From Data to Decisions: Leveraging AI for Proactive Education Strategies

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Abstract: The advancement of Artificial Intelligence (AI) and Large Language Models (LLMs) ushers in a new era in education, characterized by more adaptive, personalized learning experiences. This literature review examines the profound impact of these technologies on student engagement, achievement, and personalized learning within higher education institutions. Through a systematic analysis of scholarly articles from 2022 to 2024, this review explores how AI is reshaping educational practices through enhanced feedback mechanisms, predictive analytics, and innovative teaching methodologies. The findings indicate that AI significantly improves student support services by enabling early identification of at-risk students and by facilitating tailored educational interventions. Moreover, the deployment of chatbots and LLMs, such as GPT (generative pre-trained transformer) and BERT (bidirectional encoder representations from transformers), offers promising enhancements in instructional strategies and student assessments, fostering richer, interactive learning environments. However, the integration of these technologies also introduces ethical challenges, necessitating consideration of issues such as data privacy and bias. The review emphasizes the need for ethical frameworks and responsible AI usage to ensure technology enhances educational outcomes without compromising fairness or integrity. Future research directions are suggested, focusing on broader AI applications across various educational settings and the need for longitudinal studies to assess the long-term effects of AI integration in education.

Keywords: Educational AI, LLMs, Personalized learning, Predictive analytics, AI feedback, Chatbots

1. Introduction

AI innovations shape our daily lives, from Alexa to personalized education. The release of ChatGPT in late 2022 redefined AI, demonstrating machines' ability to learn human language and perform tasks like text generation, summarization, question answering, text classification, translation, and prediction. In education, AI and LLMs mark a significant evolution, introducing adaptive and customized learning experiences, automated grading, feedback systems, and intelligent tutoring (Wangwiwattana and Tongvivat, 2023). These technologies address student engagement, persistence, and achievement challenges but also raise ethical concerns. This study explores AI's impact on academic success, focusing on two research questions:

RQ1: How can institutions use AI to enhance student engagement and learning outcomes

RQ2: What are the implications of AI for personalized learning in higher education.

This systematic review analyses the current state and future potential of AI in education, using 172 articles from IEEE and ScienceDirect databases. The trend toward AI adoption in education aims to shape tomorrow's workforce. Our analysis shows AI technologies transforming the education environment through LLM integration, student success prediction, study preparation, and teaching. Higher education institutions use AI to personalize education, grade student work, and enhance language lessons. More research is needed to explore AI's broader impacts across educational levels and disciplines.

To guide readers through the findings and insights of this study, it is structured as follows: Section 2 discusses the methodology for data collection and screening. Section 3 examines the role of Large Language Models in enhancing educational practices, focusing on AI-Enhanced Feedback, Chatbot-Enhanced Learning, and Assessment. Section 4 delves into the application of predictive analytics to identify at-risk students. Section 5 focuses on the impact of AI tools on study preparation, using the FE exam as an example. Section 6 reviews AI applications in teaching, including enhancing motivation, classroom discourse, cognitive skills, and online engagement. Finally, Section 7 provides a summary of key findings, practical implications, and future research directions.

2. Systematic Review Approach

2.1 Data Collection

This literature review curated scholarly articles on Artificial Intelligence, Machine Learning, Large Language Models, and chatbots' educational outcomes, focusing on higher education. A systematic search and screening identified relevant literature from 2022 to 2024.

2.2 Search Strategy

An extensive search was conducted across two major databases, ScienceDirect and IEEE, using a set of predetermined search strings aimed at identifying a wide array of research focusing on the application of AI/ML/LLMs and technology adoption in education, especially within the context of minority education. The search strings were as follows:

- "machine learning" AND Education AND minority
- ("artificial intelligence in higher education") OR (HBCU AND Technology) OR (“technology adoption” AND minority) OR ("machine learning" AND Education AND minority)
- “large language model” AND education

This search yielded a total of 110 articles from IEEE and 186 from ScienceDirect. After merging the two lists and removing duplicates, 245 articles were identified. A further filter was applied to select articles published within the years 2022 to 2024, resulting in a refined list of 172 articles.

