Use of Artificial Intelligence in Education: A Systematic Review

Nixon Duarte, Yury Montoya Pérez, Adán Beltrán
Faculty of Engineering
Corporación Universitaria Remington
Medellín, Colombia
nixon.duarte@uniremington.edu.co, yury.montoya@uniremington.edu.co,
adan.beltran@uniremington.edu.co

Matilde Bolaño García
Faculty of Education Sciences
Universidad del Magdalena
Santa Marta, Colombia
mbolano@unimagdalena.edu.co

Abstract

The use of Artificial Intelligence (AI) in education has received increasing attention in recent years. AI has been used to enhance personalized learning, feedback, and student evaluation. However, there are challenges and limitations associated with its use, such as the quality of data used and the need for training and skill development for educators and students. In the last 5 years, there has been an exponential increase in interest in the use of AI in education, and the top 20 cited articles cover a wide range of topics related to the application of AI in education. One area of focus is the use of AI in early prediction of academic failure. AI can help identify students at risk of dropping out of school by analyzing large amounts of data such as grades, attendance, classroom behavior, and other factors that may affect academic performance. In conclusion, AI offers great potential to improve the efficiency and effectiveness of the teaching-learning process in education by providing personalized and adaptive feedback to students, provided that the challenges and limitations are effectively addressed and transparency and ethics in its use are ensured. AI can be a valuable tool to improve education and prepare students for the future.

Keywords
Artificial Intelligence, desertion, education, learning, teaching.

1. Introduction
Artificial Intelligence (AI) is a technology that has revolutionized many fields, including education. AI is increasingly being used in the classroom to provide personalized learning experiences and improve administrative efficiency. AI can be used to analyze and process large amounts of student data and provide personalized feedback on their learning progress, adapting course content to individual student needs. It can also significantly improve students' academic performance by providing personalized learning experiences. Additionally, AI can be used to automate administrative tasks, allowing educators to focus on teaching and interacting with students.

However, there are challenges and limitations in the use of AI in education. One of the main challenges is the quality of data used by AI. If the data is inaccurate or biased, this can negatively impact the accuracy of learning recommendations and feedback provided to students. There are also concerns about the privacy and security of student data, especially in relation to the use of machine learning technologies. Additionally, the use of AI in education raises ethical and social issues. A study published in the Ethics and Information Technology journal highlighted that the use of AI in education may widen the equity gap among students, as students who have access to advanced AI technologies may have an advantage over those who do not (Bostrom and Yudkowsky 2014). There are also concerns about the impact of AI on the role of the educator and interpersonal interaction in the classroom.

In conclusion, the use of AI in education has the potential to transform the learning experience by providing a personalized experience and improving administrative efficiency. However, it is important to address the challenges and limitations associated with the use of AI in education to ensure its long-term success. Further research and development are required to improve the quality of data used by AI and address ethical and social concerns related to its use in education.

1.1 Objectives

The objective of this systematic review article is to analyze and synthesize the scientific literature on the use of artificial intelligence in education, to identify the benefits, challenges, and limitations associated with its use in different educational contexts. It also aims to evaluate the potential of AI to improve personalized learning, feedback, and student assessment, and to examine how AI can help identify students at risk of academic failure. In addition, it intends to identify the areas of focus and gaps in current research, to guide future research work by the research group and its respective researchers.

2. Literature Review

2.1 Feedback in Real Time

Real-time feedback is one of the most promising applications of artificial intelligence in education. AI can provide immediate and personalized feedback to students, which can significantly enhance their learning process. Real-time feedback is a way of providing information about students' performance in a timely manner, which can help them improve their skills and knowledge. According to D'Mello and Graesser (2010), real-time feedback is a key aspect of effective learning and has been shown to improve students' performance in a variety of educational contexts. Real-time feedback can be particularly useful for practice and problem-solving activities, as students can receive immediate feedback on their performance and adjust accordingly.

Real-time feedback can also be personalized to suit the individual needs and abilities of students. Artificial intelligence can analyze students' performance and provide specific and relevant feedback that addresses their strengths and weaknesses. According to VanLehn (2011), personalized feedback can help students better understand the material and maintain their motivation to learn. Additionally, real-time feedback can be a valuable tool for teachers. Teachers can use real-time feedback to assess students' performance and provide additional guidance and support. Real-time feedback can also be useful for monitoring students' progress and making adjustments in teaching to better meet their needs.

