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Integration of Artificial Intelligence and Machine Learning in Education: A Systematic Review

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Abstract: This PRISMA-based systematic review analyzes how artificial intelligence (AI) and Machine Learning (ML) are integrated into educational institutions, examining the challenges and opportunities associated with their adoption. Through a structured selection process, 27 relevant studies published between 2019 and 2023 were analyzed. The results indicate that AI adoption in education remains uneven, with significant barriers such as limited teacher training, technological accessibility gaps, and ethical concerns. However, findings also highlight promising applications, including AI-driven adaptive learning systems, intelligent tutoring, and automated assessment tools that enhance personalized education. The geographical analysis reveals that most research on AI in education originates from North America, Europe, and East Asia, while developing regions remain underrepresented. Without strategic integration, the uneven implementation of AI in education may widen social inequalities, limiting access to innovative learning opportunities for disadvantaged populations. Consequently, this study underscores the urgent need for policies and teacher training programs to ensure equitable AI adoption in education, fostering an inclusive and technologically prepared learning environment.

Keywords: *Artificial intelligence, ChatGPT, education, machine learning, teacher training.*

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Introduction

Increasingly, technologies are doing things that previously only humans could do. This is so until a time comes when I do practically all of them. This is what we have been calling technological globalization (Kuleto et al., 2021; Rodríguez-García et al., 2020).

In education, these technologies are having an amazing impact, enabling access to more and different educational resources (Hoosain et al., 2020). New online learning platforms and multimedia content are emerging to enhance teaching quality. These tools leverage artificial intelligence (AI)to analyze student performance, identifying patterns such as increased failure rates in specific tasks, prolonged response times in exams, or decreased engagement with the platform over time. By detecting these trends, educators can intervene more effectively to support student learning.

Despite what it may seem, the incorporation of AI in the educational field is still in a developing phase, and is characterized by a slow adoption process. This is because emerging technologies tend to arrive in education after consolidating themselves in other sectors, such as production or social, and because there is a historical perception that teaching is a task that belongs only to human beings (Nicoletti & de Oliveira, 2020). Through different media, it has been possible to show that some professionals in the education sector are reluctant to incorporate AI (Chatterjee & Bhattacharjee, 2020; Kadhim & Hassan, 2020).

Likewise, it is clear to think that AI represents a tool with enormous potential to address critical problems such as demotivation and school dropout (Salas-Rueda et al., 2020), challenges that significantly affect the current education system, especially since there are many teachers who are not able to provide solutions related to this issue, and AI can

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provide them with points of view not contemplated until then. However, its application in this context remains an unexplored territory, offering multiple opportunities for innovation and improvement of educational processes.

The field of AI in education is attracting increasing interest due to its innovative nature and the challenges faced by teachers in terms of their training in computational thinking. The lack of previous experience and the complexity of this discipline from its foundations make it crucial to explore how AI is being applied in educational contexts and what methods are most suitable to incorporate it effectively (Chang et al., 2022).

To understand the current landscape, it is proposed to carry out a systematic review that analyzes the use of Machine Learning as part of AI. This approach will provide an innovative perspective on how these technologies are transforming the educational field, with the aim of preparing students to take advantage of the technological tools available in the future.

According to Zawacki-Richter et al. (2019), the purpose of a systematic review is to answer specific questions using a structured, transparent, and reproducible search methodology, using clear inclusion and exclusion criteria to select relevant studies. This process includes coding and data extraction, which facilitates the synthesis of findings to identify both their practical applications and existing contradictions or limitations.

The incorporation of advanced technologies such as AI in the classroom represents a complex and progressive process (Prendes-Espinosa & Cerdán-Cartagena, 2021). In this sense, a thorough review of the most recent research on the application of AI in education can offer a detailed and critical analysis of the current state of this emerging field.

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement is developed as a guide intended to provide a standard approach to conducting systematic reviews. Its main purpose is to unify procedures, ensuring that the results obtained are consistent and useful for future research in the area of study (Page et al., 2021; Urrútia & Bonfill, 2010). Although PRISMA is not a systematic review in itself, it is an essential tool to carry it out in a rigorous and structured manner.

PRISMA includes 27 elements that must be considered during the development of the research. These points allow for the generation of well-founded conclusions that reflect the state of knowledge on a specific topic, defined according to the selection criteria established for the review (Page et al., 2021; Urrútia & Bonfill, 2010).

Since systematic reviews are dynamic, it is necessary to delimit a time frame that determines which articles will be included. However, it is recommended to update them periodically to incorporate new studies that expand and enrich the analysis (Page et al., 2021; Su et al., 2022; Talan, 2021; Urrútia & Bonfill, 2010).

This research pursues the main objective of analyzing how AI and ML are integrated into educational institutions, examining the challenges and opportunities associated with their adoption. To achieve this, the study establishes the following specific objectives: to identify and compile key bibliographic sources related to the most outstanding publications in the field; and examine the findings of such publications to assess the impact of using artificial intelligence through ML-powered chatbots in education.

In order to achieve these purposes, specific objectives have been defined that allow these issues to be addressed in a structured way through analysis: to explore the ways in which AI, through ML-based chatbots, is being implemented in the educational field; to investigate teachers' perceptions perceptions of the educational value of AI and students derived from the review on the integration of AI in the classroom; and identify the AI tools and programs most used in the educational context.

Methodology

This paper presents a systematic review of scientific publications focused on the use of AI in the educational field. For its development, the PRISMA methodology was used (Hutton et al., 2016; Page & Moher, 2017; Urrútia & Bonfill, 2010).