2.3 Screening Process

Preliminary screening ensured article’s relevance and quality based on four key areas:

1. AI Relevance: Does the article provide significant insights into AI technologies that are applicable to educational settings, even if not directly applied within them?
2. Focus on Higher Education: Is the primary setting of the study or discussion within higher education institutions?
3. Empirical Evidence: Conceptual papers, while valuable for theoretical discussions, often lack the empirical data necessary to evaluate AI’s measurable impact on student outcomes. Does the article provide empirical evidence or thorough analysis of technology/AI's impact on student outcomes?
4. Relevance to Minority Education: Does the article directly reference Historically Black Colleges and Universities or other minority-serving institutions?

Each response of “Yes” to any of the screening questions was scored as 1 point. Articles scoring at least 3 points in total were selected for initial inclusion. This process yielded 56 articles

2.4 Article Grouping

After preliminary screening, articles were reviewed for relevance to AI/ML/LLMs/chatbots in improving educational outcomes. They were categorized by theme, resulting in 26 articles for the review.

2.5 Important Notes

The original design of this literature review was to focus on the application of AI technologies in Historically Black Colleges and Universities. During the literature search, it became clear that there was a significant gap in research directly addressing the use of AI within HBCUs. The limited availability of empirical studies in this context necessitated expanding the scope of the review to include general higher education settings.

This review delves into four critical areas where AI technologies, including Machine Learning and Large Language Models, contribute to educational strategies: LLM Educational Integration, Prediction – Student Success, Study Preparation, and Teaching. Each section explores different dimensions of AI application.

3. LLM Educational Integration

Large Language Models (LLMs), such as GPT and BERT, have transformed educational practices by enhancing teaching and learning processes. These AI systems, trained on extensive datasets, are adept at understanding and generating human-like text, making them invaluable in educational settings (Dai et al., 2023; Essel et al., 2023; Niloy et al., 2024; Bewersdorff et al., 2023). This section explores LLM integration in education, focusing on AI-Enhanced Feedback, Chatbot-Enhanced Learning, and Assessment.

LLMs support educators by automating student error analysis, identifying learning gaps, and tailoring educational responses. Bewersdorff et al. (2023) demonstrated that LLMs help create individualized learning strategies addressing each student's unique needs. These tools improve efficiency while allowing educators autonomy in their use of AI systems, enhancing teaching without undermining professional discretion (Bewersdorff et al., 2023; Ouatiq et al., 2022).

Ethical implications are critical in integrating LLMs in education. AI tools must enhance educational practices while addressing ethical concerns (Vetter et al., 2024). The introduction of ChatGPT in academic settings has spurred ethical discussions and empirical studies on its use by students (Niloy et al., 2024). This underscores the need to balance benefits and challenges, ensuring AI implementation is effective and responsible.

3.1 AI Enhanced Feedback

Providing effective feedback is a critical component of enhancing student engagement and learning outcomes. The role of AI-Enhanced Feedback becomes particularly relevant in addressing how institutions can utilize AI to improve these aspects. The emergence of LLMs has resulted in the creation of automated, evidence-based feedback systems, presenting a promising solution for generating such feedback (Fleckenstein et al., 2023; Meyer et al., 2023; Dai et al., 2023).

Such feedback has been shown to significantly improve students' revision performance and task motivation. As noted by Myer, “Students who received feedback generated by the LLM improved to a greater degree in the text revision compared to students in the control group” (Meyer et al., 2023, p. 6). This demonstrates LLMs' capacity to enhance student learning experiences and outcomes effectively.

In educational technology, feedback plays a crucial role in improving student learning outcomes, as it is widely acknowledged as an effective technique for improving student learning (Dai et al., 2023). This foundational role of feedback underlines its importance in the learning process, where the integration of AI tools supplemented with large language models like ChatGPT represents a significant advancement over traditional methods. For instance, in the context of computer programming, the deployment of AI as a virtual peer through ChatGPT was used to offer feedback in a study performed by Dos Santos and Cury (2023). Dos Santos and Cury (2023) discovered that using AI, such as ChatGPT, as a virtual peer within peer instruction models significantly boosted students' programming abilities and conceptual comprehension compared to conventional teaching methods.

