, 2020).

By merging computer technology with AI, electrical engineering education has shifted toward practical applications in automation control, data analysis, and system operation (Ahmad et al., 2021). For example, automation laboratories now simulate real-world environments, enabling students to experiment with AI-enabled control systems that manage processes autonomously. Through hands-on interaction with these systems, students gain not only technical skills but also a deeper understanding of the economic and social benefits AI brings, such as cost reductions and productivity enhancements that are pivotal in today's industrial landscape (Richter et al., 2022).

In practice-oriented electrical engineering programs, AI technologies further enhance experiential learning through applications like AI-based image recognition, which enables precise and rapid identification tasks (Kuang et al., 2021). These tools prepare students to work with complex systems in modern automated industries, particularly in areas such as real-time fault detection and diagnostics, essential skills for industrial maintenance and troubleshooting (Zhang, 2019). Moreover, the use of simulated distributed control systems, which are prevalent in industrial contexts, allows students to understand and engage with decentralized process control and monitoring mechanisms that elevate production quality and optimize operational costs (Talaviya et al., 2020; Abdalla et al., 2021).

AI-driven educational approaches also address the challenges inherent in decentralized electrical engineering systems, providing students with the skills to make data-informed decisions. In distributed control systems used in industrial automation, operations are divided into layered levels, including process control, monitoring, and management. This structure allows students to observe how each layer contributes to system reliability and productivity (Kanase-Patil et al., 2020; Chou & Hsu, 2022). The integration of AI aids in resolving common limitations, such as interoperability between various software and hardware components, by leveraging general-purpose drivers and improved interfaces for communication across diverse equipment (Ahmed et al., 2021).

Expanding AI across foundational electrical engineering courses is essential to provide students with a comprehensive understanding of its applications and implications. Integrating AI in critical topics such as machine learning, machine vision, data analysis, robotics, automation, and simulation allows students to appreciate its broad impact across various domains (Hsu et al., 2021). This inclusive approach prepares students for a labor market that increasingly values proficiency in AI-enabled technologies, fostering the innovation and problem-solving skills essential in modern industry (Sodhro et al., 2019).

An essential component of implementing AI in the electrical engineering curriculum is fostering collaborative research and establishing partnerships with industry (Bikar et al., 2019). Engaging students in AI-focused research projects allows them to tackle real-world challenges and gain valuable practical experience. Partnerships with industry professionals provide insights into current practices and trends, ensuring that the curriculum remains aligned with industry needs (Baltaci et al., 2024). This synergy between academia and industry offers a holistic approach to AI integration, preparing students to navigate the evolving landscape of electrical engineering with relevance and expertise.

## Challenges in Integrating AI in Electrical Engineering Education

### *Loss of Human Interaction and Fidelity of Human-AI Interaction*

The integration of AI into assessment practices often reduces direct human interaction, limiting nuanced understanding and context-sensitive feedback critical in learning environments. This shift raises concerns that AI-driven assessments, with their reliance on rigid and standardised evaluation frameworks, may stifle creativity and fail to capture the diverse ways students demonstrate their understanding. For instance, creativity in disciplines such as design or problem-solving may be overlooked if the AI lacks adaptability to unconventional responses. Furthermore, these assessments often struggle to address the specific needs of individual learners, particularly when biases embedded in training data influence outcomes (Baidoo-Anu & Owusu Ansah, 2023). Students from underrepresented groups, for example, may receive evaluations that unfairly disadvantage them due to limited diversity in AI training datasets. Such biases highlight the critical need for robust mechanisms in AI systems that enable self-correction, error detection, and adaptive learning to ensure fairness and reliability in assessments.

The fidelity of interactions between AI systems and students remains a significant challenge. Emerging technologies, such as multimodal computing that integrates bodily cues and gestures into feedback processes, offer potential to enhance assessment practices, especially in simulation-based learning environments. However, these applications remain in early stages of development and are not yet widely adopted (Dai & Ke, 2022). Compounding these challenges is the inadequacy of traditional assessment methods to mirror real-world skills or provide diverse and actionable feedback. These limitations complicate the transition to AI-enhanced systems, which must bridge the gap between traditional practices and the goal of supporting deeper, more authentic learning experiences (DiCerbo, 2020).

