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O IMPACTO DA INTELIGÊNCIA ARTIFICIAL NA EDUCAÇÃO: UMA REVISÃO SISTEMÁTICA DA LITERATURA
IMPACT OF ARTIFICIAL INTELLIGENCE ON EDUCATION: A SYSTEMATIC REVIEW OF LITERATURE
IMPACTO DE LA INTELIGENCIA ARTIFICIAL EN LA EDUCACIÓN: UNA REVISIÓN SISTEMÁTICA DE LA LITERATURA

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RESUMO

Introdução: A Inteligência Artificial (IA) está a transformar a educação através de ferramentas adaptativas, da automatização de processos e da análise de dados. Esta investigação tem como objetivo analisar o seu impacto através de uma revisão sistemática da literatura para identificar tendências, benefícios e desafios.

Objetivo: Analisar criticamente as evidências científicas sobre o impacto da IA nas metodologias de ensino, na aprendizagem personalizada e no desempenho académico.

Métodos: Foi utilizado o método de revisão sistemática de acordo com o modelo PRISMA. A pesquisa foi realizada a 15 de janeiro de 2024 nas bases de dados Scopus, WoS e ProQuest. Foram selecionados 65 artigos publicados entre 2019 e 2023, respeitando os critérios de inclusão e exclusão. Dois revisores realizaram a seleção de forma independente e a qualidade metodológica foi avaliada com a ferramenta AMSTAR-2.

Resultados: Os resultados mostram que a IA melhora o desempenho académico (um aumento de 28%, de acordo com os estudos analisados), sendo os chatbots e a realidade aumentada/virtual as ferramentas mais eficazes. A Espanha e a China concentram 26% da produção científica. A personalização da aprendizagem e o feedback automático são os benefícios mais referidos.

Conclusão: Estas conclusões servem para orientar a implementação de ferramentas de IA em instituições de ensino, destacando o seu efeito positivo no desempenho dos alunos e na personalização da aprendizagem. Sugere-se que se investiguem os efeitos a longo prazo e a padronização dos critérios de avaliação.

Palavras-chave: Inteligência Artificial; educação; aprendizagem; desempenho académico; revisão sistemática; desempenho dos alunos

ABSTRACT

Introduction: Artificial Intelligence (AI) transforms education through adaptive tools, process automation, and data analytics. This research aims to analyze its impact through a systematic literature review to identify trends, benefits, and challenges.

Objective: Critically analyze scientific evidence regarding the impact of AI on teaching methodologies, personalized learning, and academic performance.

Methods: A systematic review was conducted following the PRISMA guidelines. The search was performed on January 15, 2024, on the Scopus, Web of Science (WoS), and ProQuest databases. A total of 65 articles published between 2019 and 2023 were selected, in accordance with the inclusion and exclusion criteria. Two reviewers conducted the selection independently, and methodological quality was assessed using the AMSTAR-2 tool.

Results: The results show that AI improves academic performance (a 28% increase according to the studies analyzed), with chatbots and augmented/virtual reality being the most effective tools. Spain and China account for 26% of scientific output. Personalized learning and automated feedback are the most commonly reported benefits.

Conclusion: These findings serve to guide the implementation of AI tools in educational institutions, highlighting their positive impact on student performance and the personalization of learning. Further research is recommended on the long-term effects and the standardization of assessment criteria.

Keywords: Artificial Intelligence; education; learning; academic performance; systematic review

RESUMEN

Introducción: La Inteligencia Artificial (IA) está transformando la educación mediante herramientas adaptativas, automatización de procesos y análisis de datos. Esta investigación busca analizar su impacto mediante una revisión sistemática de la literatura para identificar tendencias, beneficios y desafíos.

Objetivo: Analizar de forma crítica las pruebas científicas sobre el impacto de la IA en las metodologías de enseñanza, el aprendizaje personalizado y el rendimiento académico.

Métodos: Se empleó el método de revisión sistemática según el modelo PRISMA. La búsqueda se realizó el 15 de enero de 2024 en las bases de datos Scopus, WoS y ProQuest. Se seleccionaron 65 artículos publicados entre 2019 y 2023, respetando los criterios de inclusión y exclusión. Dos revisores realizaron la selección de forma independiente y se evaluó la calidad metodológica con la herramienta AMSTAR-2.

Resultados: Los resultados evidencian que la IA mejora el rendimiento académico (28% de incremento según los estudios analizados), siendo los chatbots y la realidad aumentada/virtual las herramientas más efectivas. España y China concentran el 26% de la producción científica. La personalización del aprendizaje y la retroalimentación automática son los beneficios más reportados.

Conclusión: Estos hallazgos sirven para guiar la implementación de herramientas de IA en instituciones educativas, destacando su efecto positivo en el desempeño de los estudiantes y la personalización del aprendizaje. Se sugiere investigar los efectos a largo plazo y la estandarización de criterios de evaluación.