2.2 Personalization of Learning

Personalized learning is an educational practice that focuses on adapting teaching content to the individual needs, interests, and abilities of each student, with the aim of improving their learning and academic performance. In this sense, AI presents itself as a promising tool for personalized learning, as it can analyze large amounts of data and generate recommendations and suggestions automatically and in real-time. Currently, there are various AI applications that offer personalized learning at different educational levels. For example, in primary and secondary education, some AI platforms use educational games and quizzes to assess students' level of knowledge and adapt teaching content to their specific needs. In higher education, some universities use AI systems to analyze students' behavioral patterns and generate course and subject recommendations that fit their interests and abilities.

An example of an AI platform for personalized learning is Smart Sparrow, which offers personalized courses and educational resources for higher education. This platform uses AI technologies, such as machine learning and data analytics, to tailor teaching content to the individual learning needs and styles of each student. It also allows teachers to monitor their students' progress and make real-time adjustments to improve their learning. Another example of an AI tool for personalized learning is Duolingo, a language learning app that uses AI technologies to adapt teaching content to the individual skills and needs of each user. Duolingo uses a machine learning algorithm to identify students' strengths and weaknesses and offer specific exercises and lessons to improve their learning.

2.3 Identification of Students at Risk of Dropping Out of School

School dropout is a global problem that affects millions of students worldwide and has become one of the biggest concerns of educational systems. To address this issue, artificial intelligence has proven to be an effective tool for early identification of students at risk of dropping out of school. One way that artificial intelligence can help identify

students at risk of dropping out of school is by analyzing large amounts of data, such as grades, attendance, classroom behavior, and other factors that can affect academic performance. Artificial intelligence can use machine learning algorithms to detect patterns in this data and predict which students are at higher risk of dropping out of school.

In addition, artificial intelligence can also provide educators with tools to intervene early with students who show signs of dropping out. Artificial intelligence systems can alert teachers about students who need additional attention and provide specific recommendations for appropriate interventions to help these students succeed academically and avoid dropping out. A study conducted by Li et al. (2019) in China demonstrated that using artificial intelligence to identify students at risk of dropping out had a positive impact on student retention. Another study by Koutsiamanis and Tsioukas (2018) in Greece found that combining artificial intelligence and personalized support for students at risk of dropping out significantly improved the school retention rate.

2.4 Educator Efficiency Improvement

Artificial Intelligence (AI) has been widely used in education to improve the efficiency and effectiveness of the teaching and learning process (Coccoli 2020) (Lee et al. 2019). One of the most prominent applications of AI is assisting educators in performing their daily tasks, allowing them to spend more time on teaching and interacting with students (Dutta and Mandal 2019). AI can be used to automate administrative and assessment tasks such as automatic test correction, scheduling, and generating student progress reports (Blikstein et al. 2019). With the use of machine learning systems and data analytics, AI can analyze students' progress and learning patterns and provide personalized recommendations to help educators create teaching plans tailored to each student's needs (Mao et al. 2019) (Xing et al. 2021).

The Intelligent Tutoring System (ITS) is a type of AI system that has been used in education to provide personalized feedback and support to students (D'Mello and Graesser 2012) (Vanlehn et al. 2005). However, it is important to note that the implementation of AI in education also has its challenges and limitations (Wang and Li 2020). The quality of the data used for analysis and feedback can be limited if not collected properly (Baker and Siemens 2014). Additionally, some educators may feel uncomfortable with the automation of certain tasks and the dependence on technology in the teaching-learning process. In summary, AI can be a valuable tool to improve the efficiency and effectiveness of educators in teaching and supporting students (Coccoli 2020) (Lee et al. 2019) (Mao et al. 2019) (Xing et al. 2021). However, the challenges and limitations must be considered to ensure proper and effective implementation of AI in education (Baker and Siemens 2014) (Wang and Li 2020).

2.5 Challenges and Limitations

According to López-Ramos and Ramírez-Gómez (2021), artificial intelligence (AI) has been increasingly used in the educational field to improve the efficiency and effectiveness of the teaching-learning process. However, its implementation also presents challenges and limitations that must be considered to ensure proper and effective use.