### *Teacher Training and AI Literacy*

Integrating advanced AI tools in education, such as ChatGPT, underscores the critical role of educators in guiding students through an evolving digital landscape (Abulibdeh et al., 2024). Effective AI usage in classrooms depends on teachers' training in these technologies, yet many teachers currently lack the necessary AI knowledge, which may limit their ability to implement AI tools effectively (Zhao et al., 2022). To address this, ongoing support and professional development are essential (Abulibdeh et al., 2024; Zhao et al., 2022). Proficiency in AI is critical, as it enables educators to enhance learning experiences while navigating the pedagogical, ethical, and technological challenges posed by AI integration (Abulibdeh et al., 2024). A broad spectrum of training programs and resources is necessary to develop AI literacy, helping teachers apply AI effectively and fostering sustained professional growth (Zhao et al., 2022). In the digital transformation era, the teacher's role transitions from a traditional knowledge provider to a facilitator of ethical reasoning and critical thinking (Abulibdeh et al., 2024).

### *Student and Teacher Attitudes Toward AI Integration*

Human factors, particularly the attitudes and openness of both students and teachers, play a critical role in the successful integration of AI in education. While many students demonstrate enthusiasm for AI-driven learning methods, others remain hesitant and prefer traditional approaches (Hutson & Ceballos, 2023). This divergence reflects the need to address scepticism and foster acceptance through clear communication of AI's benefits and limitations. Research highlights that tools like ChatGPT are perceived by students as valuable in supporting complex tasks, such as developing components of business models—Channels, Key Resources, and Key Activities—tasks which often require extensive research and critical analysis (Vecchiarini & Somià, 2023).

These findings suggest that AI can enhance student engagement, critical thinking, and creative problem-solving when effectively introduced into the learning environment.

However, aligning these positive attitudes with potential challenges requires careful attention. For some students, concerns about the accuracy, fairness, and transparency of AI systems may hinder adoption. Addressing these concerns by incorporating AI literacy into the curriculum and involving students in discussions about ethical AI usage can help build trust and acceptance.

Equally important are teachers' attitudes toward AI, as their perspectives significantly influence implementation and classroom dynamics. Teachers who view AI as a complementary tool to their expertise are more likely to integrate it effectively into their teaching practices. However, resistance may arise from fears of being replaced by AI or uncertainty about its pedagogical value. Professional development programs that provide training on AI applications in education and address these concerns are essential for fostering teacher acceptance and confidence in using AI-driven tools. By engaging both students and teachers in meaningful dialogue and providing the necessary resources and support, educational institutions can create a more receptive environment for AI integration, addressing human factors as both a challenge and an opportunity.

### *Algorithmic Bias and Fairness in AI*

A significant challenge in AI integration is the potential for biases within AI algorithms, which can perpetuate inequalities and compromise the fairness of AI-based educational systems. Biases may stem from skewed training data, algorithmic design, or underlying societal biases encoded in training datasets. For example, AI trained on historical data reflecting educational disparities may inadvertently reinforce existing inequities, while opaque algorithms may mask these biases, complicating detection and remediation (Akgun & Greenhow, 2022; Borenstein & Howard, 2021). To address these issues, educators and developers should prioritize fairness, accountability, and transparency. This involves scrutinizing training data for biases, implementing fairness-aware machine learning techniques, and conducting routine audits to safeguard marginalized groups (Bogina et al., 2021; Xivuri & Twinomurinzi, 2023).

***Ethical Considerations in AI-Driven Education***

Integrating AI in education raises important ethical concerns around data privacy, transparency, and ethical assessment practices. Institutions must implement robust data protection measures, such as encryption and access controls, and provide transparency on data use to ensure students and families are informed and consenting (Slade & Prinsloo, 2013). Addressing algorithmic biases is crucial for fairness, as biased AI could exacerbate inequalities in educational access and outcomes (Agarwal et al., 2023; Zajko, 2021). Mitigating these biases requires diverse training data, fairness metrics, and bias-aware algorithms that reflect student diversity (Kordzadeh & Ghasemaghaei, 2022; Färber et al., 2023).

Transparency and accountability are foundational to ethical AI use in education. Institutions should openly communicate AI's role, data sources, and potential impact, establishing accountability mechanisms to address concerns and ensure responsible use. Clear explanations of algorithmic decisions and comprehensive oversight further ensure adherence to ethical standards. Additionally, using AI in student assessments poses challenges related to fairness, validity, and equity. While AI can improve assessment efficiency, it may introduce biases or demotivate students if not carefully monitored. AI-based assessments should align with educational goals, complementing human judgment and supporting student growth through holistic, multi-source evaluation (Chan, 2023).