PRISMA is structured into 27 elements that serve as a reference to ensure that systematic reviews are useful and understandable for readers (Hutton et al., 2016). The initial version of PRISMA, published in 2009, gained wide acceptance and application in various fields. However, the updated 2020 version, used in this study, introduces significant improvements, including the possibility of conducting dynamic systematic reviews, also known as "live", which can be continuously updated based on new data (Page et al., 2021).

Database Selection and Article Selection

The systematic review focused on three fundamental inclusion criteria: Machine Learning (ML), Education, and AI. The reason why these three criteria have been used was the following:

a) ML is a fundamental branch of AI that allows machines to analyze data and learn from it to make predictions or make decisions. This criterion was included due to its growing impact on the development of educational tools and applications. ML techniques such as classification algorithms, regression, and neural networks are the basis of many systems for personalizing learning, adaptive assessment, and analyzing student behavior. Its inclusion allows us to

analyze how these technologies are being used in the design and implementation of innovative educational methodologies.

b) The educational field is the key context of this review, as it seeks to explore how AI-based technologies are transforming teaching and learning methods. Including education as a criterion ensures that the selected studies are directly related to the impact of these technologies on educational institutions, pedagogical practices, and the training of students and teachers. In addition, this criterion helps to understand the specific benefits and challenges that educational communities face when incorporating AI into their processes.

c) AI is the general framework under which applications such as ML and other subfields are developed. This criterion is fundamental because it allows us to identify research that not only deals with the practical use of AI, but also with its ethical, social and pedagogical implications in the educational field. By including AI as a criterion, a broader vision is guaranteed that encompasses both specific applications and theoretical reflections on its role in the transformation of education.

Articles that met the three established criteria were selected for analysis. This selection process was carried out using databases internationally recognized for their relevance in the indexing of scientific literature, such as SCOPUS, Web of Science (WoS) and ERIC. The choice of these search sources is based on their relevance, coverage and international recognition in the indexing of scientific and academic literature.

The combination of SCOPUS, WoS and ERIC ensures comprehensive coverage of relevant studies, balancing depth of analysis in the field of education (ERIC) with the breadth and quality of multidisciplinary publications (Scopus and WoS). This allows for a more complete view of how artificial intelligence and machine learning are impacting the field of education, while ensuring that the sources selected are rigorous and reliable.

The search was carried out using a deductive approach, using keywords as the main filter and applying search strings based on Boolean operators, specifically: "Machine Learning" AND "Education" AND "Artificial Intelligence". The selected articles were exported to a spreadsheet in Excel format to facilitate their review and subsequent organization.

Subsequently, they were transferred to an external platform for the management of bibliographic references: Mendeley (desktop version). This software, which is freely accessible, is designed to collect, organize and cite research. It allows data to be imported directly from compatible websites and recognized formats, which facilitates the management of bibliographic information (Barsky, 2010).

Document Filtering and Selection

Next, the results were limited to documents with access to the full text and published in final versions (excluding preprints, since they are not definitive and could be altered in the final publication). The inclusion/exclusion criteria were as follows:

a) Inclusion criteria

- Focused on ML as part of AI applied to the educational field.

- Addresses the use of AI based on ML techniques.

- Published between 2019 and 2023.

- Applicable to any education system, without geographical or contextual restrictions.

- Includes practical applications of AI or case studies that explore potential educational uses of these technologies.

- It is limited to articles published in academic journals.

- Written in Spanish or English.

- Available in its entirety with full access to the text.

- Final documents.

b) Exclusion criteria:

- It does not address machine learning or AI as main axes.

- It is limited to dealing with a specific topic where AI is used only as a secondary tool to achieve other objectives.

- Published in 2018 or in previous years.

- Focused exclusively on a specific geographical context.

- It does not include practical applications of AI or case studies that explore potential educational uses of this technology.

- It does not correspond to articles from academic journals.

- Written in languages other than Spanish or English.

- The article is not available for full reading.

- Preprints.

The selection of articles from 2019 onwards ensures that the included studies are representative of the most current technologies, methodologies and policies, maximising the relevance and impact of the results of this systematic review. It is precisely from 2019 that a notable increase in the adoption of AI-based tools in educational contexts has been observed. This period coincides with the rise of platforms such as ChatGPT, adaptive learning systems, and educational chatbots, making studies published in this time interval especially relevant for analysis.

After this first filtering, the 297 results obtained are presented in Figure 1.