This integration demonstrates the potential of AI to not only support basic learning tasks but also to deepen student engagement with the subject matter, directly addressing the question of how AI can be utilized to enhance educational outcomes. The application of AI-Enhanced feedback directly addresses research question one by demonstrating how AI can improve student engagement and learning outcomes through personalized feedback mechanisms.

3.2 Chatbot Enhanced Learning

Enhancing student engagement and learning outcomes is crucial for educational success. AI-powered chatbots represent a significant evolution in educational environments by supporting active and self-regulated learning (SRL) strategies. Advanced tools like generative AI chatbots, such as ChatGPT and Bing Chat, provide personalized support, feedback, and guidance, fostering deeper learning (Essel et al., 2023; Lin and Chang, 2023; Meyer et al., 2023). Chatbots can simulate roles such as tutor, teaching assistant, and peer, offering round-the-clock assistance and enhancing the educational process (Yildirim-Erbasli and Bulut, 2023). It’s been stated “By leveraging the potential of chatbot technology and its ability to provide personalized support, feedback, and guidance, educators can create more engaging and effective learning environments that promote active learning and SRL” (Lin and Chang, 2023, p. 6).

The ethical integration of such technology involves ensuring responsible use, enhancing educational outcomes without compromising human interactions or leading to over-reliance on technology. This requires ongoing assessment and adaptation to align with ethical standards, safeguarding educational integrity and student welfare.

Chatbot-enhanced learning addresses both research questions by demonstrating how AI can enhance student engagement and learning outcomes (research question 1) and by exploring the implications of AI for personalized learning in higher education (research question 2). This section highlights the potential of chatbots to improve student engagement and offer learning experiences on a individualized level.

3.3 Assessment

As we explore the integration of Large Language Models within the educational framework, the realm of assessment reveals both transformative potential and challenges that need careful navigation. This aligns directly with the themes of improving educational outcomes and addressing the ethical implications of AI for personalized learning, as stipulated in both research questions. In the field of educational assessments, the complexity of evaluating student work, such as experimentation protocols, is amplified by the diverse nature of

the data. Bewersdorff et al. (2023) described the difficulty of detecting "logical errors in complex, incomplete, contradictory, and heterogeneous data, such as students' experimentation protocols". This underscores the necessity for advanced tools capable of handling such complexities. LLMs, through their sophisticated text analysis capabilities, provide a solution that could potentially streamline the assessment process. AI's role in education extends beyond mere auto-grading, offering detailed insights and feedback that can significantly enhance the quality of student assessments and learning experiences (Yildirim-Erbasli and Bulut, 2023).

3.3.1 Writing evaluation

LLMs facilitate the creation of more reflective and engaging learning environments. Their ability to generate high-quality reflective writings supports students in engaging more deeply with learning materials. Li et al., (2023) argue that advanced generative LLMs and related tools have the potential to produce high-quality reflective writing examples. This application of LLMs illustrates their versatility in fostering higher-level thinking and self-reflection, which are critical components of successful learning strategies.

In writing evaluation, LLMs are increasingly employed to provide detailed feedback, which directly addresses our second research question. This feedback can significantly enhance the learning process. The deployment of LLMs in assessments goes beyond simply automating grading. It also aims to enhance students' assessment experiences by using conversational agents to administer tasks and provide feedback (Yildirim-Erbasli and Bulut, 2023). These agents, designed for educational purposes, simulate human-like interactions, making the assessment process more engaging and less daunting for students.

