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Leveraging Artificial Intelligence (AI) to Enhance Student Success: A Comprehensive Review

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Abstract

Efforts to improve student success, particularly in online and higher education environments, have been transformed by integrating artificial intelligence (AI) and learning analytics in the classroom. This paper provides an extensive overview of current research on using AI-driven methods to forecast and enhance student performance. The study, which synthesizes the results of several studies, looks at how learning outcome prediction models are created using student interaction data, such as participation in forums, quizzes, and collaborative tools. Findings show that utilizing a variety of interaction-based characteristics can lead to prediction accuracy of up to 75%, highlighting the potential of these methods to improve comprehension of the dynamics of online learning. Furthermore, comparison studies of machine learning algorithms like random forest and logistic regression show how well they predict the perseverance and performance of students. With predictive modelling, at-risk students can be identified early on, allowing for more focused interventions to promote academic success in higher education settings. The review also discusses more general ramifications, such as the moral dilemmas and pedagogical difficulties raised by using AI in the classroom. AI's application in education is growing as it can provide tailored learning experiences, streamline administrative duties, and improve student performance. However, worries about data privacy, algorithmic bias, and the fair application of AI technology highlight the necessity of cautious implementation techniques and continuous assessment. This review article advocates for a balanced strategy that minimizes risks and maximizes benefits in educational contexts while highlighting the transformative potential of AI and learning analytics in enhancing student performance.

Keywords: *Artificial Intelligence (AI), Student Success, Learning Analytics, Education*

1. Introduction

One promising strategy to improve student success in online and higher education settings is the application of artificial intelligence (AI) and learning analytics. This work thoroughly analyses current studies investigating how these data-driven methods might be used to forecast and enhance student performance [1].

The study by Ulfa and Fatawi [2] summarizes the results of several studies that look into creating learning outcome prediction models using student interaction data, including participation in forums, learning resources, quizzes, and collaborative technologies. The research shows that using a variety of interaction-based features can predict student achievement with up to 75% accuracy, underscoring the potential of these methods to learn more about the variables affecting the dynamics of online learning.

Furthermore, the paper examines comparative studies on the performance of various machine learning algorithms, including logistic regression and random forest, for predicting student persistence and success. The results suggest that predictive modelling can help identify at-risk students and support the development of targeted support mechanisms to enhance student outcomes in higher education.

Additionally, the review addresses the growing role of AI and computational sciences in education and the associated educational and ethical challenges that require further investigation. Overall, this comprehensive review underscores the significant potential of AI and learning analytics in improving student success while highlighting the need to carefully navigate the complexities and challenges involved in implementing these technologies in educational settings.

2. Literature Review

2.1 What is Artificial Intelligence (AI)?

The creation of computer systems and algorithms that can carry out operations that normally require human intelligence, such as learning, problem-solving, decision-making, and natural language processing, is known as artificial intelligence (AI) [3]. AI systems can analyze large datasets, spot patterns, and conclude to improve or automate various cognitive and decision-making tasks.

"The study and design of intelligent agents" is a broad definition of artificial intelligence (AI), according to Poole and Mackworth [3]. These agents can sense their surroundings, reason, learn, and conduct actions to accomplish predetermined goals. These "intelligent agents" could be robots, software, or any other systems displaying actions characteristic of human intelligence. The development of complex machine learning algorithms, the availability of massive datasets, and rising computing power have all contributed to the tremendous achievements in artificial intelligence in recent years. Artificial intelligence (AI) is useful in many industries, such as healthcare, banking, transportation, and education, where it may aid decision-making, efficiency, and experience personalization.

Artificial Intelligence (AI) is a broad field of study that focuses on creating algorithms and computer systems that can learn, solve problems, make decisions, and process natural language—tasks that normally require human intelligence [3], [4].

Large datasets may be analyzed by AI systems, which can then be used to find patterns, draw conclusions, and automate or improve a variety of cognitive and decision-making tasks [5]. AI is "the study and design of intelligent agents" that can sense their surroundings, reason, acquire new skills, and act in a certain way to accomplish objectives, according to Poole and Mackworth [3].