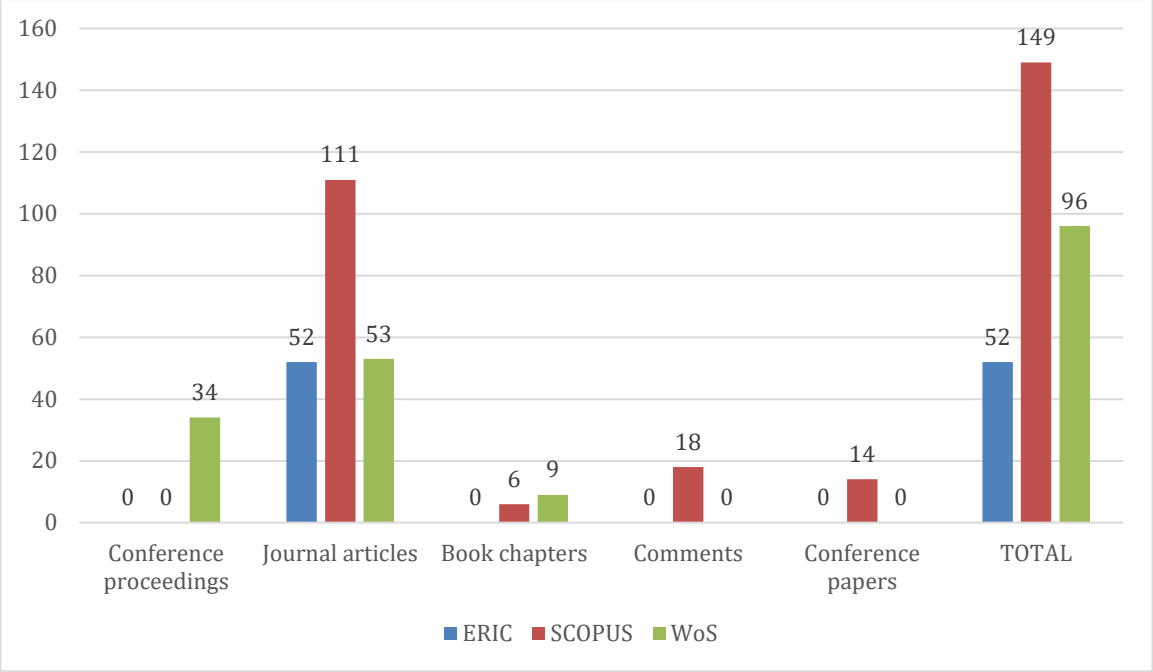

Figure 1. Initial Screening

The initial processing of the collected data was carried out using a spreadsheet in Excel format. For the SCOPUS and WoS databases, the procedure consisted of selecting the previously filtered articles and exporting them in CSV (Comma Separated Values) format, which is compatible with Excel and allows direct integration.

In the case of ERIC, the export generates a file in nbib format, a file type used primarily in the PubMed database. This format is not directly compatible with Excel, so it was necessary to use the Zotero reference manager (Alonso-Arévalo, 2015).

The PubMed database was not used for manuscript screening because its query could have incorporated studies with a bias towards biomedical applications of AI, which is not the main objective of the analysis.

Once the results of the three databases were obtained in separate Excel format files, they were manually combined into a single document. This consolidation allowed the data to be unified into a single XLSX file, from which the subsequent review and analysis was carried out.

Article Review

The review began with a total of 297 articles (Figure 2), which were consolidated into a single Excel spreadsheet to facilitate their initial management.

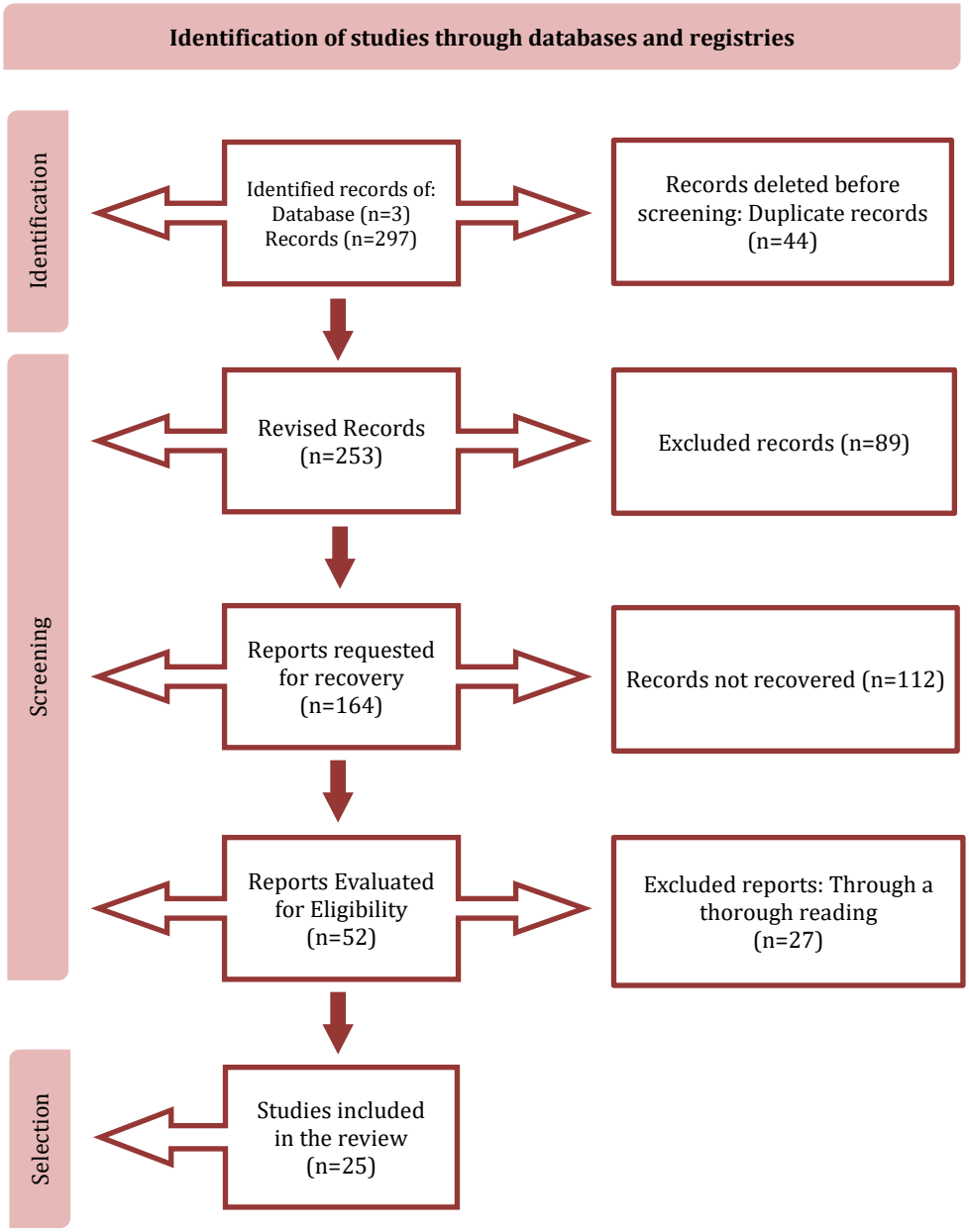

Figure 2. Flow Diagram of the Phases According to the PRISMA Model

The records were organized and those that were duplicate (44) were eliminated, noting the databases of origin for each article. After this process, 253 documents remained to continue with the analysis.