One of the main challenges is the quality of the data used for analysis and feedback. For AI to provide personalized and accurate recommendations, data must be collected properly and be representative of the students. If the data is inaccurate or irrelevant, AI can provide incorrect or ineffective feedback, which can negatively affect students' education.

Some educators may feel uncomfortable with the automation of certain tasks and the dependence on technology in the teaching-learning process. AI can make educators feel insecure about their own role in education and they may fear that AI will replace the human interaction necessary for quality education.

AI can be costly and requires technical and human resources for implementation and maintenance. The investment in AI technology may be too expensive for some educational institutions and therefore limit its adoption.

Regarding limitations, one of the main ones is the lack of understanding of the algorithms used by AI. Many educators and students do not understand how AI algorithms work and how collected data is used to generate recommendations. This can lead to a lack of confidence in AI and ultimately a decrease in its effectiveness.

Another important limitation is the privacy and security of students' data. Collecting personal data and implementing AI in education can raise concerns about the privacy and security of students' data, especially if this data is shared or sold to third parties.

Despite the challenges and limitations, AI remains a valuable tool for improving education. The key to its successful implementation is to effectively address these challenges and limitations and ensure transparency and ethics in its use (López-Ramos and Ramírez-Gómez 2021).

3. Methods

A qualitative research methodology was used, applying a document or bibliographic research technique, defined in 5 stages. In the first stage, the field of study was identified as "Artificial Intelligence in Education," without restriction on the period to be analyzed. In the second stage, Scopus was chosen as the source of information because it is a robust and reliable database, considered one of the largest bibliographic databases of peer-reviewed literature, including scientific journals, books, and conference publications. In the third stage, the search was carried out according to the following equation: TITLE-ABS-KEY ("Artificial Intelligence in Education"), which yielded a total of 377 publications to date. In the fourth stage, management and purification of the results obtained from the search equation were performed, using Scopus' search results analysis tool, VOSviewer, and Excel. Finally, in the fifth stage, the analysis of the results was carried out.

4. Data Collection

4.1 Publications by Years

As can be seen in Figure 1, according to the search equation, the first article was published in 1976 and the average publication rate until 2010 was 1.2 articles per year. Between 2011 and 2020, the average publication rate was 12.7 articles per year, while between 2021 and 2023 the average publication rate is 69 articles, considering that, in this last time interval, only two years have passed, since at the time of this query, 2023 is starting and ending its second month of the year. This demonstrates a strong trend and research interest in the use of artificial intelligence in education, since 2021 and coinciding with the COVID-19 pandemic.