Palabras clave: Inteligencia Artificial; educación; aprendizaje; rendimiento académico; revisión sistemática

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INTRODUCTION

Education today faces a complex and dynamic scenario marked by multiple challenges and opportunities. According to (UNESCO (2021) The advance of digital technologies has revolutionized the quest for access to information and is transforming education systems worldwide, promoting both equity and enabling more personalized learning that is adaptable to the individual needs of students. Where (González, 2019) mentions that in a globalized context in constant transformation, access to information has been democratized thanks to digital technologies, modifying both teaching methods and learning expectations, allowing for greater personalization in education and the possibility of learning to be more flexible and adapted to individual needs.

On the other hand, UNICEF (2024) works intensively on digital education for children and young people in vulnerable contexts in the face of the educational gaps that worsened during the pandemic, and has launched programs to integrate digital learning and provide access to educational technologies in developing countries. It is thus known that emerging technologies have had a significant impact on education (Vasconez & Vásconez, 2023) that the use of recent technological innovations, such as artificial intelligence, augmented reality, machine learning, and interactive educational platforms are transforming the teaching-learning process, allowing for more personalized, accessible and flexible learning, adapting content to the individual needs of students and facilitating distance learning, but their implementation also poses challenges, such as the need for teacher training and the reduction of the digital divide to ensure equitable access to these advances.

Over the last two decades, students, teachers, and educational institutions have extensively incorporated digital tools, where by (UNESCO, 2023) mentions that the number of students enrolled in massive open online courses has grown from 0 students in 2012 to around 220 million in 2021, with the maximum benchmark in 2023 being the language learning application Duolingo had 20 million daily active users, and Wikipedia recorded 244 million daily visits to its pages in 2021. Likewise, we have more relevant data, such as according to the 2018 Program for International Student Assessment (PISA), 65% of 15-year-old students in OECD countries attended schools where principals confirmed that teachers had the necessary technical and pedagogical skills to incorporate digital devices in their classes, and 54% studied in centers with effective online learning platforms.

Other relevant data according to (L. García, 2021) mentions that during the COVID-19 pandemic, the percentages of integration of digital tools in education increased due to the need to adopt online learning as a response to health restrictions, where many educational institutions were forced to implement digital platforms to continue distance learning, this change coincided with the remarkable increase of Internet use worldwide, which went from 16% in 2005 to 66% in 2022. By the same year, approximately half of the world's secondary schools were already connected to the Internet for educational purposes, facilitating access to digital resources and enabling more students to continue their education remotely.

On the other hand, if we talk about emerging technologies for education, we can refer to artificial intelligence as an essential tool for students, where (González-González, 2023) mentions that through applications such as intelligent tutoring systems, AI personalizes learning by adapting content to the skills and pace of each student, where a study shows that the use of AI in learning platforms increased by 85% in the last five years, and it is estimated that by 2030 more than 75% of educational institutions will use some form of AI to improve the educational experience.

We can say that artificial intelligence (AI) is transforming education thanks to qualities such as personalization of learning, automation of tasks, and analysis of educational data, where (Fernández, 2023) mentions that currently 65% of academic institutions in developed countries already employ AI to adapt teaching to individual needs, which has increased student performance by 28% and it is projected that by 2025, more than 60% of assessments will be automated through AI, reducing by 40% the time teachers spend on repetitive tasks such as correcting exams, being these data the positive impact that AI can have on the efficiency and effectiveness of the education system.

Finally, artificial intelligence in an educational framework, according to (Carbonell et al., 2023) mention that this tool allows the creation of adaptive environments where students can progress at their own pace and receive instant feedback, allowing teachers to focus on more meaningful pedagogical activities, where in a constantly evolving digital world, AI becomes an essential tool to improve educational efficiency, promote equity in access to knowledge and prepare students for the challenges of the future.

Despite the growing number of publications in recent years, there is no systematic review that critically synthesizes the evidence on the comparative effectiveness of AI versus traditional teaching, the specific tools used, contextual factors contributing to success, and future prospects. Therefore, this review aims to fill this gap.

The main objective of this research is to critically analyze the scientific evidence regarding the impact of AI on teaching methodologies, personalized learning, and academic performance.

1. METHODS

1.1 Type of study

The present research is a systematic review of the field of scientific research, so that (F. García, 2022) mentions that it allows for rigorous collection, analysis, and synthesis of existing evidence on a specific topic, providing a comprehensive view of previous

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studies, and identifying research gaps and areas where further study is needed, which is crucial for the advancement of knowledge and the application of solutions based on solid data in various disciplines.

For this reason, the PRISMA Model was developed to help in a more transparent way the items found, where (Cely & Quiñones, 2022) mention that PRISMA provides a structured framework for conducting systematic reviews transparently and comprehensively, as this model guides the process of study selection and evaluation, ensuring that rigorous criteria are followed to include only relevant research, which reinforces the validity of the conclusions and facilitates decision-making based on the scientific evidence gathered. Figure 1 shows the updated PRISMA flowchart detailing the results by database (see below) .