3.3.2 Ethical use in assessment

The ethical use of AI in assessments raises several important concerns, particularly around fairness, academic integrity, and the authenticity of student work. The capabilities of LLMs pose significant challenges to maintaining the integrity of student submissions (Vetter et al., 2024). Human instructors cannot consistently differentiate between AI-generated text and student-authored content, further complicating the issue. Current AI detectors, while improving, are far from flawless, with notable misclassification rates that either falsely flag authentic student work or fail to identify AI-generated content (Fleckenstein et al., 2023). These limitations highlight the inadequacy of relying solely on detection tools to address the problem of academic dishonesty.

Rather than attempting to outlaw the use of AI in education, educators should consider the development of a comprehensive framework that integrates AI tools into their teaching practices (Vetter et al., 2024). Such a framework would allow instructors to adapt their pedagogy, using AI to enhance learning objectives rather than viewing it as a threat to academic integrity. This pedagogical shift should include clear guidelines for the ethical use of AI, ensuring that students understand the benefits and boundaries of these tools in the learning environment (Fleckenstein et al., 2023; Vetter et al., 2024).

The ethical implications of AI use in education cannot be ignored. AI tools, while powerful, raise questions about dependency on technology and the authenticity of student work (Vetter et al., 2024). Ensuring that AI supports educational goals without compromising assessment quality or fairness is critical. Educators must establish clear guidelines and ensure transparency in the responsible use of AI, balancing the benefits of these technologies with the need to uphold academic integrity, motivate students and foster genuine learning while preventing misuse (Yildirim-Erbasli and Bulut, 2023).

Writing Evaluation and Ethical AI Use in Assessment sections show that while LLMs can enhance assessment efficiency and effectiveness, their integration must focus on learning outcomes and ethical standards (Vetter et al., 2024). This alignment with academic objectives and ethical considerations addresses research question two.

4. Prediction – Student Success

It is essential to understand the factors that influence student success to improve educational outcomes. Predictive analytics in education aims to enhance student outcomes and institutional effectiveness by identifying risk factors for underperformance or dropout, addressing our second research question. These analytics are used across various educational levels and regions, demonstrating their broad appeal and necessity (Alwarthan, Aslam and Khan, 2022; Qin et al., 2023). Beyond immediate academic outcomes, predictive analytics impact long-term educational and career trajectories, as dropout negatively affects job opportunities and long-term earning potential (Manir and Deshpande, 2023). Addressing dropout factors can secure better futures for students. Research across universities highlights predictive analytics' transformative potential. Studies at

various institutions, from large public universities to small private colleges, aim to understand and mitigate student attrition factors.

Minority student underachievement in higher education remains significant and troubling, requiring urgent attention (Manir and Deshpande, 2023). This emphasizes the need for targeted interventions facilitated by predictive analytics. A study at Marquette University, which is not an HBCU, demonstrated effective use of machine learning algorithms to monitor and predict academic success, particularly focusing on demographic factors that contribute to the academic success of minority students. This study highlights the relationship between academic achievement and demographic factors, providing valuable insights into how predictive analytics can support minority students (Manir and Deshpande, 2023).

Marquette University's study also showed the efficacy of sophisticated machine learning models like Random Forests in predicting student outcomes. Random Forest achieved the highest accuracy for undergraduate and graduate datasets, with 96.7% and 91.1%, respectively (Manir and Deshpande, 2023). These models handle complex datasets and uncover hidden patterns, enhancing performance (Manir and Deshpande, 2023).

Other institutions have used various predictive models with differing success, often depending on data quality and educational context. Deep learning methods to analyse data from learning management systems (LMS) provide insights to refine academic programs and support services (Souai et al., 2022; Sagala et al., 2022; Vaarma and Li, 2024; Pecuchová and Drlík, 2023; Vives et al., 2024; Hlosta et al., 2022). The importance of Learning Management Systems (LMS) in predictive analytics is increasingly recognized. LMS data provides insights into student engagement and progress. Vaarma and Li (2024) suggest that LMS data features have strong predictive power and should be evaluated as independent variables in dropout predictions, facilitating better-targeted interventions (Vaarma and Li, 2024).