The first filter applied consisted of selecting only articles published in academic journals, reducing the number to 164. Documents discarded at this stage were archived for possible future research related to this line of study. These 164 articles were then evaluated by reviewing their titles, abstracts, and keywords. We included or excluded them on the basis that they met the objectives of the review.

After applying the inclusion and exclusion criteria, 112 studies were excluded due to unavailability of full text, irrelevance to the research objectives, or lack of empirical data. Following this process, a total of 52 articles were downloaded and managed using the bibliographic reference software Mendeley for detailed reading and evaluation, aligning with the principles of Open Science. During this comprehensive review, previously established inclusion and exclusion criteria were reapplied. Among the main reasons for discarding items were the following:

- The articles dealt with AI and ML tangentially, focusing on the specific content that was sought to work with these technologies, which does not meet the criterion that the focus should be on AI and ML as central elements.

- The studies could not be extrapolated to broad education systems, as they were limited to very specific contexts or conditions, failing to meet the criterion of being applicable to any education system.

- Although they addressed topics related to the object of study, they did not include practical applications of AI or case studies that showed specific uses in the educational field, which contravenes the established criteria.

- Some papers identified as case studies turned out to be systematic reviews, failing to meet the type of approach sought for this review.

Finally, after this process, 25 manuscripts were identified that met all the inclusion criteria and were selected to be part of the analysis (Figure 2).

Final Selection of Articles

After applying the inclusion and exclusion criteria, and carrying out a detailed analysis of the selected manuscripts, 25 final documents were obtained. These were organized in a specific subfolder within the Mendeley bibliographic manager and, subsequently, exported to an Excel spreadsheet to facilitate their handling and subsequent analysis (Table 1).

Table 1. First Screening

No.	Year	Author	Educational Level	Title of the Article	Database		
1	2023	Billingsley et al.	K-12	Can a robot be a scientist? Developing students' epistemic insight through a lesson exploring the role of human creativity in astronomy	SCOPUS	--	--
2	2022	Jokhan et al.	Higher Education	Increased digital resource consumption in higher educational institutions and the artificial intelligence role in informing decisions related to student performance	SCOPUS	Wos	--
3	2022	Nuankaew	Higher Education / General	Self-regulated learning model in educational data mining	--	--	ERIC
4	2022	Niyogisubizo et al.	Not specified	Title not available in references	SCOPUS	Wos	ERIC
5	2022	Grunhut et al.	Medical Education	Needs, challenges, and applications of artificial intelligence in medical education curriculum	SCOPUS	--	--
6	2022	Zammit et al.	K-12	Learn to machine learn via games in the classroom	SCOPUS	--	--
7	2022	Vir-Singh and Kant-Hiran	Higher Education	The impact of AI on teaching and learning in higher education technology	SCOPUS	--	--
8	2021	Stadelmann et al.	General / Hybrid	The AI-Atlas: Didactics for teaching AI and machine learning on-site, online, and hybrid	SCOPUS	Wos	--
9	2021	Kuleto et al.	Higher Education	Exploring opportunities and challenges of artificial intelligence and machine learning in higher education institutions	SCOPUS	--	--
10	2021	Lampos et al.	Special Education / Autism	An artificial intelligence approach for selecting effective teacher communication strategies in autism education	SCOPUS	--	--
11	2021	Harati et al.	General / K-12	Assessment and learning in knowledge spaces (ALEKS) adaptive system impact on students' perception and self-regulated learning skills	SCOPUS	--	--
12	2021	Action	Not specified	Title not available in references	--	Wos	--
13	2021	Pu et al.	General / Bibliometric	Identification and analysis of core topics in educational artificial intelligence research: A bibliometric analysis	--	Wos	--
14	2021	Kanglang	Higher Education	Artificial intelligence (AI) and translation teaching: A critical perspective on the transformation of education	SCOPUS	--	--

Table 1. Continued

No.	Year	Author	Educational Level	Title of the Article	Database		
15	2021	Druzhinina et al.	Mathematics / General	Development of an integrated complex of knowledge base and tools of expert systems for assessing knowledge of students in mathematics	SCOPUS	Wos	ERIC
16	2020	Salas-Rueda et al.	General / Higher Ed	Impact of the web application for the educational process on the compound interest considering data science	--	Wos	--
17	2020	Marques et al.	K-12	Teaching machine learning in school: A systematic mapping of the state of the art	SCOPUS	--	--
18	2020	Muniasamy and Alasiry	Not specified	Title not available in references	--	--	ERIC
19	2020	Rodríguez-García et al.	K-12 / General	LearningML: A tool to foster computational thinking skills through practical artificial intelligence projects	--	Wos	ERIC
20	2020	Kadhim and Hassan	Higher Education	Towards intelligent e-learning systems: A hybrid model for predicting the learning continuity in Iraqi higher education	SCOPUS	--	--
21	2019	How & Hung	K-12 / STEAM	Educing AI-thinking in science, technology, engineering, arts, and mathematics (STEAM) education	SCOPUS	Wos	--
22	2019	Ruipérez-Valiente et al.	Higher Ed / MOOCs	Using machine learning to detect 'multiple-account' cheating and analyze the influence of student and problem features	--	--	ERIC
23	2019	Palasundram et al.	Higher Education / Chatbots	Sequence to sequence model performance for education chatbot	SCOPUS	--	--
24	2019	Sharma et al.	Higher Ed / General	Building pipelines for educational data using AI and multimodal analytics: A 'grey-box' approach	--	Wos	--
25	2019	Luckin and Cukurova	General	Designing educational technologies in the age of AI: A learning sciences-driven approach	SCOPUS	--	--