1.2 Research Questions

As described above, this research led to the formulation of the following questions:

- RQ1. How effective is artificial intelligence in education worldwide compared to traditional education?
- RQ2. What are the main artificial intelligence tools and techniques applied in the education sector that contribute to improving learning?
- RQ3. Which countries have most effectively adopted artificial intelligence in education, and what are the factors influencing its successful implementation?
- RQ4. What are the prospects for using artificial intelligence in education, and how is it anticipated to affect learning in the long term?

1.3 Search strategy

The search was conducted on January 15, 2024. Synonyms and keywords were used to search the articles of the present study, as follows: "AI", "educational institutions", "students", and "learning" for a better understanding of the topic; likewise, all the information was obtained in the three databases mentioned above, performing an extensive search using the keywords.

The combination of terms used in the search engines were the following variables: (TITLE-ABS-KEY (artificial AND intelligence) AND TITLE-ABS-KEY (education) AND TITLE-ABS-KEY (student) AND TITLE-ABS-KEY (schools)) AND PUBYEAR > 2017 AND PUBYEAR < 2024 AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Spanish") OR LIMIT-TO (LANGUAGE , "Portuguese")) AND (LIMIT-TO (EXACTKEYWORD , "Artificial Intelligence") OR LIMIT-TO (EXACTKEYWORD , "Students") OR LIMIT-TO (EXACTKEYWORD , "Education")).

1.4 Eligibility Criteria

Regarding this eligibility criterion, Table 1 shows the inclusion and exclusion parameters, which are crucial to clearly define which studies or data will be considered in the analysis.

Table 1 - Inclusion and Exclusion Criteria

Inclusion	Exclusion
I01: Research published between January 2019 and December 2023.	E01: Unpublished research outside that period.
I02: Research focused on the use of AI in educational environments.	E02: Studies addressing AI without a focus on education.
I03: Empirical research articles and systematic reviews.	E03: Opinions, unsupported theoretical essays.
I04: Publications in English, Spanish, and Portuguese.	E04: Studies in languages other than the prescribed languages.

1.5 Selection process and quality assessment

Two reviewers (authors 1 and 2) independently screened titles, abstracts, and full-text articles. Inter-reviewer agreement was assessed using the Kappa coefficient (0.89). Disagreements were resolved by consensus or with a third reviewer. The methodological quality of the included studies was assessed using the AMSTAR-2 tool for systematic reviews and the QUADAS-2 scale for empirical studies.

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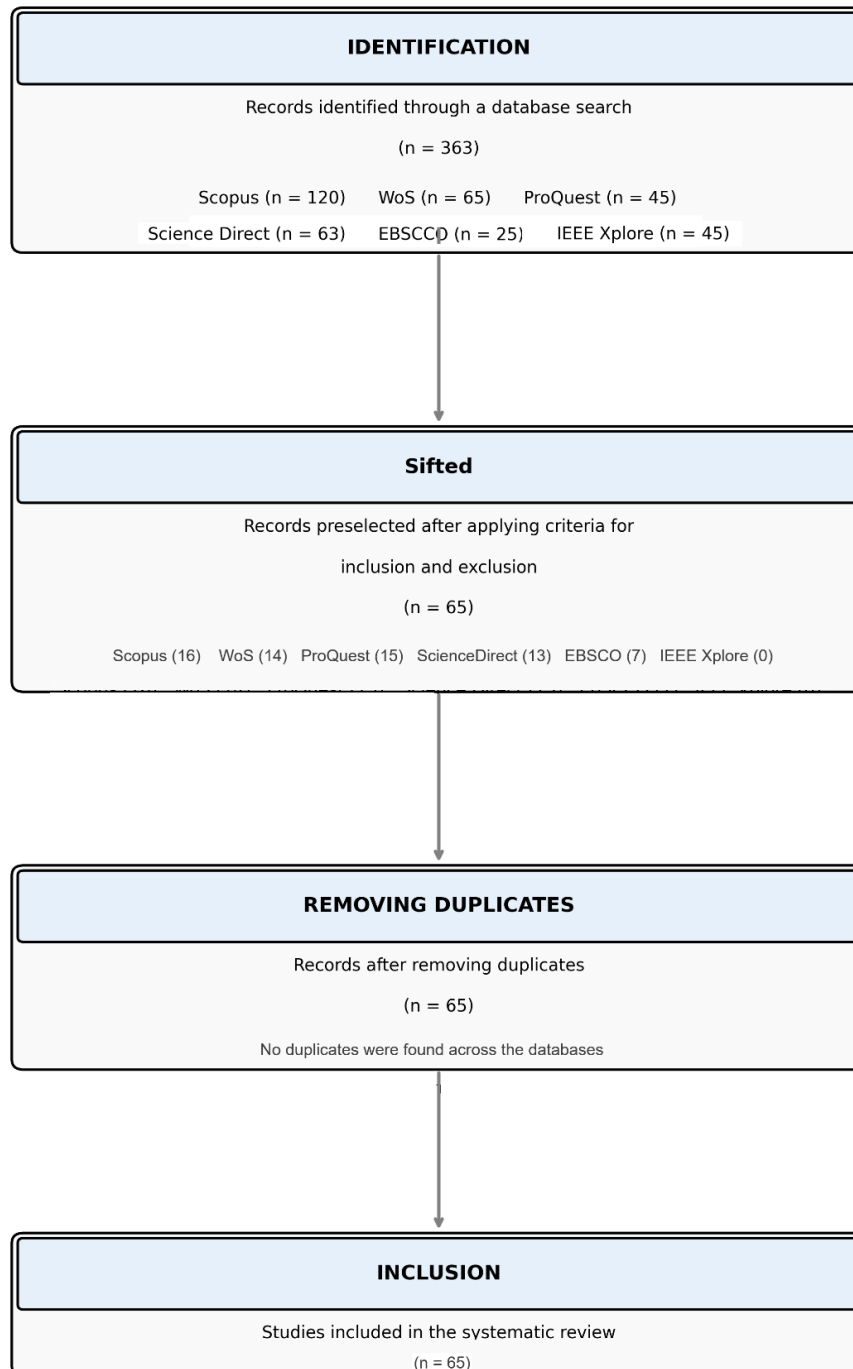