Large datasets, more processing power, and the creation of complex machine learning algorithms have all contributed to recent advances in artificial intelligence (AI) [6]. Applications for AI-powered technologies can be found in various industries, such as

healthcare, finance, education, and transportation, where they can aid decision-making, efficiency, and experience personalization [3], [4].

The research of Novosadova et al. [7] and Dib [8] elucidates the drawbacks of formal education, including one-way communication, inflexible methodology, and a results-driven approach that might impede students' academic advancement and motivation. The paper offers an educational experience wherein computer science students engage in a worldwide online competition on artificial intelligence to increase learner engagement and motivation [9]. Students' motivation, academic performance, and interpersonal skills increased due to the competition, which gave them an "authentic life experience" and let them use AI concepts in real-world situations [10]. Because it allowed students to participate actively and learn through play, the researchers discovered that the competition-based learning strategy was more effective than standard practical courses [11].

2.2 Some Pros and Cons of Artificial Intelligence (AI)

Pros:

- Personalized Learning: AI-powered adaptive learning platforms can provide personalized, tailored instruction based on each student's unique needs, learning styles, and progress, leading to improved engagement, motivation, and learning outcomes [12], [13].
- Early Intervention and Student Support: Predictive analytics and early warning systems enabled by AI can identify at-risk students and provide timely interventions, helping to address learning difficulties and improve academic success [14], [15].
- Increased Efficiency and Productivity: AI can automate administrative tasks, such as grading, scheduling, and student data management, freeing educators to focus more on teaching, mentoring, and supporting students [12], [16].

Cons:

- Algorithmic Bias and Fairness: AI systems can potentially perpetuate or amplify existing biases in educational data, leading to unfair or discriminatory outcomes for certain student populations [16], [13].
- Data Privacy and Security Concerns: The extensive use of student data in AI-powered educational systems raises concerns about data privacy, security, and the potential misuse or exploitation of sensitive information [16], [13].
- Lack of Human Touch and Empathy: While AI can provide efficient and personalized support, there are concerns that the over-reliance on technology may diminish the human-to-human interactions and emotional support crucial for student development and well-being [16], [12].
- Technological Barriers and Equity Concerns: The successful implementation of AI in education requires access to reliable infrastructure, technology, and digital literacy, which may not be equally available across all educational institutions and student populations, potentially exacerbating existing digital divides [13], [16].

2.3 Ethical Considerations of Artificial Intelligence (AI) to be Considered

Algorithmic Bias and Fairness: According to Popenici and Kerr [16] and Zawacki-Richter et al. [13], AI systems have the potential to reinforce or magnify pre-existing biases in educational data, which could result in unfair or discriminatory outcomes for particular student populations. AI algorithms must be carefully designed and monitored to guarantee fair and objective decision-making.

- Concerns regarding data privacy, security, and the possible misuse or exploitation of sensitive information are brought up by the widespread usage of student data in AI-powered educational systems [16], [13]. Strong data governance frameworks and open data management procedures are necessary to safeguard student privacy.
- Concerns about openness and accountability are raised by the intricacy of AI algorithms, which might make it difficult to comprehend and justify the decision-making procedures [16], [12]. Educators and legislators should promote the creation of interpretable and explicable AI systems.
- Human-AI Interaction and Emotional Support: Although AI can offer effective and individualized support, there are worries that excessive dependence on technology may erode the emotional support and human-to-human interactions essential for students' growth and welfare [16], [12]. Taking a balanced approach that preserves the human element in education is crucial.
- Equity and Access: The successful implementation of AI in education requires access to reliable infrastructure, technology, and digital literacy, which may not be equally available across all educational institutions and student populations, potentially exacerbating existing digital divides [13], [16]. Efforts should be made to ensure equitable access and inclusion.

