The Contribution of Artificial Intelligence in the Domain of Education

Zongcheng Gu[a]
Shanghai Soong Ching Ling School, Shanghai, China

Keywords: Education, Natural Language Processing, Deep Learning, Intelligent Tutoring System, Reinforcement Learning, Artificial Intelligence.

Abstract: This paper explores the current roles of Artificial Intelligence (AI) in education, focusing on two key areas: Natural Language Processing (NLP) and Deep Learning (DL). NLP is enabling advancements in language assessment, automated essay grading, intelligent tutoring systems (ITSs), and personalized feedback tools. Through the use of transformer models, NLP is making strides in educational settings, including supporting non-English-speaking students and offering real-time analytics to enhance teacher-student interactions. Deep learning, with its multi-layered neural networks, is furthering personalized learning through performance prediction, classroom behavior monitoring, and reinforcement learning algorithms. These technologies help create adaptive learning paths that fulfill individual student needs. Nonetheless, this paper also discusses limitations and challenges regarding AI's presence in education, such as data bias, the complexity of AI models, ethical concerns regarding surveillance, and issues of accessibility persist. While AI tools promise greater collaboration between educators and technology, their growing role raises concerns about over-reliance, privacy, and fairness in educational outcomes. Looking forward, this paper exhibits future possibilities of AI, and suggested its integration into education should be evolved continuously, with a focus on personalized learning, enhanced explainability, and equitable access, while ensuring that human-centered design principles guide the progression and implementation of AI systems in education.

1 INTRODUCTION

In recent years, the field of education has undergone nonnegligible reformation, largely driven by the exploration of sufficient help from artificial intelligence (AI) technologies regarding teaching people. AI, with its ability to analyze enormous amounts of data and provide real-time feedback, has begun to revolutionize the way students learn and educators teach. Among the various subfields of AI, Natural Language Processing (NLP) and Deep Learning (DL) have emerged as key technologies that are reshaping educational practices. NLP, which focuses on enabling machines to understand and interpret human language, plays a crucial role in automating tasks such as essay grading, real-time feedback, and personalized learning. On the other hand, deep learning, a subset of machine learning that uses neural networks to analyze and predict complex patterns, has paved the way for intelligent tutoring systems (ITS), student performance prediction, and personalized learning paths.

As educational systems increasingly adopt AI-driven tools, the integration of NLP and DL is becoming more widespread. NLP facilitates a wide range of applications, from automating essay grading to creating interactive educational chatbots. Deep learning, on the other hand, drives the personalization of learning by enabling systems to analyze student performance and adjust learning paths accordingly. The integration of these technologies not only enhances the efficiency and effectiveness of educational tools but also brings a level of personalization and scalability previously unimaginable in traditional classroom settings.

For instance, NLP techniques have been applied to assess student writing, provide personalized feedback, and even assist teachers grading students work. Intelligent tutoring systems, powered by deep learning, are being deployed to offer customized

[a] https://orcid.org/0009-0009-0024-6063

Gu, Z.
The Contribution of Artificial Intelligence in the Domain of Education.
DOI: 10.5220/0013677100004670

In *Proceedings of the 2nd International Conference on Data Science and Engineering (ICDSE 2025)*, pages 5-10
ISBN: 978-989-758-765-8

learning experiences that adapt to the needs of individual students. The growing interest in these AI technologies in education reflects their potential to improve learning outcomes, enhance student engagement, and alleviate the burdens on teachers. However, despite the promise these technologies hold, there remain significant challenges, including concerns over data privacy, algorithmic bias, and the ethical implications of AI's growing role in education.

This paper aims to provide a comprehensive review of the applications of AI, particularly NLP and deep learning, in the field of education. The review covers the evolution of these technologies, their current applications, and the challenges associated with their integration into educational practices. Specifically, this paper examines how NLP is used in language assessment, feedback provision, and learning support, and how deep learning models are applied to create personalized learning experiences, predict student performance, and monitor classroom behavior.