Figure 1 - PRISMA diagram with a breakdown by database

2. RESULTS

A total of 65 articles met the inclusion criteria and were analyzed. In Figure 2, we can highlight the distribution in quantity and percentage of the articles reviewed according to the country of origin of the research, where the analysis shows that Spain is the country with the highest contribution, representing 13.86% of the total number of studies, followed by China with 12.32%. Colombia and Ecuador contribute 9.24% each, with six studies each, thus standing out as important countries in the scientific production reviewed. Other countries such as Germany, Canada, Italy, and the United States are also represented, but with smaller

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contributions compared to Spain and China. In total, research from 27 countries was included, reflecting a significant geographic diversity that can provide a variety of approaches and perspectives.

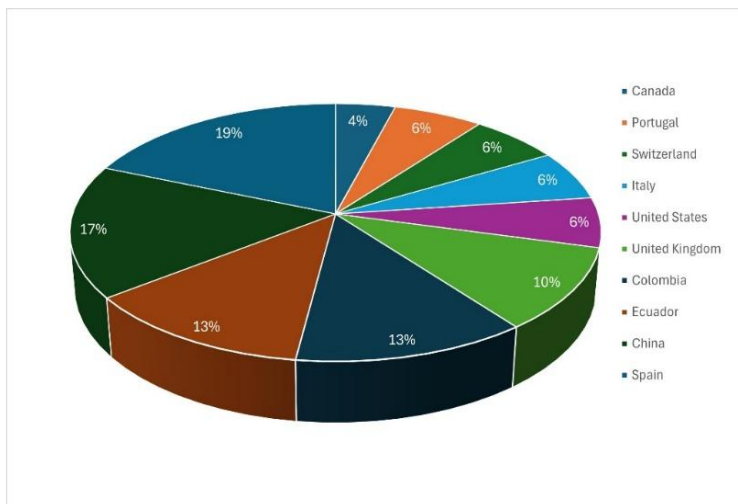


Figure 2 - Percentage of articles analyzed by country (top 10)

Figure 3 shows the distribution of the studies according to the databases used for the collection of articles. The largest proportion of the studies came from the Scopus database, with 16 publications representing 25%, followed by ProQuest with 15 representing 23%, and finally WOS (Web of Science) with 14 publications representing 22% of the total. The remaining articles up to number 65 come from other secondary sources, such as cross-references.