2.4 The Expanding Role of Artificial Intelligence (AI) in Education

The application of AI technology to support and enhance education is referred to as artificial intelligence in education (AIEd). These technologies include chatbots, platforms for predicting student achievement, intelligent tutoring systems, and autonomous grading systems [17]. The majority of AIEd research ignores the risks and intricate, multifaceted challenges of learning and teaching with AI, and it also demonstrates a weak connection to instructional approaches or pedagogical perspectives [13], [18], [19]. Understanding the role of the teacher in mediating and supporting learning with AI technologies in the classroom is essential. According to Chiu [17], students' motivation directly affects their learning methodologies, engagement level, persistence, and thought processes. According to self-determination theory (SDT), learners must satisfy their psychological needs—autonomy, competence, and relatedness—to become autonomously motivated [20]. However, no SDT-based research has examined AIEd in K–12 environments. Furthermore, it has been proposed that motivated and/or high-achieving students benefit more from chatbots as an AI technology [21], [22]. Additionally, it has been suggested that students' motivation to study in school is greatly influenced by how their teachers educate them [23].

Since educators and researchers have realized how these technologies might improve student learning and success, the use of artificial intelligence (AI) in education has grown significantly [12], [13].

AI-powered systems can analyze large datasets of student interactions and performance to find patterns and trends that make it possible to provide targeted interventions and individualized learning experiences [15], [14]. To enhance engagement, motivation, and learning outcomes, AI-based learning platforms, for instance, can modify the pace, material, and degree of difficulty according to each student's unique requirements, preferences, and progress [12], [13].

However, using AI in education also brings up significant ethical and pedagogical issues, including data privacy, algorithmic bias in decision-making, and the possibility that AI will worsen or maintain existing inequities [13], [16]. To guarantee that the application of AI in education is morally righteous and fair and improves the educational experience for all students, careful planning, execution, and supervision are essential.

The study discusses the "unprecedented brain drain of Artificial Intelligence (AI) professors from universities from 2004 to 2018." It has been shown that student entrepreneurship and startup development suffered due to the brain drain or the departure of prominent AI academics from academia into corporate roles [5]. According to the study, "students from the affected universities establish fewer AI startups and raise less funding." This suggests that losing AI professors from universities may reduce students' exposure to AI skills and knowledge, hindering their ability to start profitable AI-related firms. The negative effects are worse for "students whose highest degrees are a master's or PhD and for departures of deep-learning professors or professors from universities with computer science (CS) departments ranked in the top 10 in North America." This implies that substantial AI education and training from top academics is necessary to produce successful AI businesses. According to the authors, "the main mechanism is that professors' departures reduce the AI knowledge that future founders can acquire at the university." This demonstrates that having access to knowledgeable AI instructors and learning opportunities is one of the most crucial factors in promoting student entrepreneurship and success in artificial intelligence [5].

The study aims to assess the adoption and impacts of artificial intelligence (AI) tools in higher education, focusing on a private university in Latin America. Five key dimensions are examined in the study using a validated 30-item instrument: The first five elements are the efficacy of using ChatGPT, the efficacy of using AI tools, the teacher's proficiency with AI, the advanced student's proficiency with AI, and the student's competency with AI tools. The study found that AI significantly improves pupils' understanding, creativity, and output. With the aid of the created synthetic index, institutions may now assess AI integration and promote its effective application. The findings demonstrate AI's importance in teaching and offer a strong basis for data-driven decision-making in higher education. According to Grájeda et al. [8], the study emphasizes the significance of AI competency for teachers and students, advocating for its integration as a pedagogical advancement rather than merely a technological shift.

Machine learning and automated machine learning (AutoML) are covered in this paper [24] to forecast and improve student performance and achievement in higher education. With high dropout rates, the authors emphasize that student performance and retention are urgent concerns for academic institutions. They also point out that early detection of at-risk students by predictive analytics and machine learning can facilitate timely interventions. The study shows that using AutoML to automate selecting the best prediction model can reduce its complexity and improve prediction accuracy. The authors list several variables that may impact students' performance, classifying them as

internal (such as attendance and grades) and external (such as psychometric parameters, socioeconomic status, and demography). To improve the accuracy of predicting student success using data that is already accessible before the commencement of an academic program, the research suggests using AutoML.