Screening Update

In a first phase, the systematic review considered the articles available in the databases up to February 2023. However, before concluding the first report in July 2023, a second search was conducted to include articles published between the two periods, which had not been initially evaluated.

This additional search followed the same criteria and procedures previously established, although the time range was adjusted to include only documents published in 2023. After applying the inclusion and exclusion criteria, two new articles were identified (Table 2) that met the requirements and provided relevant conclusions to the study. Thus, the final review included a total of 27 articles.

Table 2. New Items Added

No.	Year	Author	Educational Level	Title of the Article	Database		
26	2023	Gilson et al.	Medical Education	How does ChatGPT perform on the United States medical licensing examination? The implications of large language models for medical education and knowledge assessment	SCOPUS	--	--
27	2023	Chung et al.	General / AI Applications	Technology acceptance prediction of robo-advisors by machine learning	SCOPUS	--	--

Figure 2 presents a cluster map generated with VOSviewer from the keywords extracted from the analyzed articles. This map shows the close connection between machine learning (ML) and artificial intelligence (AI), highlighting how

both concepts are interrelated and complement each other in the processing and classification of data using these technologies.

In addition, Figures 2 and 3 shows that AI is linked to various subject areas, while ML is directly associated with the data that AI collects and processes.

Connected to smaller nodes, such as "adaptive education" or "data processing," these terms can be inferred to represent specific applications or areas of interest related to ML and AI.

Another identified cluster is composed of terms such as *"STEM," "educational assessment,"* and *"technology in the classroom,"* indicating that several articles specifically explore the application of AI and ML technologies in teaching and evaluation processes within educational contexts (How & Hung, 2019; Sharma et al., 2019).

Another group of key words such as *"adaptive learning," "personalized education,"* and *"student engagement"* reflects the growing research interest in AI-driven systems designed to tailor educational experiences to individual learner needs (Grunhut et al., 2022; Zammit et al., 2022).

Finally, another group focuses on *"ethical concerns," "teacher training,"* and *"technological barriers,"* highlighting the challenges that educators face when integrating these technologies into their practices (Kadhim & Hassan, 2020; Singh & Hiran, 2022). Together, these clusters illustrate the diversity of research topics within the field and reinforce the multidimensional impact of AI and ML on education.

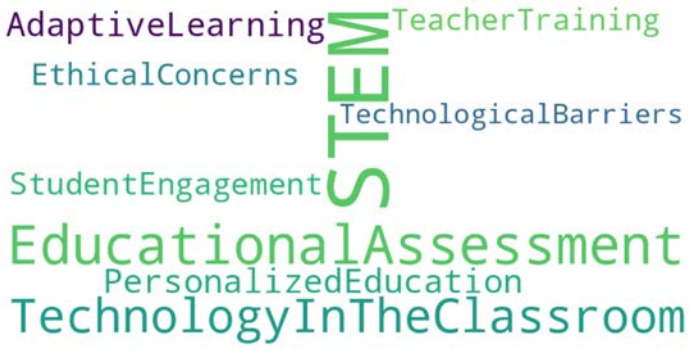

Figure 2. Main Keywords Extracted from the Reviewed Studies on AI and ML in Education

This reinforces the idea that ML and AI are interdependent components, underlining the relevance of this study and its contribution to the understanding of these technologies in the educational field.