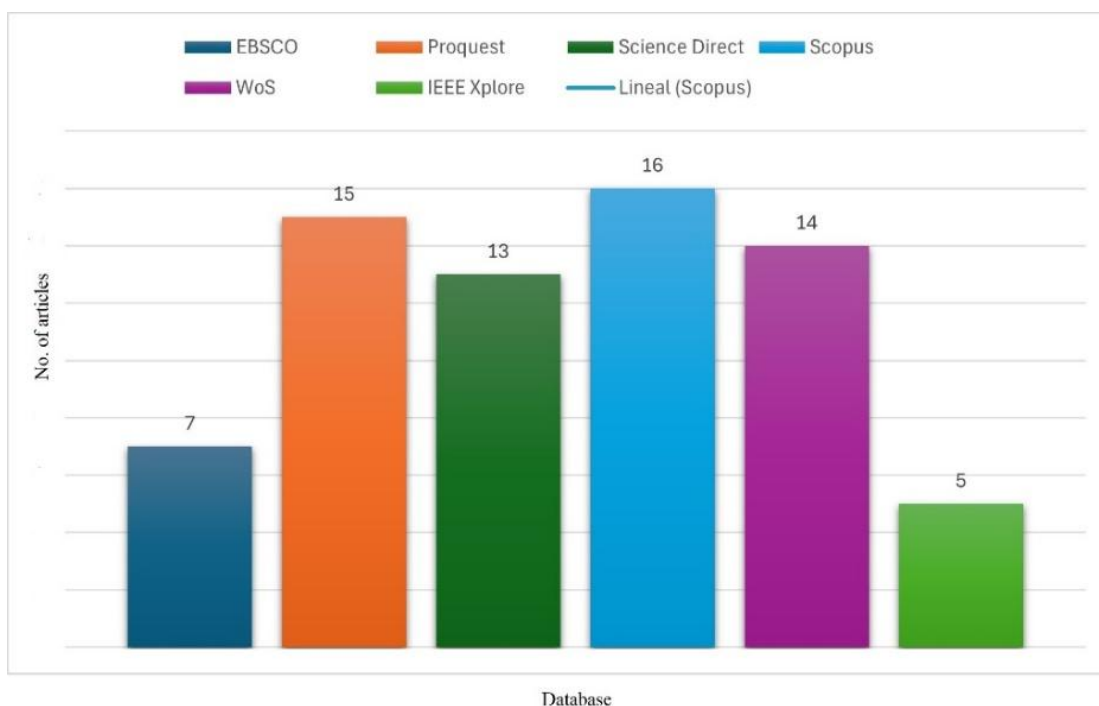


Figure 3 - Articles analyzed by the database

Figure 4 presents a temporal distribution of the reviewed studies analyzed by year and grouped by country, where the year 2023 is notable, with 33 reviewed publications belonging to this period, suggesting that most of the relevant literature is recent. The year 2022 is in second place, with 11 publications, while the previous years, from 2019 to 2021, have a much lower representation.

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Results for RQ1: Comparative effectiveness of AI

Table 2 and Figure 6 show that AI outperforms traditional teaching in several areas. The largest number of studies (22 articles) focuses on "creative activities without digital tools," followed by "traditional approaches to teaching mathematics" (7 articles).

Table 2 - Comparative effectiveness of artificial intelligence and traditional education worldwide

Traditional education	Application of AI	Articles
Manual academic prediction	AI models that analyze student data to identify at-risk students.	(Pacheco et al., 2023) (Jiao et al., 2022) (Malik et al., 2023)
Basic use of technology in the classroom		(Pande et al., 2023)
Theoretical approach to concept learning	AI simulations and interactive visual aids.	(E. Velastegui et al., 2023) (Huang et al., 2022) (Moral et al., 2023)
Standard evaluation	Automated AI-enabled evaluations that provide immediate feedback.	(Valencia & Figueroa, 2023) (Rezazadeh et al., 2023) (Li & Su, 2020) (Venter et al., 2023) (Escalante et al., 2023)
Creative activities without digital tools	AI applications that foster creativity in student projects.	(Marrone et al., 2022) (Liang et al., 2022) (Ahmer et al., 2023) (AlAli et al., 2022) (Tung & Dong, 2023) (Wang et al., 2023) (Al-Qerem et al., 2023) (Boillat et al., 2021) (Rezazadeh et al., 2023) (Yu et al., 2023) (Pincay et al., 2022) (Pande et al., 2023) (Sharma et al., 2023) (Escalante et al., 2023) (Malik et al., 2023) (Huang, 2021) (Buabbas et al., 2023) (Ahmad et al., 2023) (Teng et al., 2022) (Cheng et al., 2020) (Suh & Ahn, 2022)(Liu et al., 2022)
Traditional approach to teaching mathematics	AI chatbots to help with personalized learning.	(Tominc & Rožman, 2023) (Moral et al., 2023) (Venter et al., 2023) (Wang et al., 2023) (Nguyen et al., 2023) (Li & Su, 2020) (Sanabria et al., 2023)