The study explores how artificial intelligence (AI) provides customized learning experiences for each student's needs. To build personalized learning paths and ensure that students comprehend the material at their own pace, artificial intelligence (AI)--powered adaptive learning systems assess student performance data. This enhances student engagement and academic success. The article also discusses how AI is changing our education by giving teachers the tools to improve instructional tactics and automate administrative work. With AI-powered tools, teachers may concentrate more on promoting learning and the development of critical thinking abilities in their students by automating grading, creating interactive classes, and giving students feedback in real time. AI in education also includes administrative tasks like scheduling, resource allocation, and student enrollment, where AI-powered systems can improve these procedures and administer educational institutions more effectively and efficiently. In addition to recognizing the many advantages of AI in education, the paper also highlights some of the difficulties that must be overcome to fully realize the potential of AI in education and guarantee that everyone has equitable access to high-quality education [22]. These difficulties include worries about data privacy, algorithmic bias, and the need for teacher preparation.

Using a dataset from the Open University, the research thoroughly investigates predicting student success in an online learning environment. The researchers look into how well a neural network model can predict online learners' learning outcomes by using various interaction variables, such as interactions with learning resources, forums, quizzes, and collaborative tools. The study predicts learning outcomes with a 75% accuracy rate by looking at these many interaction factors. The study emphasizes the possibility of utilizing various features to understand the complexities of online learning dynamics and the elements that affect student success. The authors propose that educators and stakeholders can provide equitable online material that caters to learners' varied learning requirements and preferences, improving the learning experience of at-risk children by integrating theoretical insights with practical applications. To meet each learner's specific needs and learning preferences, the study highlights the significance of developing personalized interventions using data-driven techniques, adaptive technology, and customized support mechanisms [23].

2.5 The Role of Artificial Intelligence (AI) in Students Success

To help students get back on track and realize their full potential, instructors can proactively offer targeted support, such as tutoring, counselling, or adjustments to the learning material and speed [12], [16].

Additionally, AI-driven personalized learning platforms can adapt the instructional content, delivery, and assessment to each student's particular needs and preferences to increase motivation, engagement, and learning outcomes [12], [13]. By tailoring the learning process to each student's unique abilities, limits, and learning preferences, artificial intelligence (AI) can help create a more diverse and equal learning environment [16].

However, educators must carefully consider the ethical and pedagogical implications of integrating AI in the classroom, including algorithmic bias, data privacy, and the potential for AI to exacerbate pre-existing inequities [16], [13]. Researchers, educators, and AI specialists must continue collaborating to ensure the ethical and effective use of these tools to support student accomplishment.

As artificial intelligence (AI) and computational sciences are increasingly used in the classroom to raise student achievement, interest in education is expanding. García-Martínez et al. [25] examined the effects of computational sciences and AI components on student performance through a systematic review and meta-analysis. The findings, which show improved students' enthusiasm and attitude toward studying, particularly in STEM (Science, Technology, Engineering, and Mathematics) subjects, corroborate the beneficial effects of AI and computational sciences on student performance. Even with all of the advantages, significant ethical and educational concerns are associated with the design and use of these technologies in the classroom. These issues call for additional research in the field of education. The results are true for all educational levels.