While AI-driven assessments offer objective evaluations, students often find them impersonal, expressing a preference for human feedback. This issue is particularly evident in specialized fields, such as medical education, where traditional structures may impede the adoption of AI-enhanced assessment techniques (Lentz et al., 2021). Balancing formative and summative assessments within AI-driven systems requires further research to integrate both approaches effectively (Wiliam, 2018). Ensuring ethical integrity in AI assessments, such as fairness and alignment with educational theories, also remains essential for creating equitable and effective educational practices (Yang & Xin, 2022).

## Opportunities of AI Tools in Electrical Engineering Education

### *Real-Time Feedback and Assessment*

AI facilitates real-time feedback and assessment, providing students with immediate insights into their learning processes. This instantaneous feedback can effectively reinforce concepts and clarify misunderstandings, particularly in challenging subjects such as engineering, through formative assessments and experiential learning (Abdulla et al., 2019). A significant advantage of tools like ChatGPT in engineering education is their potential to increase student engagement and enhance the overall educational experience (Nikolic et al., 2023). Students can interact conversationally with ChatGPT, posing questions and receiving tailored feedback in real time. Furthermore, AI can assist in grading student work, thereby allowing educators to allocate more time to complex pedagogical tasks (Celik et al., 2022).

Parambil et al. (2022) describe an AI-powered system capable of tracking students' emotions and attention levels in real time during classroom instruction. This system provides teachers with immediate graphical feedback, enabling them to accurately assess and respond to student engagement levels (Parambil et al., 2022). Such technologies enhance the effectiveness of teaching, accommodating a diverse array of student needs and potentially leading to improved academic outcomes (Parambil et al., 2022). Additionally, AI can be employed to predict student performance. Jiao et al. (2022) developed an AI-enabled predictive model for academic performance in online engineering courses. Their findings indicate that knowledge acquisition, class participation, and summative assessment results are the primary factors influencing academic performance, with prerequisite knowledge being less significant (Jiao et al., 2022).

### *Enriched Laboratory Preparations*

AI algorithms significantly enrich laboratory preparations in EE education by enabling the creation of simulations and virtual experiments. These tools provide students with hands-on learning experiences in controlled, interactive environments, overcoming limitations of traditional laboratory setups, such as resource constraints and safety concerns (Zhang et al., 2022). AI-powered virtual laboratories promote inclusivity and reduce infrastructural barriers by offering greater accessibility and cost-effectiveness, allowing students to access a wide range of resources anytime and anywhere (Munawar et al., 2018). This approach facilitates more effective application of theoretical concepts and addresses challenges in resource-scarce environments.

***Efficient Grading and Feedback Mechanisms***

AI has the potential to streamline the grading and feedback process in EE education, reducing the time required for instructors to provide feedback and enhancing learning outcomes (Ouyang et al., 2023). Automated grading systems can alleviate the repetitive workload of instructors while offering standardised and unbiased evaluations. This can accelerate the feedback loop, enabling students to quickly identify and address knowledge gaps, particularly in assignments that build upon one another (Darvishi et al., 2022; Shaik et al., 2022).

However, it is important to acknowledge the limitations of AI-driven grading systems. Despite their efficiency, these systems are not without flaws. The feedback generated by AI may be error-prone and could fail to accurately capture students' abilities or provide the nuanced insights needed for improvement. A relevant example of such limitations can be seen in the PTE exam, where students have exploited algorithmic weaknesses to their advantage. As such, while AI grading systems offer significant potential, their effectiveness depends on continual refinement and human oversight to ensure the feedback is accurate and truly reflective of student performance. This highlights the importance of balancing AI's efficiency with careful consideration of its limitations in educational contexts.

***Contributions to Goal-Directed Practice and Feedback***

Goal-directed practice, combined with targeted feedback, is crucial for enhancing the quality of student learning. This principle emphasizes that students should engage in practice with a clear objective, appropriate challenge level, and sufficient repetition, accompanied by timely feedback that guides their progress toward goals (Lovett et al., 2023). Generative AI can support goal-directed practice by acting as virtual tutors, providing ongoing assistance outside regular class hours, thus making learning more accessible and convenient (Sok & Heng, 2023; Lo, 2023).

AI-enhanced tools can offer quick responses to queries and provide immediate feedback on assignments, projects, and other concerns (Rasul et al., 2023; Nee et al., 2023). This timely feedback enables students to correct misconceptions, improve their understanding, and make necessary revisions to their work more efficiently. Chatbots also assist students in project development by guiding problem definition, objective setting, methodology selection, and resource identification (Sok & Heng, 2023). However, there is a risk of over-reliance on these systems, which could undermine students' ability to independently evaluate their work. Moreover, chatbots may provide superficial or inaccurate feedback, especially on complex tasks in specialized fields (Lo, 2023).