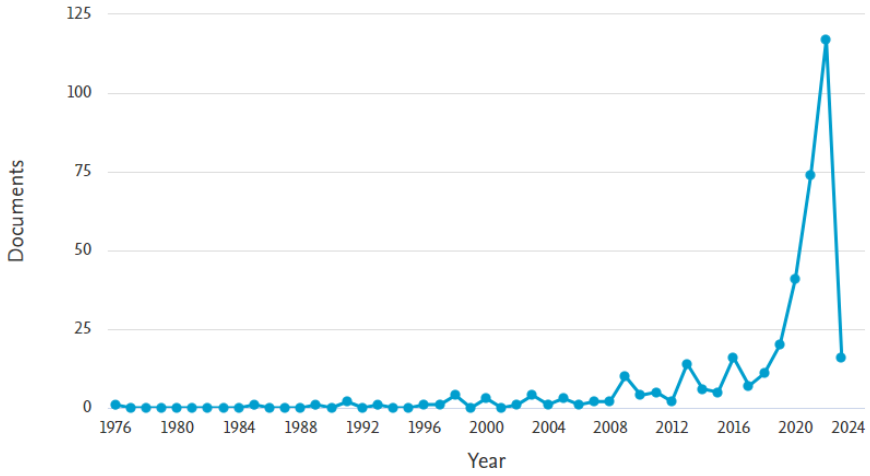

Figure 1. Documents per year

The 5 most cited articles published in 2022 explore the following topics: with 44 citations, Holmes et al. (2022) addresses the ethical challenges related to the use of artificial intelligence in education. The authors propose a community ethical framework to guide responsible implementation of AI in education, with the goal of ensuring transparency, equity, and protection of students' rights. X. Chen et al. (2022), with 38 citations, provide a review of the last 20 years of research on artificial intelligence in education, highlighting advances and challenges in the field. The authors identify emerging research topics, as well as challenges and opportunities for the future of AI in education. With 24 citations, Khosravi et al. (2022) explore the limitations and challenges of AI in education and propose an explainable AI approach to enhance students' and educators' confidence and understanding in using the technology. Ouyang et al. (2022), with 12 citations, present a systematic review of empirical research on the use of artificial intelligence in online higher education. The authors identify the most common themes in the literature and discuss the implications and challenges of using AI in online education. Lameras and Arnab (2022), also with 12 citations,

examine how artificial intelligence can empower teachers in their teaching practice. The authors review the benefits and challenges of implementing AI in education and propose a framework to help teachers effectively integrate AI into their classes and improve student learning.

4.2 Top 10 Publications by Country

According to Figure 2, among the top 10 countries with the highest number of published documents, the United States ranks first with 64 publications, China second with 53 publications, the United Kingdom third with 42 publications, Canada and India tied for fourth place with 24 publications, Australia fifth with 20 publications, Germany sixth with 19 publications, Brazil and Spain tied for seventh place with 15 publications, Hong Kong eighth with 14 publications, Taiwan ninth with 12 publications, and Malaysia tenth with 8 publications.

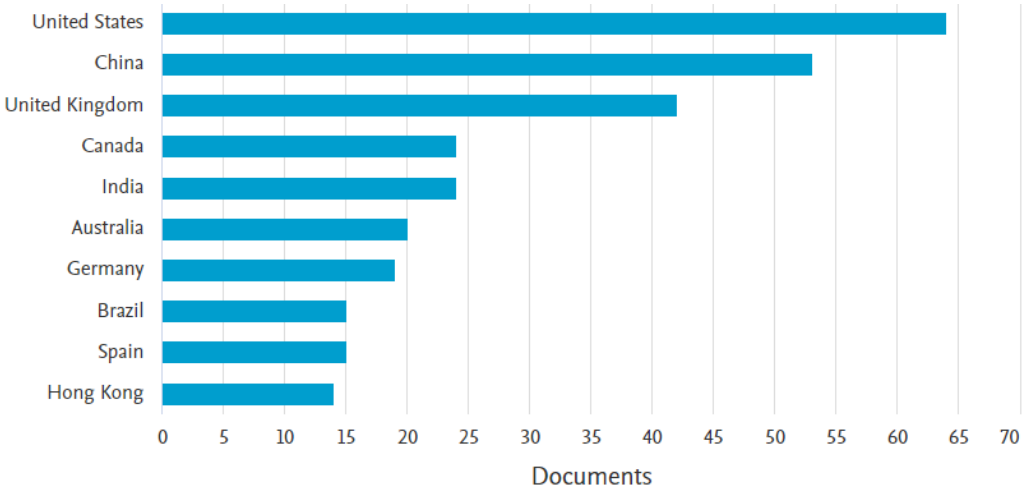

Figure 2. Publications by country

4.3 Top 10 of the Most Productive Authors

See Figure 3, the author with the highest production is Ouyang, F. with 6 documents, in second place are Aleven, V., Koedinger, K.R., Xie, H., with 5 documents, and in the third position are Chen, X., Conati, C., Cukurova, M., Gašević, D., Jiao, P., Kay, J., with 4 published documents.