The review synthesizes recent research, highlighting the ways in which NLP and deep learning are transforming education. Key applications discussed include automated essay grading systems, intelligent tutoring systems, recommender systems, educational chatbots, and sentiment analysis tools for assessing student engagement and performance. Through a detailed analysis of these systems, this paper explores both the opportunities and limitations posed by AI in educational contexts.

Moreover, the paper examines the ethical implications of AI use in education, particularly regarding issues of data privacy, fairness, and transparency. As AI systems become increasingly integrated into educational environments, the question of how to balance technological innovation with ethical responsibility becomes ever more critical. This review also identifies key areas for future research, emphasizing the need for further exploration into improving the accuracy of AI models, addressing biases in algorithms, and ensuring that AI tools are designed in ways that support, rather than replace, human educators.

By providing a thorough examination of AI technologies in education, this paper aims to contribute to the ongoing conversation about the role of AI in educational practices, offering both a critical perspective on its limitations and a hopeful outlook on its future potential.

2 AI APPLICATIONS IN EDUCATION

This section will discuss the utilization of AI in the current education system from two parts through analyzing past papers.

2.1 Natural Language Processing

Natural Language Processing (NLP) plays a pivotal role in the development of AI tools for education. As one of the most impactful subfields of AI, NLP enables machines to understand, interpret, and generate human language. This ability is leveraged across various educational applications, from automated essay grading to real-time feedback through intelligent tutoring systems (ITSs), enhancing both learning and teaching experiences. In this section, this review explores the core NLP techniques and their applications in education, focusing on key systems that support language assessment, writing instruction, and interactive learning environments.

Several recent studies highlight the diverse applications of NLP in educational settings. One of the uses of NLP in education is its ability to provide personalized support for both learners and educators. One of the recent paper explores how did people used three transformer-based models, mT5, BanglaT5, and mBART50, to solve Bengali mathematical word problems, advancing education for a low-resource language (Jashim Era et al., 2025). This work exemplifies how NLP models can be adapted to serve educational needs in diverse linguistic contexts, especially for languages with fewer resources. The use of NLP in such a context allows for automated problem-solving and the generation of educational content in a native language, breaking down barriers for students in non-English speaking regions.

Another critical application of NLP in education is in creating intelligent tutoring systems and feedback tools. One paper discusses the potential for AI to assist teachers by providing real-time analytics of student performance and offering personalized feedback based on NLP algorithms (Luckin & Holmes, 2016). Through real-time monitoring of student responses, NLP-powered systems can assess written texts, identify areas of improvement, and generate targeted suggestions. The role of NLP in providing instant feedback is invaluable in educational settings where timely interventions can significantly improve learning outcomes. Another example of NLP in intelligent tutoring systems (ITSs) offers great promise in adapting learning experiences

to individual student needs. Beck et al. emphasize that ITSs are designed to track student performance, using student models that represent individual learning paths. These systems adjust teaching strategies based on the pedagogical module, providing personalized instruction tailored to the student's progress (Beck et al., 1996). An example of this in practice is RECIPE, a writing platform that integrates ChatGPT to help students improve their writing. The platform, designed by Kim et al., uses NLP to offer real-time feedback and align instructional strategies with students' learning objectives, demonstrating the powerful synergy between AI and human-centered educational tools (Kim et al., 2024).

Furthermore, NLP techniques can enhance classroom communication and instructional strategies (Carey et al., 2010). NLP can help educators better understand students' needs, overcome language barriers, and adjust their teaching methods accordingly. NLP tools can even analyze student language patterns to detect learning struggles, making it easier for teachers to provide more personalized support. An application of NLP that is described to be useful in detecting and adjusting is used in automated essay grading (AEG). Maliha et al. introduce a Collaborative Deep Learning Model (CDLN) for AEG, which not only evaluates the grammatical structure of essays but also assesses the overall coherence and idea development (Maliha & Pramanik, 2024). This model has demonstrated an impressive accuracy of 85.50%, surpassing previous state-of-the-art systems. The ability to evaluate essays on multiple levels—both structure and content—makes AEG systems more nuanced and effective, offering personalized feedback to students (Maliha & Pramanik, 2024). A paper from Litman provides a detailed overview of how NLP methods are used to assess student proficiency in language skills, from syntactic analysis to semantic evaluation. NLP models are employed to detect errors in writing and speech, providing formative feedback to help students refine their language use. This is particularly useful in language learning environments, where consistent assessment and personalized feedback are crucial for student improvement (Litman, 2016).