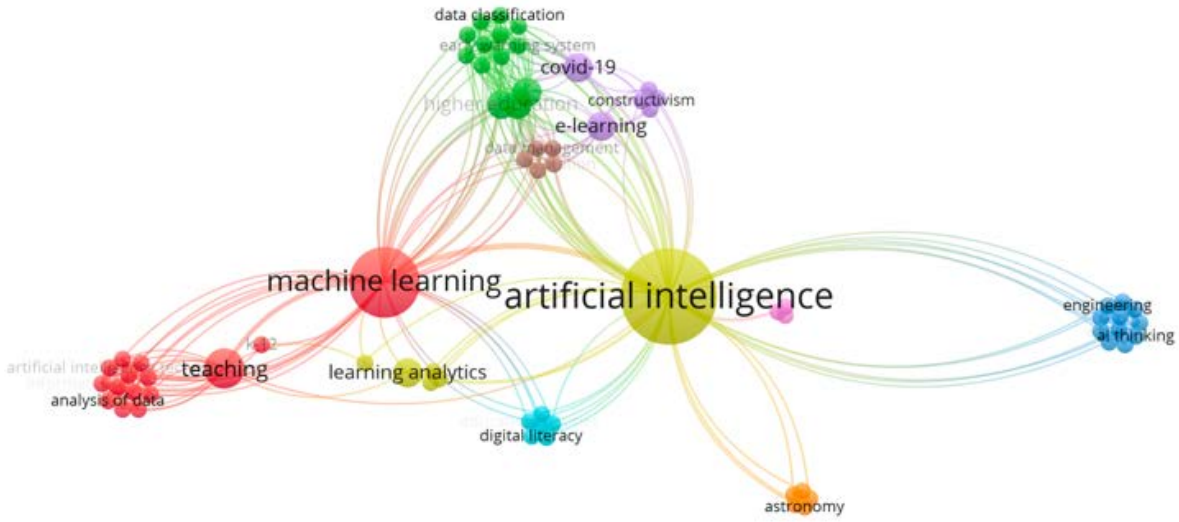

Figure 3. Map of the Relationship Between Articles. Made With VOSviewer

Results

After screening scientific manuscripts, a total of 27 studies published between 2019 and 2023 in various databases were analyzed. The results show that the main sources of information used were SCOPUS, Web of Science (WoS) and ERIC.

The total number of studies per database has been:

- SCOPUS: 19 studies.

- Web of Science (WoS): 10 studies.

- ERIC: 6 studies.

The temporal distribution reflects a progressive growth in the publication of research related to AI and ML:

- *2023*: 3 studies (Billingsley et al., 2023; Chung et al., 2023; Gilson et al., 2023).

- *2022*: 6 studies (Grunhut et al., 2022; Jokhan et al., 2022; Niyogisubizo et al., 2022; Nuankaew, 2022; Singh & Hiran, 2022; Zammit et al., 2022).

- *2021*: 8 studies (Druzhinina et al., 2021; Harati et al., 2021; Kanglang & Afzaal, 2021; Kuleto et al., 2021; Lampos et al., 2021; Pu et al., 2021; Stadelmann et al., 2021; Talan, 2021).

- *2020*: 6 studies (Kadhim & Hassan, 2020; Marques et al., 2020; Muniasamy & Alasiry, 2020; Rodríguez-García et al., 2020; Salas-Rueda et al., 2020).

- *2019*: 4 studies (How & Hung, 2019; Palasundram et al., 2019; Ruipérez-Valiente et al., 2019; Sharma et al., 2019).

Following the analysis of the selected studies, a thematic classification was developed to align the results with the research objectives and to better understand how AI and ML are being integrated into educational institutions. Three main themes emerged, reflecting the diverse applications and challenges identified in the literature. This categorization also highlights the potential and limitations of AI and ML in educational contexts.

1) Curriculum development for AI education (7 studies):

These studies focus on integrating AI literacy and computational thinking into educational curricula, particularly at the K-12 level. How and Hung (2019) proposed incorporating AI-thinking into STEM education, aiming to foster analytical skills from early stages. Marques et al. (2020) conducted a systematic mapping of machine learning teaching in schools, identifying a growing interest in practical AI education. Zammit et al. (2022) examined game-based learning approaches to teach AI concepts, demonstrating positive effects on student engagement. Similarly, Rodríguez-García et al. (2020) introduced the LearningML tool to promote computational thinking skills through AI projects, while Stadelmann et al. (2021) explored didactic strategies for teaching AI in hybrid environments. Talan (2021) reinforced the importance of including AI in education through a bibliometric study, and Kanglang and Afzaal (2021) critically examined the role of AI in translation teaching, stressing curriculum adaptation needs.

2) Implementation of AI and ML tools in educational platforms (11 studies):

This theme includes studies that analyze the use of AI-powered tools and platforms designed to enhance learning experiences and educational processes. Palasundram et al. (2019) tested the effectiveness of chatbots in supporting student learning. Vázquez-Cano et al. (2021) developed a chatbot to improve Spanish punctuation skills, enhancing flexible learning environments. Kadhim and Hassan (2020) proposed a hybrid AI model to predict learning continuity in higher education. Salas-Rueda et al. (2020) demonstrated the impact of web applications using data science for teaching compound interest. Jokhan et al. (2022) analyzed AI's role in digital resource consumption and decision-making regarding student performance. Harati et al. (2021) evaluated the adaptive ALEKS system's impact on self-regulated learning. Additionally, Grunhut et al. (2022) and Gilson et al. (2023) studied AI applications in medical education, particularly the potential of large language models like ChatGPT in knowledge assessment. Nuankaew (2022) developed a self-regulated learning model based on educational data mining. Sharma et al. (2019) proposed AI and multimodal analytics pipelines, while Ruipérez-Valiente et al. (2019) applied ML to detect cheating behaviors in MOOCs.

3) Barriers and challenges to AI adoption in education (9 studies):

The final group of studies focused on identifying obstacles to effective AI integration in education. Singh and Hiran (2022) emphasized the digital divide and lack of educator readiness as significant barriers. Druzhinina et al. (2021) explored the complexity of expert AI systems in mathematics learning environments. Pu et al. (2021) conducted a bibliometric analysis revealing geographical and educational level disparities in AI research coverage. Kuleto et al. (2021) examined challenges related to AI and ML implementation in higher education institutions. Biurrun (2023) highlighted societal-level concerns, such as national restrictions on tools like ChatGPT. Similarly, Murphy-Kelly (2023) discussed ethical risks and global calls for caution in AI development. Nicoletti and de Oliveira (2020) proposed ML-based models for dropout prediction, underlining the need for further research on equity and accessibility. Lampos et al. (2021) analyzed AI's potential to support teachers in autism education, identifying the need for better integration strategies. Finally, Cruz-Jesus et al. (2020) addressed the use of AI to assess academic achievement, stressing the importance of considering contextual barriers.