Predictive models to identify students at risk of academic failure enhance student performance in higher education (Pecuchová and Drlík, 2023). These models play a crucial role in early intervention strategies, significantly enhancing student support mechanisms (Souai et al., 2022; Sagala et al., 2022; Vaarma and Li, 2024; Pecuchová and Drlík, 2023; Vives et al., 2024; Hlosta et al., 2022).

However, traditional models like Random Forest and logistic regression have limitations. Individual classification algorithms have performance limits, which can be overcome by using ensembles of classifiers (Pecuchová and Drlík, 2023). This indicates a shift toward ensemble methods that integrate multiple models to enhance prediction accuracy and reliability.

Predictive models must be carefully designed to consider data availability and relevance. Even with limited data, carefully selected indicators can yield reliable predictions (Souai et al., 2022; Sagala et al., 2022; Vaarma and Li, 2024; Pecuchová and Drlík, 2023; Vives et al., 2024; Hlosta et al., 2022). Pecuchová and Drlík (2023) demonstrated that even with a small sample size, carefully selected indicators can assess various performance metrics, making predictive analytics accessible to smaller educational settings.

Challenges arise from the unpredictable nature of student life, affecting learning outcomes and retention. Hlosta et al. (2022) found that unexpected events during studies significantly impact student behaviour. Recognizing these variables is crucial for developing adaptive and responsive predictive models.

Advancements in deep learning technologies offer new avenues for predictive analytics in education. A study on tertiary education found that deep learning methodologies can analyse student performance. Researchers proposed expanding the study by incorporating additional interpretable factors (Hasib et al., 2022). This highlights the potential for integrating more complex algorithms to delve deeper into predictive factors, suggesting future research directions.

5. Study Preparation

Enhancing study preparation is essential for academic success, particularly in preparing for critical examinations. Advancements in AI have shown significant promise in transforming various aspects of education, including study preparation. This area addresses both research questions by showcasing how AI tools can enhance study preparation, improve learning outcomes, and provide personalized study experiences.

In a recent study that investigated the potential of AI tools like ChatGPT for preparing students for critical examinations, several notable findings were revealed. This study specifically focused on the US Fundamentals of Engineering (FE) exam, a key steppingstone for engineering students in the United States. The purpose of the study by Pursnani et al. (2023) is to provide insights into the effective use of AI in preparing for standardized

exams. By leveraging AI tools, educators can offer more personalized and adaptive learning experiences that cater to the specific needs of students (Pursnani et al., 2023).

This finding suggests that while AI may not yet fully replace human tutors, it serves as a valuable complement, particularly in areas where scalable and individualized feedback is beneficial. This study's value rests in its ability to be applied across various academic disciplines, not just engineering. These findings could have broader implications, potentially benefiting a wide range of educational fields by adapting AI tools for different types of exam preparations. Pursnani et al. (2023) observed both the significant potential and limitations of AI in education, indicating that its role in this field is continually advancing. They acknowledge that while AI can significantly enhance study preparation, ongoing refinement and customization are necessary to maximize its effectiveness and applicability in diverse educational settings.

6. Teaching

This section addresses the first research question: How can institutions use AI to enhance student engagement and learning outcomes? By exploring various aspects of AI applications in teaching, we examine how these technologies can foster motivation, improve classroom interactions, and develop cognitive skills.

6.1 AI Enhanced Motivation

Motivation is a critical factor in educational success. Lai, Cheung, and Chan (2023) explored how AI tools can influence student motivation. Their study found that AI technologies can significantly enhance motivation, leading to greater engagement and more favourable attitudes towards learning. This underscores the potential of AI to boost student engagement by fostering motivation, directly addressing the first research question.

6.2 Classroom Discourse

Improving classroom interactions is another vital aspect of enhancing student engagement. Wang, Yang, and Chen (2023) conducted a systematic review on the impact of AI in classroom discourse. Their findings indicate that AI tools consistently enhance classroom dynamics, leading to greater engagement and improved student behaviours. This demonstrates how AI can create more interactive and lively learning environments, further addressing the first research question.