In addition to these assessment applications, NLP is also crucial in chatbot-based learning environments. Khensous et al. discuss the use of educational chatbots that assist both students and teachers by offering personalized learning experiences (Khensous et al., 2023). Chatbots act as virtual tutors, providing real-time answers to students' questions and offering feedback on exercises. They reduce the teacher’s workload by automating repetitive tasks, while also supporting students in language learning, where personalized tutoring is key.

NLP has undoubtedly transformed education by enabling real-time feedback, enhancing assessments, and creating more engaging, personalized learning experiences. The research suggests that NLP-based systems can automate routine tasks such as grading and provide personalized feedback, which is crucial for maintaining engagement in large classes or online learning platforms (MOOCs). However, the effective implementation of NLP systems still requires careful attention to data quality, biases in algorithmic decisions, and the ethics of AI in education (Holmes & Miao, 2023). As NLP continues to evolve, future research must focus on improving accuracy, addressing the misuse of AI in academic settings (e.g., cheating), and ensuring human-centered design principles that prioritize the teacher-student relationship over automation (Kim et al., 2024; Litman, 2016).

2.2 Deep Learning

Deep learning is a subset of machine learning and has significant applications in education. By utilizing multi-layered neural networks, deep learning models can process complex data, learn from it, and make predictions or classifications with high accuracy. In the context of education, deep learning has been applied to student performance prediction, image and language recognition for monitoring student’s behavior, and personalized learning paths based on individual student needs. This section explores these applications and the role of deep learning in personalized education.

One promising application of deep learning is student performance prediction. Khensous et al. highlights how Recommender Systems (RS) can leverage deep learning algorithms to predict student performance based on data from their academic history and learning behavior (Khensous et al., 2023). These systems are designed to recommend appropriate learning materials, identify at-risk students, and suggest actions to improve academic performance. Such predictive tools have the potential to tailor educational interventions to individual students, ensuring that learning resources are matched to their needs (Beck et al., 1996) .

Deep learning is also making strides in classroom behavior monitoring. Recent developments in image recognition and video analysis use deep learning to track student engagement, identify patterns of behavior, and even assess classroom dynamics in real time. For instance, facial recognition systems can

gauge students' emotional states, providing valuable insights into their engagement levels. These technologies can help teachers adjust their teaching strategies or identify students who might require additional support (Luckin & Holmes, 2016) . While such tools are still in the early stages, they hold promise for creating real-time, data-driven feedback systems for teachers, enabling them to provide personalized interventions based on students' non-verbal cues. On the other hand, the researchers utilize deep learning algorithms to distinguish between human-written and AI-generated content (Najjar et al, 2025). This study highlights the growing role of deep learning in maintaining academic integrity in educational settings, a concern that is becoming more prominent as generative AI tools are used by students to complete assignments. Deep learning's ability to analyze large volumes of data and identify subtle patterns is instrumental in the detection of AI-generated content and ensures that academic institutions maintain rigorous standards.

Reinforcement Learning (RL), another branch of deep learning, is being increasingly used to design personalized learning paths for students. RL algorithms adapt to individual learning styles and adjust the learning process to maximize educational outcomes. For example, the adaptive learning systems powered by RL can guide students through problem sets at a pace that suits their learning speed, presenting more challenging tasks as they improve while offering easier ones when they struggle. This dynamic adjustment ensures that every student follows a learning path tailored to their unique needs (Maliha & Pramanik, 2024). For another instance, students in computing education are adopting deep learning-based models such as ChatGPT for problem-solving (Hou et al., 2024) . This shift from traditional help-seeking behavior (peer support, class forums, etc.) to AI-driven help reflects how deep learning systems, like large language models, are integrated into student learning as key tools for answering questions, generating ideas, and providing explanations. As students become more reliant on reinforcement learning models for educational support, these systems are poised to become foundational resources in learning environments, especially for more complex subjects like computer science.