This thematic distribution not only provides a structured overview of how AI and ML are currently applied in educational contexts but also directly addresses the study's objectives by revealing specific trends, applications, and challenges across diverse educational levels. The reviewed studies confirm that while AI and ML offer significant potential to enhance educational practices—ranging from curriculum innovation to adaptive learning platforms—their implementation still faces notable barriers, particularly regarding teacher preparedness, ethical concerns, and equitable access. These findings emphasize the need for future research and practical initiatives that strengthen the pedagogical integration of AI as a sustainable and supportive tool in education.

Building on this thematic analysis, the following section examines in greater detail how the reviewed studies conceptualize AI's role in educational practice, particularly whether it is positioned as a complementary tool or a core methodology within teaching and learning processes.

The analysis also reveals that most studies conceptualize AI as a supplementary tool aimed at supporting specific educational tasks, rather than integrating it as a core methodology embedded within teaching practices. For instance, studies focusing on chatbots or predictive models (Palasundram et al., 2019; Salas-Rueda et al., 2020; Vázquez-Cano et al., 2021) emphasize AI's role in assisting particular learning activities but stop short of proposing AI as a continuous support system for educators. Similarly, research on adaptive learning environments (Harati et al., 2021; Kadhim & Hassan, 2020) showcases AI's potential for personalization but does not address its integration into broader pedagogical strategies. This reflects a limited perspective on AI's potential for long-term pedagogical integration.

Technical and Pedagogical Barriers to AI and ML Adoption

One of the main barriers identified across the reviewed studies is the *technical complexity* associated with implementing AI and ML in educational settings. Several authors report that the development and configuration of these technologies require advanced knowledge in handling large datasets, complex algorithms, and data processing techniques, which creates accessibility issues for educators without technical backgrounds (Druzhinina et al., 2021; Nuankaew, 2022; Palasundram et al., 2019).

This challenge is further reinforced by findings that emphasize the *difficulty educators and students face in understanding ML models and processes,* limiting their effective integration into teaching practices (Chung et al., 2023; Harati et al., 2021; Lampos et al., 2021). Figure 4, adapted from Chung et al. (2023), visually represents a structured ML workflow that helps illustrate the key stages of model development: data preparation, preprocessing, algorithm selection, training, evaluation, and improvement.

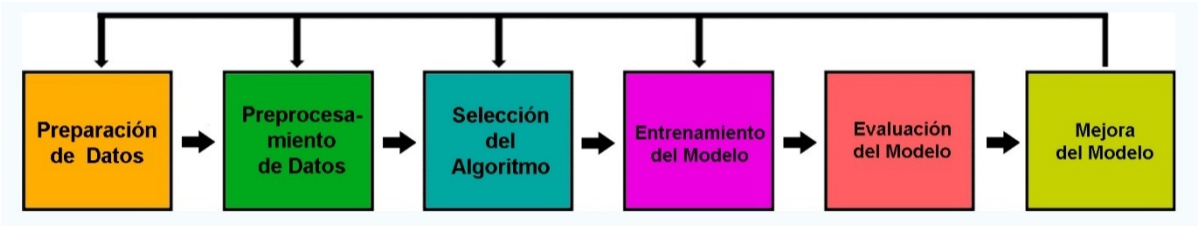

Figure 4. How ML Works (Adapted from Chung et al., 2023)

Such visual frameworks serve as pedagogical tools that could reduce conceptual barriers and foster AI literacy in education, as supported by studies like Grunhut et al. (2022) and Luckin and Cukurova (2019). However, despite the growing availability of user-friendly AI tools like ChatGPT (Gilson et al., 2023), research on their pedagogical integration remains limited.

Moreover, the *lack of teacher training* and *pedagogical concerns* emerged as recurrent barriers. Studies reveal that technologies such as chatbots and adaptive systems are often limited to educators with specific technical training or prior knowledge, reducing their broader adoption in classrooms (Kanglang & Afzaal, 2021; Kuleto et al., 2021; Lampos et al., 2021; Luckin & Cukurova, 2019). This highlights the need for targeted professional development to equip educators with the necessary skills to implement AI tools effectively.

Educational Potential and Current Limitations of AI and ML Tools

Several studies reviewed describe small-scale experiences aimed at making AI and ML applications more accessible for educators with limited technical expertise. These initiatives propose simplified activities and tools designed to introduce teachers and students to fundamental AI concepts (How & Hung, 2019; Ruipérez-Valiente et al., 2019). However, authors such as Kadhim and Hassan (2020) highlight that these approaches often remain at a basic level, limiting the potential to fully exploit the advanced capabilities of ML and, consequently, its transformative impact on education.

Despite these limitations, such practices play a valuable role in fostering initial contact with AI, offering opportunities for professional development and laying the groundwork for future integration into teaching practices (Kadhim &

Hassan, 2020; Ruipérez-Valiente et al., 2019). Moreover, studies indicate that students generally demonstrate a positive attitude and willingness to explore AI-based technologies, leading to increased motivation and engagement when using these tools in educational settings (Harati et al., 2021; Luckin & Cukurova, 2019; Salas-Rueda et al., 2020).

The integration of AI into classrooms is seen not only as a response to current educational demands but also as a way to prepare students for future challenges related to digital competence and technological fluency (Kadhim & Hassan, 2020; Lampos et al., 2021). Among the key benefits identified, the predictive capacity of AI-powered tools stands out, offering teachers valuable resources to optimize instruction and providing students with personalized support for autonomous learning (Jokhan et al., 2022; Sharma et al., 2019).

Finally, several studies confirm that AI-based systems, particularly educational chatbots, serve as effective pedagogical assistants inside and outside the classroom, supporting teaching and learning processes and enhancing educational outcomes (Salas-Rueda et al., 2020; Vázquez-Cano et al., 2021).