***Contributions to the Acquisition, Completion, and Activation of Prior Knowledge***

Prior knowledge plays a critical role in how students learn, as it influences their ability to interpret, filter, and retain new information (Lovett et al., 2023). When students possess accurate and relevant prior knowledge, they can better understand and process new material. Conversely, incomplete or incorrect prior knowledge can hinder learning. AI chatbots help students acquire relevant background information quickly by providing access to a wealth of resources, including textbooks, research articles, and other online materials (Ahmad et al., 2023).

By interacting with AI-enhanced tools in natural language, students can receive personalized responses that align with their learning needs, allowing them to activate and apply prior knowledge to new concepts (Rahman & Watanobe, 2023). Additionally, AI chatbots can deliver instant and personalized explanations of complex concepts and theories, making them more accessible and relatable to students (Wardat et al., 2023). The ability of chatbots to facilitate connections between new and prior knowledge supports a deeper understanding of the content and improves the coherence of students' written work (Sok & Heng, 2023). For example, students can use AI tools to create structured outlines for essays or reports, enhancing the organization of their ideas during the research and writing process (Meyer et al., 2024; Punar & Yangin; Lo, 2023).

Moreover, AI chatbots can enhance group discussions and debates by providing personalized guidance. They suggest relevant discussion topics, propose discussion structures, and break down complex concepts into simpler components for better assimilation (Rahman & Watanobe, 2023; Lo, 2023; Wardat et al., 2023).

## New Strategies for Electrical Engineering Assessment in the Era of AI

Incorporating artificial intelligence (AI) into educational practices presents both novel opportunities and distinct challenges, especially within the assessment landscape of electrical engineering. Traditional assessment methods are being re-evaluated to ensure they remain relevant and effective in cultivating essential skills for future engineers. This section explores three major assessment strategies—active learning, lab-based learning, and project-based assessment—that align with the capabilities and limitations of AI, ensuring that students develop not only cognitive knowledge but also practical skills and critical thinking that AI tools cannot replicate.

### *Active Learning for Student-Centered Learning and Assessment*

Active learning has gained prominence as a transformative educational strategy, emphasizing student engagement and active participation rather than passive information absorption. In an AI-enhanced educational environment, active learning becomes even more critical. While AI can offer powerful tools for content delivery and assessment automation, it lacks the capacity to replace the human aspect of learning, which requires students to actively construct knowledge and engage deeply with course material. Active learning approaches, therefore, play a crucial role in assessment by fostering students' critical thinking and problem-solving skills—competencies essential for engineering.

Defined as instructional methods that involve students directly in the learning process, active learning contrasts with lecture-dominant formats. The “Active Learning Continuum” illustrates that activities beyond passive listening and note-taking correlate with enhanced academic outcomes, as students who engage actively in class also exhibit higher comprehension and retention of knowledge (Stains et al., 2018). This shift to an active model is particularly relevant in engineering disciplines, where practical skills and reflective thinking are integral. To maximize the effectiveness of active learning, educators should clearly communicate its structure and goals, thereby setting clear expectations for how engagement impacts assessment through quizzes, projects, and exams (Froyd et al., 2013).

Various active learning techniques can be embedded within the curriculum to enhance student understanding. Methods such as Thinking-Aloud Pair Problem Solving (TAPPS) and Think-Pair-Share encourage collaborative learning and critical thinking, which are critical in engineering education (Clark et al., 2018). Additionally, tools like clickers and visible quizzes offer instant feedback, creating a dynamic and interactive learning environment where students are not only consumers of knowledge but also active participants in their learning journey. These techniques emphasize action and reflection, encouraging students to engage with material beyond superficial understanding.

### *The Importance of Lab-Based Learning in the Era of AI*

Laboratory-based learning remains an indispensable component of electrical engineering education, as it enables hands-on experiences that AI cannot replicate. Although AI technologies have significantly influenced instructional and assessment methods, their limitations in handling tasks requiring psychomotor skills and real-world problem-solving underscore the value of laboratory-based assessments (Nikolic et al., 2021). Laboratories provide students with unique opportunities to develop practical skills, gain familiarity with equipment, and engage in experiential learning—components essential to engineering education.

Hands-on laboratory work fosters competencies beyond cognitive understanding, addressing vital psychomotor and affective domains. In addition, the laboratory environment cultivates teamwork, communication skills, and sensory awareness, skills that AI-driven assessments cannot adequately evaluate (Gustavsson et al., 2009; Feisel & Rosa, 2005). Through traditional, remote, and simulated lab activities, students develop a holistic understanding of engineering processes, and a blended approach can strengthen both tactile and conceptual knowledge. This approach is critical for students transitioning to high-stakes engineering roles, where handling high-risk materials and adhering to safety protocols are key to professional success (Memik & Nikolic, 2021).