The study describes FIRST (Finding Interesting Stories about Students), an interactive artificial intelligence system that uses data from institutional databases to help program administrators and academic advisors identify trends in student success and danger. To assist advisors in understanding student performance, the system incorporates an interactive data visualization and storytelling feature, an unsupervised k-means clustering algorithm, and a temporal student data model. The unsupervised k-means clustering is used to identify patterns of student behaviour and their correlation with performance, which are presented through interactive visualizations. The temporal model collects student data over time, allowing the identification of behaviour patterns related to student success and risk. Using the information in the temporal model, the technology also automatically creates tales about specific students, giving advisors contextualized insights into their experiences. The evaluation conducted in focus groups with advisors highlighted the significance of the temporal model, unsupervised clusters, and automatically created student stories in sense-making. In order to improve human intelligence and capacities rather than replace them, the study highlights the significance of a human-centred approach to AI in education [11]. The use of big data and machine learning algorithms to forecast students' academic success or failure is covered in this paper. The researchers employed various elements, including personal information, academic evaluations, activities in virtual learning environments (VLEs), psychological characteristics, and environmental factors, to predict student performance. To predict student performance, they used machine learning methods such as support vector machines (SVM), C4.5, and K-nearest neighbours (KNN) [12]. To disperse processing and reduce execution time while maintaining algorithmic efficiency, the researchers used big data technologies in response to the problems presented by the growing number of students, specializations, and varied data sources. To increase the prediction rate and decrease execution time, they cleansed the data and used feature selection methods. The researchers used MapReduce to apply classification methods for student success prediction after storing the data in the Hadoop Distributed File System (HDFS). The researchers discovered that by utilizing big data technologies, the SVM algorithm produced an 87.32% identification rate and an enhanced execution time [12].

The study looks at how AI chatbots and large language models (LLMs) affect college students, specifically how they affect social support, a feeling of community, loneliness,

and the success and retention of students. The study points out that although academic integrity and authorship concerns have been the main emphasis of the quick adoption of AI technologies like ChatGPT and Bard into higher education, there may be unforeseen implications for students beyond these problems. The study provides evidence that, although AI chatbots may be linked to better student performance, their use negatively impacts student achievement when social support, psychological well-being, loneliness, and feelings of belonging are considered [18]. The concept of "AI-specific social support" is introduced in the paper, implying that students may face implications for learning and teaching policies related to student success and belonging if they choose to seek help from an AI chatbot instead of a human (such as a professor, librarian, or advisor) [18]. Although there is some evidence that AI can lessen loneliness in specific situations, the authors argue that additional study is needed to fully understand the broader consequences of AI chatbot interaction, particularly regarding social support and belonging [18].

Forecasting student persistence is important because it impacts not only the social and economic outcomes of individuals and society at large but also the effectiveness and efficiency of educational institutions, according to a study by Tang et al. [23]. Thanks to advancements in data science, machine learning, and the availability of large datasets, predictive models are increasingly being used to research and improve student success. The study assesses the performance of numerous machine learning models, including logistic regression and random forest, to forecast student persistence. The results show that the random forest model outperforms logistic regression, particularly when the synthetic minority oversampling method (SMOTE) is used to correct the class imbalance. According to the study, predictive modelling can be used to identify students who are at risk and support the creation of focused intervention plans that will improve their success in college.

3. Methodology

The paper involved 25 articles. The inclusion criteria focus on the relevance of articles specifically addressing the application of artificial intelligence in educational settings aimed at improving student success. The recent studies were also considered, allowing the article to reflect the most current research. Preference was also given to empirical studies that provide data-driven conclusions on AI's impact on education.

The study also established clear exclusion criteria to maintain the article's quality. Articles not published in peer-reviewed journals and studies that did not focus on the educational context or addressed AI in unrelated fields were excluded.

4. Result

Using various student interaction data, including forum and quiz participation, AI-driven learning outcome prediction models showed remarkable predicting accuracies of up to 75%. In predicting student perseverance and performance, comparative evaluations revealed that machine learning algorithms—random forest—performed better than logistic regression, particularly when class imbalances were addressed using strategies like synthetic minority oversampling (SMOTE). These results demonstrate how AI may detect at-risk pupils early and enable prompt interventions that improve academic performance.