Conclusions

The integration of AI and ML in various societal contexts is becoming increasingly significant as these technologies evolve and adapt to social demands. In particular, their impact on education has demonstrated promising potential for transforming teaching and learning processes. By fostering personalized and autonomous learning environments, AI and ML hold the promise of democratizing access to high-quality knowledge, as highlighted by several studies analyzed in this review.

However, a major challenge persists: the digital divide between students and educators. While many students are eager to adopt these tools, some faculty members struggle due to a lack of technical expertise or perceived complexity. This divide underscores the need for continued development of user-friendly and intuitive tools, as Marques et al. (2020) emphasized, to encourage broader adoption among educators. Recent advancements, such as the development of preconfigured tools with accessible interfaces, have shown promise in overcoming these barriers.

Moreover, the rapid pace of AI development requires ongoing evaluation and reflection. As previous research by Cruz-Jesus et al. (2020) and Pu et al. (2021) underscores, current tools serve as a foundational basis for future innovations. Studies like those by Talan (2021) and Li et al. (2023) further emphasize the importance of detailed analysis of ML within educational contexts, reinforcing the findings of this review.

Ethical Considerations and Future Research

In addition to its educational implications, AI's transformative potential poses broader societal challenges. As Murphy-Kelly (2023) notes, even industry experts have advocated for a temporary pause in AI development to allow society to adapt. Countries like Italy, China, and Australia, among others, have implemented restrictive measures to regulate AI usage, particularly tools such as ChatGPT (Biurrun, 2023). These actions highlight the global uncertainty surrounding AI's rapid evolution.

Ultimately, the need for educators to lead this transformative process is paramount. Their role is vital in training new generations to use AI ethically and responsibly, ensuring it becomes a driver of social progress. Continuous updates and detailed analyses of existing studies are imperative to monitor advancements, address challenges, and explore the implementation of AI in diverse professional sectors (Chung et al., 2023).

AI and ML represent transformative technologies that are reshaping society and education. Despite their rapid development and the perception of complexity surrounding them, their potential to create personalized and autonomous learning environments and democratize access to quality education is undeniable. The studies reviewed in this article confirm that AI will play a critical role in the future, although the digital divide between students and educators must be addressed to ensure its widespread adoption.

The development of more accessible tools and interfaces has begun to bridge this gap, enabling broader integration of AI in educational contexts. As Marques et al. (2020) suggested, the exponential growth of ML will be pivotal in advancing education, a claim supported by the findings of this review. Furthermore, the ethical and responsible use of these tools, championed by educators, will be essential for leveraging AI as an engine of social development.

Research Limitations and Future Research Needs

This manuscript provides a comprehensive foundation for future research, demonstrating that mastering AI will be crucial for accessing new opportunities across professional sectors. As new innovations emerge, ongoing evaluations will be necessary to understand their impacts and ensure their benefits extend to society as a whole.

The primary limitation of this study is the restriction imposed by the character length of this report, which has constrained the comprehensive presentation of the results obtained. This limitation prevents a more detailed exploration of certain aspects of AI and ML integration. However, this constraint also highlights an opportunity for future research to delve deeper into the topics addressed, offering more exhaustive analyses. Despite these restrictions,

the present work provides significant value by establishing a starting point that aligns with the current needs and challenges of society, adapting to its evolving demands.

To ensure the successful integration of AI and ML in education, it is crucial to address the digital divide by promoting technical training for educators. Many faculty members perceive these tools as complex or inaccessible due to a lack of technical expertise. By providing focused training, educators can better understand and adopt these technologies, enabling them to create innovative learning environments and meet the needs of modern students.

Equally important is the continued development of intuitive and user-friendly tools. As Marques et al. (2020) highlighted, the creation of preconfigured programs and accessible interfaces is instrumental in encouraging broader adoption. By simplifying the implementation process, these advancements can make AI and ML more approachable for educators and students alike, fostering their integration into educational contexts.

Ethical and responsible use of AI must also be a priority. Teachers play a vital role in guiding new generations to utilize AI effectively and responsibly, ensuring that its transformative potential serves as a driver of social progress. This ethical leadership is essential to harness AI's power in ways that align with societal values and objectives.

In addition, continuous research is necessary to explore the evolving impact of AI across various professional sectors. Studies like those of Chung et al. (2023) emphasize the importance of analyzing AI's implementation to understand its benefits and challenges fully. Regular evaluations of advancements will help ensure that AI continues to adapt to societal needs while addressing potential risks.

Finally, fostering global collaboration is critical to managing the uncertainty surrounding AI's rapid development. Restrictive measures in countries such as Italy and China (Biurrun, 2023) underscore the importance of international cooperation in shaping policies and frameworks that guide AI's growth. By working together, nations can ensure that AI evolves in a manner that maximizes its benefits while minimizing potential harm.

Conflict of Interest

The authors declare that they have no conflict of interest.

Generative AI Statement

As the authors of this work, we used the AI tool ChatGPT-4o for grammatical style correction, semantic review, and verification of the referenced bibliography in accordance with the journal's required standards. After utilizing this AI tool, we thoroughly reviewed and validated the final version of our work. We, as the authors, take full responsibility for the content of our published work.

Authorship Contribution Statement

Manuel Reina-Parrado: Conceptualization, design, analysis, writing, editing/reviewing. Pedro Román-Graván: Conceptualization, design, analysis, writing, editing/reviewing. Carlos Hervás-Gómez: Conceptualization, design, analysis, writing, editing/reviewing.

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