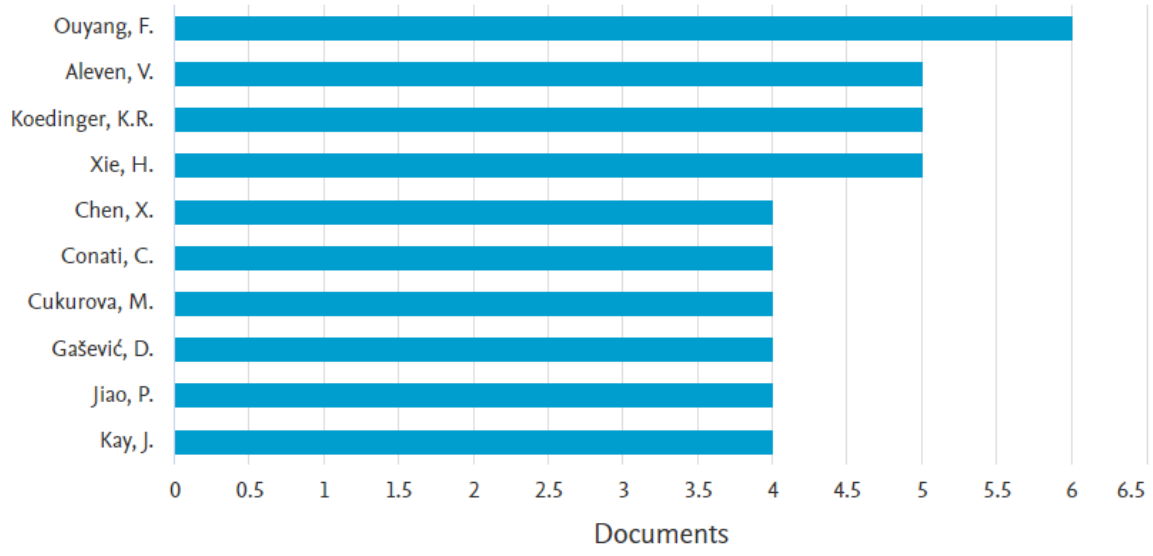

Figure 3. Most productive authors

The authors' articles address general topics related to the application of artificial intelligence (AI) in education. Some, such as Xu and Ouyang (2022b), Ouyang et al. (2022), and Xu and Ouyang (2022a), focus on the systematic review of studies on the use of AI in higher education and STEM, while others present conceptual frameworks for understanding the role of AI in the educational system. Additionally, specific uses of AI in engineering are investigated, both in improving learning and designing intelligent systems for engineering education. In general, common themes include analyzing the benefits and challenges of using AI in education, identifying critical success factors, and exploring new opportunities and possibilities that AI offers for improving education.

Furthermore, they investigate topics related to education and learning, addressing different aspects of using artificial intelligence in education, such as creating intelligent tutors, organizing learning problems, implementing competitive games to improve learning, and reflecting on the ethical and communal framework necessary for using AI in education. Additionally, the articles generally address the need for an interdisciplinary approach to address the challenges and opportunities in using artificial intelligence in education.

4.4 The 20 Most Cited Publications

The 20 most cited articles, Table 1, cover a wide range of topics related to the application of Artificial Intelligence (AI) in education. A common theme throughout these articles is the potential for AI to revolutionize the way we teach and learn. However, challenges persist in terms of effectively integrating AI into education and ensuring that educators remain at the center of the process. One area of focus is the use of AI in early prediction of academic failure in programming courses. They also evaluate the effectiveness of data mining educational techniques for this purpose. Another area of focus is the potential of AI to support collaborative learning and electronic debates.

Additionally, it analyzes the use of AI in Massive Open Online Courses (MOOCs). While MOOCs have the potential to reach a large audience, there are challenges related to ensuring that students receive personalized attention and feedback. Other articles focus on the technical aspects of AI in education, including the development of semantic web-based educational systems and domain ontologies from text. In addition, the potential of AI to support surgical and medical training is explored. A recurring theme is the importance of human-centered AI in education. AI should not replace human educators, but support and enhance their efforts. Ultimately, the reviewed articles highlight the many potential benefits of AI in education, but also recognize the need for ongoing research and collaboration between educators and AI experts.