6.3 Cognitive Skills Development via ChatGPT

Research on the cognitive skills of undergraduate students using ChatGPT showed significant improvements. Essel et al. (2023) found that students who used ChatGPT demonstrated substantial enhancement in critical thinking skills compared to those who did not. This highlights the role of AI tools in fostering cognitive development, contributing to better learning outcomes and addressing the first research question.

6.4 Predictive Models for Online Learning

In online education, understanding and predicting student engagement is crucial. Verma et al. (2023) demonstrated the effectiveness of AI models in analysing teacher behaviours and movements in video conferencing to gauge student engagement. This use of AI to tailor educational content dynamically supports and enhances student engagement in online learning environments, aligning with the first research question.

7. Key Insights

This literature review highlights several significant impacts of AI and Large Language Models in education, which provide a comprehensive understanding of how these technologies can transform educational practices. The key insights from the review are as follows:

- Enhanced Personalized Learning: AI and LLMs create adaptive and personalized learning environments. These technologies allow for tailored educational experiences, improving student engagement and learning outcomes by addressing individual needs.
- Predictive Analytics for Student Success: The use of machine learning and predictive analytics effectively identifies at-risk students, enabling early interventions. These tools help institutions to proactively support students, reducing dropout rates and improving overall academic success.
- Innovative Teaching Methodologies: AI tools such as chatbots and virtual peers enhance teaching methodologies. By providing instant feedback, personalized support, and fostering interactive learning environments, these tools improve student motivation and cognitive skills.

- Improved Assessment Practices: LLMs streamline and enhance assessment processes by automating the evaluation of student work and providing detailed, evidence-based feedback. This improves the efficiency and effectiveness of assessments, supporting better learning outcomes.
- Ethical Considerations: The integration of AI in education raises important ethical issues, including data privacy, bias, and the authenticity of student work. There is a critical need for ethical frameworks to ensure responsible AI usage that maintains fairness and integrity in educational practices.
- Broader Implications for Minority Education: There is a noted gap in the literature concerning the application of AI in Historically Black Colleges and Universities.

8. Conclusion

The incorporation of Artificial Intelligence and Large Language Models in education is reshaping traditional educational practices, leading to more adaptive and personalized learning experiences. This literature review has highlighted several key areas where AI technologies have significantly impacted student engagement, achievement, and personalized learning within higher education institutions. By providing enhanced feedback mechanisms, predictive analytics, and innovative teaching methodologies, AI is transforming the educational landscape.

8.1 Implications for Practice

The results of this review offer several practical implications for educators and institutions:

- Integrating AI Tools: Educators should leverage AI to enhance interactive learning and support student engagement. These tools can provide immediate, personalized feedback, helping to keep students motivated and involved in the learning process.
- Customized Learning Plans: AI can offer personalized feedback and assessment, allowing educators to tailor educational content to meet individual student needs. This customization can help address diverse learning styles and improve overall student outcomes.
- Ethical Deployment: Institutions must address the ethical challenges associated with AI integration, such as data privacy, bias, and the authenticity of student work. Establishing clear ethical guidelines and frameworks is crucial to ensure that AI enhances educational outcomes without compromising integrity or fairness.

8.2 Future Research Directions

Future research should explore several areas to fully comprehend and employ the capabilities of AI in education:

- Broad AI Applications: More research is needed on AI applications across different educational levels and disciplines to understand the broader impacts. Investigating how AI can be used in primary, secondary, and higher education will provide insights into its versatility and effectiveness.
- Longitudinal Studies: Long-term studies are necessary to assess the effects of AI integration on student retention and success.
- HBCU Education: More focused research on AI applications in Historically Black Colleges and Universities is needed. Understanding how AI can support these institutions and address their unique challenges will be crucial for ensuring equitable access to AI-enhanced educational opportunities.

8.3 Final Thoughts

In conclusion, AI and LLMs hold great potential to transform education by fostering more personalized and engaging learning environments. However, it is critical to tackle the ethical considerations and ensure responsible AI usage to maximize the benefits for all students. By continuing to explore and understand the implications of AI in education, institutions can effectively leverage these technologies to enhance educational outcomes and student success.

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