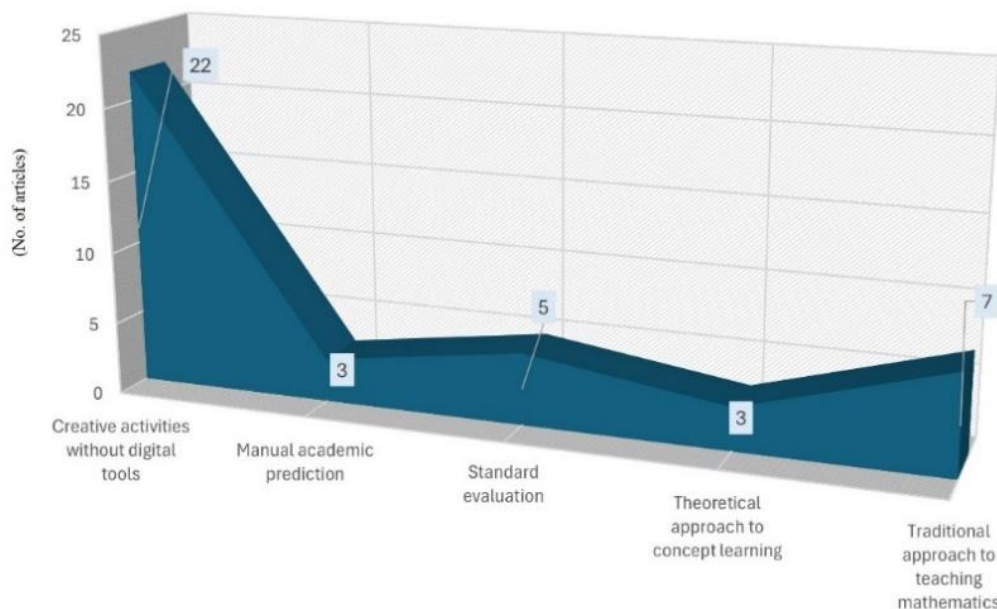


Figure 6 - Comparative effectiveness of artificial intelligence and traditional education

Results for RQ2: AI Tools and Techniques

Table 3 and Figure 7 show that augmented/virtual reality and educational chatbots are the most frequently cited tools (4 articles each), followed by predictive analytics (3 articles).

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Table 3 - AI tools and techniques in education

Tools or techniques	Influence	Articles
Predictive analytics for AI acceptance	Improving the acceptance of AI among future teachers.	(Zhang et al., 2023) (Wang et al., 2023) (Pacheco et al., 2023)
Augmented Reality (AR) and Virtual Reality (VR)	Educational simulation for the development of cognitive and behavioral competencies.	(Benvenuti et al., 2022) (Suh & Ahn, 2022) (Yu et al., 2023) (Yuskovych-Zhukovska et al., 2022)
Natural Language Processing (NLP) Educational chatbots	Text analysis and development of customized curricula. Instant support and personalization of learning experiences.	(Chun & Elkins, 2023) (Pande et al., 2023) (Moral et al., 2023) (Wang et al., 2023) (Williams, 2023)
Automated writing feedback systems	Real-time text analysis and proofreading.	(Escalante et al., 2023)

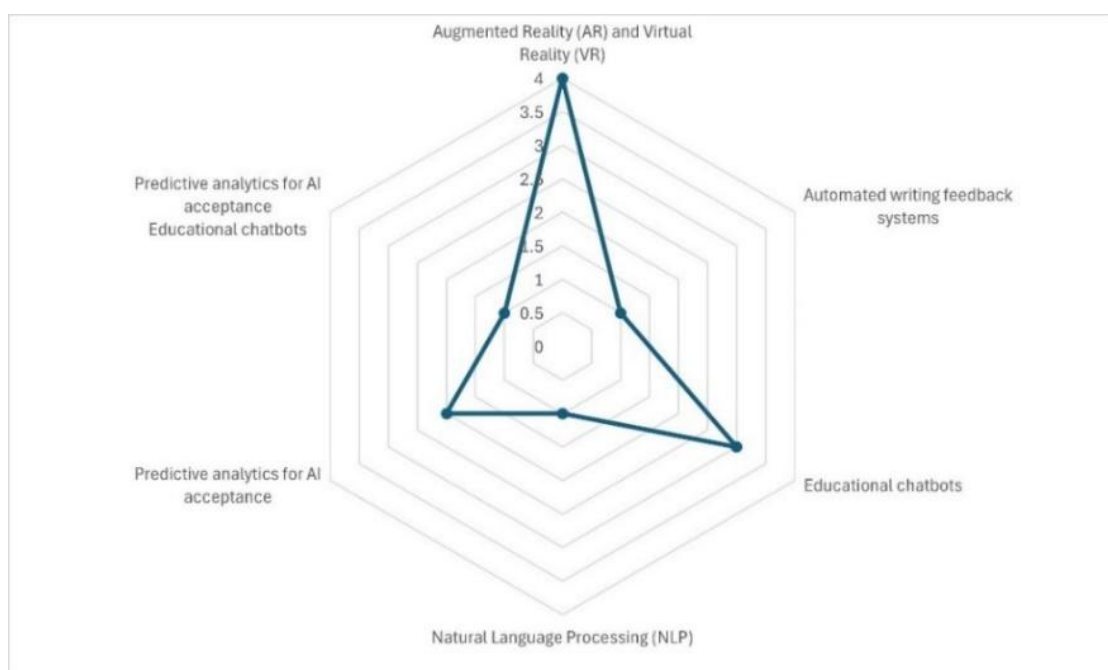


Figure 7 - Main artificial intelligence tools and techniques applied in the education sector

Results for RQ3: Countries with effective adoption

Spain (9 articles), China (8 articles), Colombia, and Ecuador (6 each) lead in production. Table 4 summarizes the success factors: public policies, infrastructure, international collaboration, and ethical approaches.