Table 1. Most cited publications

Document Title	Year	# Quote
Systematic review of research on artificial intelligence applications in higher education – where are the educators? (Zawacki-Richter et al. 2019)	2019	328
Evaluating the effectiveness of educational data mining techniques for early prediction of students' academic failure in introductory programming courses (Costa et al. 2017)	2017	240
Evolution and Revolution in Artificial Intelligence in Education(Roll & Wylie 2016)	2016	201
MOOCs: So many learners, so much potential.(Kay et al. 2013)	2013	163
Artificial Intelligence in Education: A Review(L. Chen et al. 2020)	2020	147
Vision, challenges, roles and research issues of Artificial Intelligence in Education(Hwang et al. 2020)	2020	141
Letting Artificial Intelligence in Education out of the Box: Educational Cobots and Smart Classrooms(Timms 2016)	2016	141
Application and theory gaps during the rise of Artificial Intelligence in Education(X. Chen et al. 2020)	2020	133
STyLE-OLM: Interactive open learner modelling(Dimitrova 2003)	2003	129
Face-to-Face Interaction with Pedagogical Agents, Twenty Years Later(Johnson and Lester 2016)	2016	108
SMILI: A Framework for Interfaces to Learning Data in Open Learner Models, Learning Analytics and Related Fields(Bull and Kay 2016)	2016	95
A computational model for developing semantic web-based educational systems(Bittencourt et al. 2009)	2009	77
BEETLE II: Deep natural language understanding and automatic feedback generation for intelligent tutoring in basic electricity and electronics(Dzikovska et al. 2014)	2014	71
Supporting collaborative learning and e-discussions using artificial intelligence techniques(McLaren et al. 2010)	2010	71
The virtual operative assistant: An explainable artificial intelligence tool for simulation-based training in surgery and medicine(Mirchi et al. 2020)	2020	67
Knowledge elicitation methods for affect modelling in education(Porayska-Pomsta et al. 2013)	2013	67
Building Domain Ontologies from Text for Educational Purposes(Zouaq et al. 2008)	2008	67
Technology Support for Discussion Based Learning: From Computer Supported Collaborative Learning to the Future of Massive Open Online Courses(Rosé & Ferschke 2016)	2016	64
Human-centered artificial intelligence in education: Seeing the invisible through the visible(Yang et al. 2021)	2021	63
Artificial intelligence and computer science in education: From Kindergarten to university(Kandlhofer et al. 2016)	2016	59

4.5 Keyword Co-Occurrence Map

Three main clusters were identified corresponding to keywords related to "The use of Artificial Intelligence in Education" and grouped into related themes representing the identified research fronts or lines. These clusters can be seen in Figure 4, in order of importance with their respective keywords, as follows:

Artificial Intelligence (in red): This research line focuses on aspects of AI related to e-learning, education technologies, decision-making, philosophical aspects, technological ethics, teachers, grades, adaptive learning, natural language processing, among others.

Education (in green): This research line focuses on aspects such as machine learning, teaching, data mining, intelligent robots, engineering education, learning processes, learning algorithms, among others.

Learning systems (in yellow): This research line focuses on aspects such as intelligent education, intelligent systems, intelligent tutoring systems, decision-making, curricula, among others.

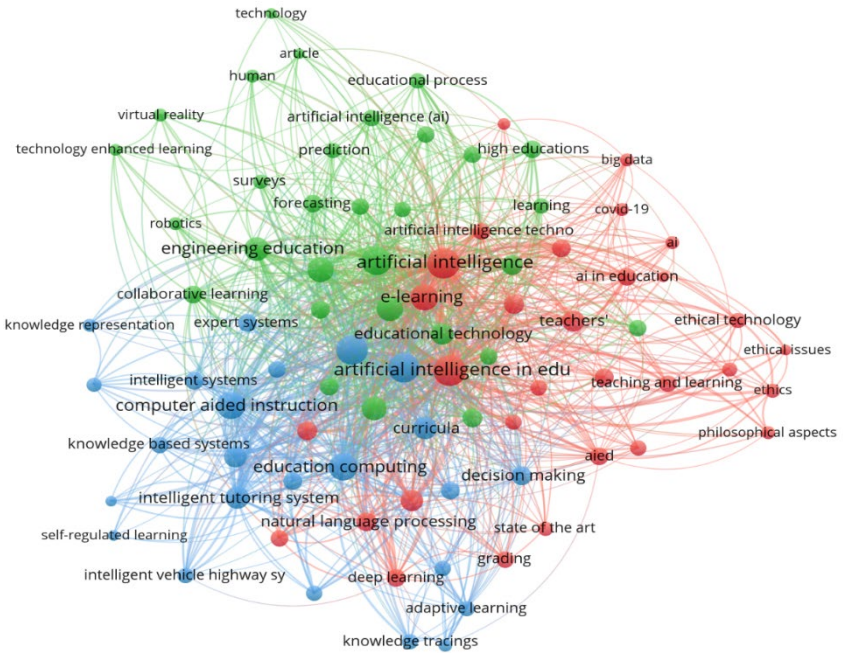

Figure 4. Co-Occurrence Map

5. Results and Discussion

Artificial intelligence (AI) has become an increasingly important tool in education, offering opportunities to improve the efficiency and effectiveness of the teaching and learning process. As AI has become more accessible, educational institutions have begun adopting it in various areas, from data collection to personalized feedback.