Lab-based learning also aligns with broader educational goals, such as employability and industry-readiness, by integrating work-integrated learning and career-focused skills. As industry and government increasingly value these attributes, laboratory assessments ensure that students build competencies applicable in real-world settings (Nikolic et al., 2016). Thus, laboratory-based learning not only reinforces technical knowledge but also prepares students for complex professional challenges that extend beyond the cognitive capabilities of AI.

***Project-Based Learning and Assessment***

Project-based assessment offers an alternative evaluation method that aligns closely with the objectives of project-based learning (PBL). PBL is defined as a learner-centred approach where students conduct research, apply theoretical knowledge, and develop solutions to real-world problems (Savery, 2006). In the age of AI, project-based assessments are particularly valuable, as they demand hands-on problem-solving and creativity—tasks that AI tools struggle to replicate. This makes PBL assessments resilient to AI's influence, allowing for authentic evaluation of student competencies in practical contexts.

Unlike traditional assessment methods focused on standardized tasks, project-based assessment emphasizes comprehensive skill development, including problem-solving, teamwork, adaptability, and self-directed learning. Engineering fields, such as power electronics and photovoltaic systems, have successfully implemented PBL, showing its effectiveness in developing both technical and professional competencies (Martínez et al., 2011; Mitchell et al., 2010). Moreover, the implementation of process-oriented evaluations, such as portfolios and reflective journals, can offer insights into students' development over time, making it possible to assess both their technical knowledge and professional growth (Mitchell et al., 2010).

Project-based learning and assessment strategies serve as powerful methods in engineering education, fostering an educational experience that combines theoretical and practical applications. By focusing on real-world problem-solving, PBL cultivates a range of competencies that AI tools alone cannot replicate. This approach reinforces technical understanding while promoting critical thinking, creativity, and professional readiness.

## Conclusion

The integration of generative AI in higher education, particularly within Electrical Engineering (EE), represents both a transformative opportunity and a complex challenge. As this study has highlighted, generative AI tools hold the potential to enhance learning experiences by offering personalized feedback, fostering active engagement, and enabling innovative assessment methods. However, fully realizing these benefits requires careful consideration of the discipline-specific demands of EE, such as the need for precision, hands-on skill acquisition, and critical problem-solving abilities.

AI's role in EE education is multifaceted: it not only enhances technical learning but also prepares students for real-world industry applications, bridging the gap between theoretical knowledge and practical skill sets essential for modern engineering roles. By incorporating AI-driven simulations, automated control systems, and data analytics into the curriculum, educators can create more dynamic, industry-relevant learning environments that align with the demands of today's labour market.

However, this integration also necessitates new assessment models that account for the unique capabilities and limitations of AI in the learning process. Active learning strategies, lab-based assessments, and project-based evaluations emerge as essential complements to AI-enhanced instruction, ensuring that students engage deeply with course material and develop skills AI alone cannot cultivate, such as hands-on proficiency and critical thinking. These approaches provide students with a holistic, practical education that not only deepens their technical knowledge but also hones their adaptability and collaborative skills—key attributes for engineers in an AI-enhanced workforce.

Future research should focus on the development of adaptive AI-driven assessments that align with individual student needs and learning paths, as well as the ethical implications of using AI in educational settings, such as data privacy and bias mitigation. Additionally, longitudinal studies are needed to understand the long-term impact of AI-integrated education on skills acquisition, job readiness, and adaptability in real-world engineering contexts. Exploring cross-disciplinary applications can also reveal insights into how AI can enhance teaching and assessment practices beyond Electrical Engineering, offering a broader framework for AI's role in higher education. Lastly, further investigation into human-AI collaboration in project-based learning could optimize AI as a supportive tool that enhances, rather than replaces, student-driven problem-solving and innovation.

Overall, while the integration of generative AI in EE offers immense potential for educational innovation, its success depends on the balanced design of AI-supported curricula and assessments. By advancing both the pedagogical and technical dimensions of AI in EE, addressing contextual factors such as institutional policies and infrastructure readiness, and fostering a culture of acceptance across disciplines, educators can ensure that AI technologies serve as enablers of student success. This balance is essential for ensuring that AI remains a tool that supports, rather than overshadows, the critical human elements of learning, innovation, and professional growth in engineering education.

## Authors

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