Table 4 - Effective implementation of "AI" in education countries

Country	Effective implementation of AI in education	Success factors	Articles
Germany	Improving prospective teachers' willingness and acceptance of technology in the classroom.	Adoption and confidence in educational AI	(Zhang et al., 2023)
Italy	Fostering adaptability and creativity in students.	Development of new educational competencies	(Benvenuti et al., 2022) (Shamkuwar et al., 2023) (Cornejo & Cippitani, 2023)
Switzerland	Improving student learning experience through chatbots and generative AI.	Personalization of learning and academic adaptation	(Buabbas et al., 2023) (Marrone et al., 2022) (Wang et al., 2023)
Ecuador	Increased motivation and retention of information in learning.	Participation and complex problem-solving	(Pacheco et al., 2023) (E. Velastegui et al., 2023) (Molina et al., 2023) (Játiva & Beltrán, 2021) (Cortera et al., 2023) (A. Velastegui et al., 2023)
Spain	Optimization of educational practices through digital technologies.	Feedback and autonomous learning	(Moral et al., 2023) (Valencia & Figueroa, 2023) (Flores & García, 2023) (Sanabria et al., 2023) (Carrasco, 2023) (Salvador et al., 2023) (Gómez, 2022)

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Results for RQ4: Future Outlook

Figure 8 shows that 35% of the studies project greater integration of AI into complex diagnostics and clinical simulations, followed by the development of AI-based educational platforms (22%).

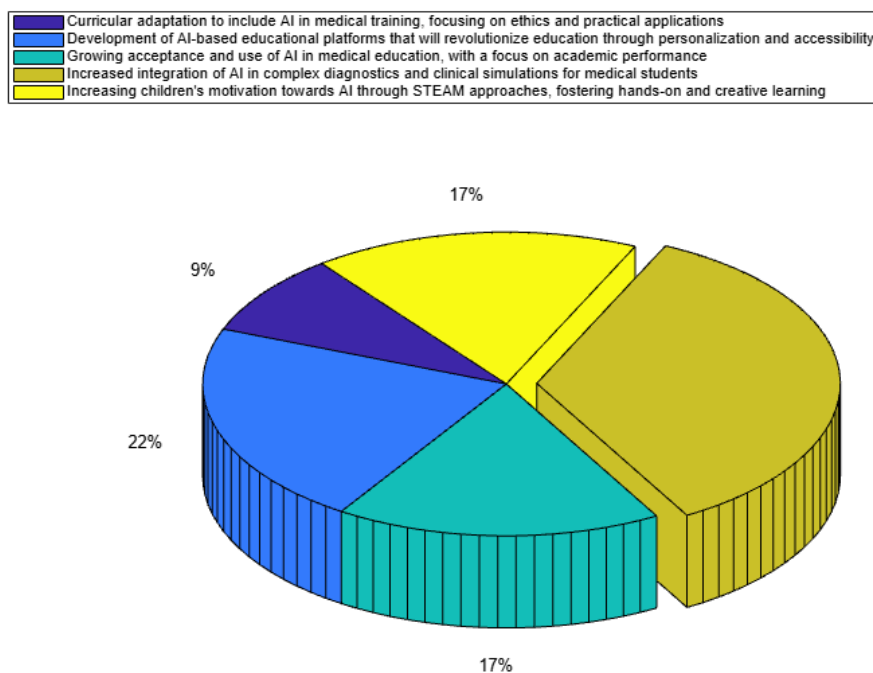


Figure 8 - Future perspectives on the use of artificial intelligence in education

3. DISCUSSION

The most relevant findings are interpreted below in light of the existing literature.

First, the results confirm that AI is effective in improving academic performance and personalizing learning, in line with previous studies (Pacheco et al., 2023); (Marrone et al., 2022). However, effectiveness varies by field of study: it is more pronounced in STEM fields than in the social sciences, as noted (E. Velastegui et al., 2023). This variability suggests that the implementation of AI should be tailored to the disciplinary context.

Second, the most promising AI tools are educational chatbots and augmented/virtual reality, which supports the findings of (Benvenuti et al., 2022) and (Suh & Ahn, 2022). However, the lack of standardization in evaluation criteria (Shamkuwar et al., 2023) limits the comparability between studies. Future research should use validated tools such as AMSTAR-2 or QUADAS-2.

Third, the countries with the highest scientific output (Spain, China, Colombia) share common factors such as public policies on digitization and partnerships with international institutions, which confirms the findings of (Zhang et al., 2023) regarding the importance of faculty buy-in and infrastructure.