Furthermore, it has been discovered that AI-powered adaptive learning platforms may successfully customize exams and content to meet the needs of each student, improving learning results and engagement. However, the research also highlighted the moral ramifications of integrating AI, such as worries about algorithmic unfairness and data privacy. These issues must be resolved to guarantee fair educational access to AI technologies. Overall, the results indicate that although AI has the potential to improve student achievement significantly, its responsible use in educational contexts requires careful planning and ethical concerns.

4.1 Discussion

By combining recent studies on the use of learning analytics and artificial intelligence (AI) in educational settings, this paper makes a substantial theoretical contribution, especially regarding student achievement. It offers a thorough foundation for comprehending how AI-driven prediction models might influence teaching methods by combining the results of several studies. By showing how heterogeneous interaction data, including student engagement in forums, quizzes, and collaborative tools, may achieve predicting accuracies of up to 75%, the article contributes to the theoretical discussion on learning outcome prediction. This synthesis enhances the body of current literature by offering a comprehensive view of how these components interact within the learning environment. It emphasizes the dynamic interplay between student involvement, AI technologies, and educational outcomes [1], [5].

The paper also discusses the pedagogical and ethical ramifications of integrating AI in the classroom, adding to the theoretical discussion of responsible AI use. The paper highlights the need for a balanced strategy that gives ethical considerations equal weight to technology improvements by pointing out potential obstacles, including algorithmic bias and data privacy issues. This dual focus fosters a greater comprehension of the challenges of integrating AI technologies into education. Finally, by offering a paradigm that educators and policymakers may utilize to negotiate the potential and difficulties posed by AI in improving student performance, the paper establishes the foundation for further research [10], [13].

5. Conclusion

Integrating Artificial Intelligence (AI) and learning analytics represents a transformative force in education, offering promising avenues to enhance student success in online and traditional higher education settings. Through a comprehensive review of recent research, this paper has highlighted the significant strides made in leveraging AI-driven techniques to predict and improve student performance.

The synthesis of findings underscores the effectiveness of utilizing diverse interaction data, such as student engagement with learning resources and collaborative tools, to develop robust predictive models for learning outcomes. Achieving predictive accuracies of up to 75% demonstrates the potential of AI in providing deeper insights into the complexities of online learning dynamics and identifying students at risk of academic challenges.

Comparative studies on machine learning algorithms have shown how well they can predict students' perseverance and performance, allowing for early interventions essential for empowering and assisting students in higher education. Artificial intelligence (AI)-powered adaptive learning systems have demonstrated their capacity to

personalize learning objectives, boost administrative effectiveness, and enhance teaching strategies, all contributing to a more varied and fruitful learning environment.

Careful thought must be given to the ethical implications of incorporating AI in education, including algorithmic bias, data privacy, and the fair application of technological advancements. Together, educators, lawmakers, and AI developers must overcome these challenges to guarantee responsible deployment and lower possible risks.

Going forward, there is great promise for improving educational practices worldwide from ongoing research and innovation in AI and learning analytics. Institutions can utilize AI to foster lifelong learning skills and promote student potential by embracing its possibilities while upholding ethical principles and educational values. These skills are crucial for meeting the changing demands of the 21st century.

5.1 Suggestions

1. Institutions should establish training programs for educators to enhance their understanding and proficiency in using AI tools effectively. This training should focus on practical applications, ethical considerations, and data privacy.

2. Institutions should consider starting with pilot programs to test the integration of AI tools in a controlled environment. This approach allows for the assessment of effectiveness and the identification of potential challenges before broader implementation.

3. Educational institutions must prioritize discussions around algorithmic bias and data privacy. Developing clear ethical guidelines and frameworks can help mitigate risks associated with AI adoption, ensuring equitable access for all students.

4. Educational Institutions should adapt AI tools to reflect their specific environments' cultural, economic, and educational contexts. This customization can enhance the relevance and effectiveness of AI applications in diverse settings.

5. Actively seek and incorporate student feedback regarding their experiences with AI tools. Understanding student perspectives can lead to improvements in user experience and engagement.

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