The applications of deep learning in education point to a future where personalized learning is the norm. Deep learning models can process vast amounts of educational data, making it possible to create learning environments that are highly responsive to each student's progress. However, the challenge lies in data privacy, the ethical implications of using AI for prediction and surveillance, and the need for teacher involvement to interpret and act on the insights provided by AI systems (Kim et al., 2024) . As these systems become more sophisticated, educators must balance the benefits of automation with the need for human judgment and interaction in the learning process.

3 EXISTING LIMITATIONS AND FUTURE OUTLOOK

This section will introduce the existing limitations when utilizing AI for education and discuss the future potential of AI.

3.1 Existing Limitations

While AI applications in education, particularly those involving NLP and deep learning, hold great promise, several challenges remain. The first significant limitation is the data bias inherent in many AI systems. For example, deep learning algorithms rely heavily on large datasets, and if these datasets are not diverse or representative of all students, the systems may inadvertently reinforce existing biases, leading to inaccurate predictions or unfair grading (Khensous et al., 2023). Jashim Era et al. also further highlight the importance of training AI models on diverse datasets, but it also underscores the challenge of ensuring that AI models are not inadvertently biased against minority languages or non-English speakers (Jashim Era et al., 2025).

The second limitation is the complexity of AI models can sometimes make them opaque, leading to difficulties in understanding how decisions are made. This lack of transparency raises concerns about the accountability of AI in education (Litman, 2016). As seen by the work of Najjar et al., while AI models such as XGBoost and Random Forest demonstrate strong performance in distinguishing between human-written and AI-generated content, these models often operate as black boxes, making it difficult to understand how certain conclusions are reached (Najjar et al, 2025). This lack of interpretability is a significant concern for educators and students who need to understand how AI assessments or feedback are generated. The ability to explain AI decisions, particularly in educational contexts, is crucial for maintaining trust in these technologies.

The third limitation is the ethical concerns surrounding the use of AI in education. The increasing use of surveillance technologies, for example facial recognition and classroom monitoring tools, raises questions about student privacy and the potential for misuse of data. AI tools must be designed with ethical principles in mind, ensuring that student data is handled responsibly and that AI is used to support, rather than replace, human educators (Holmes & Miao, 2023) .

The fourth limitation is that While AI systems like ChatGPT and other generative models are becoming essential resources for students, there is a concern that over-reliance on these tools could undermine critical thinking and problem-solving skills. While students increasingly rely on AI tools for assistance, their engagement with traditional resources like peer support and class forums is decreasing (Hou et al., 2024). This shift could lead to students becoming passive learners, relying too heavily on AI for answers without developing the necessary skills to engage critically with material or collaborate effectively with peers.

The fifth limitation focuses on accessibility and equity. The widespread use of AI in education also raises issues of access and equity. Not all students have the same level of access to AI-powered tools, which can create disparities in educational outcomes (Najjar et al, 2025). Students from low-income backgrounds or regions with limited internet access may find it difficult to leverage AI resources, exacerbating the digital divide.

3.2 Future Outlook

The future of AI in education looks incredibly promising, with advancements in technology expected to address many of the current limitations. One of the most exciting developments is the increasing integration of AI-driven personalized learning systems. As noted by Holmes et al., AI can enable educators to cater to the individual needs of students, providing real-time feedback and customized learning experiences that adapt to each student's strengths and weaknesses (Luckin & Holmes, 2016). This will likely generate greater collaboration between AI systems and human educators, with AI playing a supportive role in assisting teachers with several tasks, including grading, providing feedback, and tailoring instruction to individual students (Beck et al., 1996). In the future, AI could help create highly personalized educational journeys, ensuring that every student receives the support they need to succeed.