Finally, future prospects point toward the deep integration of AI into medical education and STEAM learning from an early age. However, as (Moral et al., 2023) caution, it is necessary to study the long-term sustainability of these effects and address ethical challenges to ensure equitable implementation.

Limitations of the study: Among the main limitations are the scarcity of longitudinal studies, the methodological heterogeneity of the included articles, and the potential lack of consistency in the evaluation criteria. In addition, the search was limited to three databases and to articles published in English, Spanish, and Portuguese, which may have excluded relevant literature in other languages.

CONCLUSION

Artificial intelligence has proven to have a transformative impact on secondary and higher education, contributing to the personalization of learning, the automation of administrative processes, and the democratization of access to educational resources. In response to the stated objectives:

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- 1) Effectiveness compared to traditional teaching: The studies reviewed (65 articles) indicate that AI improves academic performance (by up to 28% in some contexts) and facilitates the early identification of at-risk students. However, its effectiveness depends on academic discipline and the level of technological integration.
- 2) Key tools and techniques: Educational chatbots, augmented/virtual reality, predictive analytics, and automated feedback systems are the most widely used and effective tools.
- 3) Countries with the highest adoption rates: Spain, China, Colombia, and Ecuador stand out for their scientific output, driven by public policies, infrastructure, and international collaboration.
- 4) Future Outlook: Greater integration of AI is expected in medical education (clinical simulations) and in STEAM approaches for children, as well as the development of personalized educational platforms. In the long term, AI could reduce educational barriers and better prepare students for technological challenges, provided that ethical and equity considerations are addressed.

THEORETICAL AND PRACTICAL IMPLICATIONS

In theory, this review consolidates our understanding of the impact of AI on education and provides a foundation for future explanatory models. In practice, the findings serve as a guide for educational institutions and policymakers to implement AI solutions tailored to their local contexts, fostering collaboration with technology experts.

FUTURE STUDIES

It is recommended to investigate the long-term effects of AI on performance and equity, as well as to standardize evaluation criteria to enable meta-analyses. It is also crucial to explore the use of AI in crisis situations (such as pandemics) to ensure educational continuity.

AUTHORS' CONTRIBUTION

Conceptualization, A.P.V.; data curation, J.G.; formal analysis, J.G.; investigation, M.C.C.; methodology, A.P.V. and J.G.; project administration, M.C.C.; resources, A.P.V. and M.C.C.; software, J.G.; supervision, M.C.C.; validation, J.G. and M.C.C.; visualization, A.P.V. and J.G.; writing – original draft, A.P.V.; writing – review & editing, M.C.C.

CONFLICT OF INTERESTS

The authors declare no conflict of interests.

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APPENDIX 1

Table 5 – Articles organized according to the research questions

Reference	RQ1	RQ2	RQ3	RQ4
(Ahmad et al., 2023)	X			X
(Ahmer et al., 2023)	X			X
(AlAli et al., 2022)	X			X
(Al-Qerem et al., 2023)	X			
(Benvenuti et al., 2022)		X	X	X
(Boillat et al., 2021)	X			
(Buabbas et al., 2023)	X		X	X
(Carbonell et al., 2023)				
(Carrasco, 2023)			X	
(Cheng et al., 2020)	X			X
(Chun & Elkins, 2023)		X		
(Cornejo & Cippitani, 2023)			X	
(Cortera et al., 2023)			X	
(Escalante et al., 2023)	X	X		
(Flores & García, 2023)			X	
(Gómez, 2022)			X	
(Huang, 2021)	X			
(Huang et al., 2022)	X			X
(Játiva & Beltrán, 2021)			X	X
(Jiao et al., 2022)	X			X
(Li & Su, 2020)	X			
(Liang et al., 2022)	X			
(Liu et al., 2022)	X			X
(Malik et al., 2023)	X			X
(Marrone et al., 2022)	X		X	
(Molina et al., 2023)			X	
(Moral et al., 2023)	X	X	X	X
(Nguyen et al., 2023)	X		X	X
(Pacheco et al., 2023)	X	X	X	X
(Pande et al., 2023)	X	X		
(Pincay et al., 2022)	X			
(Rezazadeh et al., 2023)	X			X
(Salvador et al., 2023)			X	
(Sanabria et al., 2023)	X		X	
(Shamkuwar et al., 2023)			X	
(Sharma et al., 2023)	X			X
(Suh & Ahn, 2022)	X	X		X
(Teng et al., 2022)	X			
(Tominc & Rožman, 2023)	X			
(Tung & Dong, 2023)	X			X
(Valencia & Figueroa, 2023)	X		X	
(A. Velastegui et al., 2023)			X	X
(E. Velastegui et al., 2023)	X		X	
(Venter et al., 2023)	X			
(Wang et al., 2023)	X	X	X	
(Williams, 2023)		X		
(Yu et al., 2023)	X	X		X
(Yuskovych-Zhukovska et al., 2022)		X		X
(Zhang et al., 2023)		X	X	