However, the use of AI in education also presents challenges and limitations that must be carefully considered. One of the main challenges is the quality of the data used for analysis and feedback. AI requires accurate and representative data to provide personalized and precise feedback. If the data is not accurate or relevant, AI can provide incorrect or ineffective feedback, which can negatively impact students' education.

Another significant challenge is resistance to change and possible lack of trust in AI by educators and students. The automation of certain tasks and reliance on technology can raise concerns about the role of educators in education and the quality of human interaction necessary for effective education. There may also be concerns about the privacy and security of student data.

Despite these challenges, AI remains a valuable tool in education, with the potential to improve the efficiency and effectiveness of the teaching and learning process. By effectively addressing the challenges and limitations and ensuring transparency and ethics in its use, the potential of AI in education can be fully realized.

6. Conclusion

The use of AI in education must be carefully considered and managed and should be part of a comprehensive strategy to improve the teaching-learning process. If the challenges and limitations are effectively addressed and transparency and ethics are ensured in its use, AI can be a valuable tool to improve education and prepare students for the future.

Artificial intelligence has the potential to transform education by helping educators identify students at risk of dropping out and provide specific interventions to help these students succeed academically and stay in school. In doing so, artificial intelligence can improve educational outcomes and reduce dropout rates, which will benefit students, educators, and society.

Artificial Intelligence offers great potential to improve the efficiency and effectiveness of the teaching and learning process in education, by providing personalized and adaptive feedback to students.

Despite the challenges and limitations presented by the implementation of artificial intelligence in education, it is important to effectively address them to ensure its proper and ethical use.

Artificial intelligence can improve accessibility to education for people with disabilities and marginalized communities, by offering personalized and adaptive solutions that fit their specific needs.

A balanced and critical approach is necessary in implementing artificial intelligence in education, to ensure that educators and students understand the benefits and limits of this technology and can use it effectively to improve the teaching-learning process.

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Biographies

Nixon Duarte Acosta is a professor at the Remington University Corporation, in Medellín Colombia. He teaches at the undergraduate and graduate levels, with 12 years of teaching experience. He graduated as a Systems and Computing Engineer, a Specialist in Network Software Construction and a master's in systems and computing Engineering. Also, he has more than 20 years of professional experience in national and international companies, as a Software Developer and Architect, Systems Auditor, Business Architect, IT coordinator and leader. Additionally, he is an Academic Peer of the Ministry of National Education (MEN), for the verification of quality conditions of qualified registration of academic programs of Higher Education Institutions (IES).

Matilde Bolaño García has a degree in basic education with an emphasis in informatics, a Master's degree in educational informatics and a PhD in education. She has more than 15 years of research experience in cyber-education, education, inclusion, and human development. She is a research teacher linked to the group of educational informatics-GINFED categorized in B by Minciencias.

Yury Montoya Pérez is a Systems and Computer Engineer and master's in systems engineering. Since 2014, she has participated in the Software Quality Research Group of the Department of Computer Science and Decision at UNAL. She teaches at the undergraduate level, with more than 10 years of experience. She is currently a Professor at the Remington University Corporation, her research interest is focused on issues related to Software Quality, Software Engineering.

Adán Beltrán PhD candidate in Computer Science at the Autonomous University of Barcelona UAB - Institute of Artificial Intelligence IIIA, Master of Science in Information and Communications, Master in Web Site Administration and Engineering. Specialist in Mathematics and Software Engineering, Systems Engineer, Bachelor of Mathematics and Physics. Director of undergraduate, specialization, and master's degree projects. Principal researcher of R+D+i projects financed by Minciencias and other entities.