In terms of AI tools for content generation and assessment, deep learning models will continue to evolve and improve, becoming more accurate in their assessments and more capable of offering personalized learning experiences. Hou et al. suggest that AI tools will become increasingly integrated into students' study habits, becoming indispensable for their academic success (Hou et al., 2024). Over time, these tools could even replace traditional learning materials or act as complementary resources to facilitate independent learning.

Moreover, the focus on explainability and transparency in AI models is expected to improve. As Najjar et al. highlights, the integration of Explainable AI (XAI) is crucial for ensuring that educators and students can understand and trust AI-driven assessments (Najjar et al, 2025) .

As AI becomes more embedded in education, it will also raise new ethical and regulatory challenges. In particular, educators and policymakers will need to address issues related to academic integrity, the potential for AI to perpetuate biases, and ensuring that AI is used responsibly and equitably. Ethical frameworks for AI in education must continue to evolve, with an emphasis on human-centered design that prioritizes the needs of students and educators over purely technological advancements (Kim et al., 2024).

4 CONCLUSIONS

In conclusion, AI applications in education, particularly those involving NLP and deep learning, hold immense potential to revolutionize the learning and teaching experience. These technologies enable personalized learning, real-time feedback, and efficient assessment methods, improving the educational process for both students and educators. NLP tools have demonstrated success in automating tasks like grading and providing individualized support, particularly in language learning and essay evaluation. Similarly, deep learning models are improving student performance prediction and behavior monitoring, offering insights that can guide instructional adjustments. However, despite these advancements, challenges such as data bias, model opacity, ethical concerns, and accessibility remain. The need for diverse and representative datasets, transparent AI systems, and responsible data handling is critical to ensure the fair and effective use of AI in education. Furthermore, the over-reliance on AI tools could undermine essential skills like critical thinking and collaboration. Looking forward, AI is expected to

continue evolving, offering more personalized and adaptable learning experiences while addressing current limitations. Nonetheless, its integration into education will require careful attention to ethical considerations, human-centered design, and the balance between technology and human input to ensure equitable and responsible use.

REFERENCES

Beck, J., Stern, M., & Haugsjaa, E. (1996). Applications of AI in Education. XRDS: Crossroads, The ACM Magazine for Students, 3(1), 11-15.

Carey, J., Churches, R., Hutchinson, G., Jones, J., & Tosey, P. (2010). Neuro-Linguistic Programming and Learning: Teacher Case Studies on the Impact of NLP in Education. Online Submission.

Holmes, W., & Miao, F. (2023). Guidance for generative AI in education and research. UNESCO Publishing.

Jashim Era, J., Paul, B., Sattar Aothoi, T., Rahman Zim, M., & Shah, F. M. (2025). Empowering Bengali Education with AI: Solving Bengali Math Word Problems through Transformer Models. arXiv e-prints, arXiv-2501.

Khensous, G., Labed, K., & Labed, Z. (2023). Exploring the evolution and applications of natural language processing in education. Revista Română de Informatică și Automatică, 33(2), 61-74.

Kim, M., Kim, S., Lee, S., Yoon, Y., Myung, J., Yoo, H., ... & Lee, T. Y. (2024). LLM-Driven Learning Analytics Dashboard for Teachers in EFL Writing Education. arXiv preprint arXiv:2410.15025.

Litman, D. (2016, March). Natural language processing for enhancing teaching and learning. In Proceedings of the AAAI conference on artificial intelligence (Vol. 30, No. 1).

Luckin, R., & Holmes, W. (2016). Intelligence unleashed: An argument for AI in education.

Maliha, M., & Pramanik, V. (2024). Hey AI Can You Grade My Essay?: Automatic Essay Grading. arXiv preprint arXiv:2410.09319.

Najjar, A. A., Ashqar, H. I., Darwish, O. A., & Hammad, E. (2025). Detecting AI-Generated Text in Educational Content: Leveraging Machine Learning and Explainable AI for Academic Integrity. arXiv preprint arXiv:2501.03203.

Hou, I., Nguyen, H. V., Man, O., & MacNeil, S. (2024). The Evolving Usage of GenAI by Computing Students. arXiv preprint arXiv:2412.16453.