REVISTA INVECOM
ISSN en línea: 2739-0063

Scientific production on artificial intelligence in education: a bibliometric analysis based on metadata using VOSviewer (2015-2026)

Producción científica sobre inteligencia artificial en educación: un análisis bibliométrico basado en metadatos mediante VOSviewer (2015-2026)

Received: 10/04/2026 **- Accepted:** 25/06/2026

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Abstract

In the current educational landscape, artificial intelligence (AI) has generated a paradigmatic transformation toward the so-called Education 4.0, significantly transforming teaching methods, personalization, and learning assessment. Consequently, this research allowed for the analysis of scientific production on AI in education identified in the Scopus database during the 2015-2026 period, employing a methodology based on the deductive process, with a quantitative perspective, a descriptive scope, and a documentary and longitudinal research design. The metadata collection instrument was a structured search string with Boolean operators with 4,599 analyzed documents, processing the information through VOSviewer software for the sociometric mapping of co-occurrence and institutional collaboration networks. Accordingly,

the results obtained identified an exponential increase in publications starting in 2023, driven by the rise of generative AI, where original articles served as the main channel of scientific communication, accounting for 65.9% of the total production. The bibliometric analysis reveals an intellectual distribution organized into three dominant clusters: the technological axis, pedagogical applications, and the emerging ethical axis focused on academic integrity and the use of ChatGPT. Furthermore, the geographic analysis highlights the fundamental role of universities in Peru within Latin America, contributing 23.6% of the publications associated with the development of research skills in university students. In conclusion, AI acts as an essential cognitive assistant that does not replace the teacher; instead, it requires pedagogical leadership guided by ethical principles and social inclusion.

Keywords: bibliometric analysis, education, artificial intelligence.

Resumen

En la situación educativa actual, la inteligencia artificial, ha generado una transformación paradigmática hacia la denominada Educación 4.0, transformando notablemente los métodos de enseñanza, personalización y evaluación del aprendizaje. Consecuentemente, esta investigación permitió analizar la producción científica sobre IA en educación identificada en la base de datos Scopus durante el periodo 2015-2026, empleando una metodología basada en el proceso deductivo, con una perspectiva cuantitativa, un alcance descriptivo y un diseño de investigación documental y longitudinal. El instrumento de recolección de metadatos fue una cadena de búsqueda estructurada con operadores booleanos con 4599 documentos analizados, procesando la información mediante el software VOSviewer para el mapeo sociométrico de redes de co-ocurrencia y colaboración institucional. Los resultados obtenidos han permitido identificar un incremento exponencial de las publicaciones a partir del año 2023, promovido por el uso de la IA generativa, donde los artículos originales son el principal medio de comunicación científica con un 65,9% de toda la producción total. El análisis bibliométrico muestra una distribución intelectual organizada en tres clústeres dominantes que son el eje tecnológico, las aplicaciones pedagógicas y el eje ético emergente basado en la integridad académica y en el uso de ChatGPT. Además, el análisis geográfico muestra el rol fundamental de las universidades del Perú en América Latina con un 23,6% de las publicaciones asociadas al desarrollo de las competencias investigativas en universitarios. En conclusión, la IA funciona como un apoyo cognitivo esencial que no reemplaza al docente, sino que requiere de un liderazgo pedagógico con principio éticos y de inclusión social.

Palabras clave: análisis bibliométrico, educación, inteligencia artificial.

Introduction

Digital tools have transformed the educational environment in recent years, becoming embedded in diverse teaching methodologies that not only foster the skills required for professional performance but also prepare students for practical settings in a constantly changing world (Vallejo, 2024). Within this scenario, artificial intelligence (AI) has emerged as one of the most significant technological developments of the twenty-first century, reshaping how teaching and learning occur while offering novel forms of personalization that merge automation with educational decision-making (Villarroel-Molina et al., 2025). This growth aligns with the concept of Education 4.0, characterized by the integration of emerging technologies to enhance efficiency, flexibility, and equity across educational systems worldwide (UNESCO, 2024).

A decisive moment occurred in November 2022 with the introduction of generative artificial intelligence (GAI), particularly ChatGPT, which accelerated the integration of such tools into higher education, moving them from experimental resources to commonplace components of the learning process (UNITEC, 2025; Rivas, 2025; Hasham, 2026). Consequently, scientific production experienced exponential growth (Pérez-Campdesuñer et al., 2025), fueled by the pressing need to systematize information on the

effectiveness of adaptive learning systems, cognitive performance, and automated student progress monitoring (Aparicio-Gómez & Aparicio-Gómez, 2024; Ansari & Qamari, 2025).

Nevertheless, this expansion confronts a major challenge: the gap between technological accessibility and teachers' digital competencies. Although educators possess knowledge of basic digital tools, many lack specialized training in AI systems, which diminishes their effectiveness and compromises assessment quality (Flores Arguelles et al., 2025; Rivas, 2025; Santos Criado, 2026). To this are added ethical concerns related to algorithmic bias and academic honesty vis-à-vis AI, given that 92% of university students report using these technological tools, compelling institutions to revise their policies in order to safeguard the value of degrees (Villarroel-Molina et al., 2025; Hasham, 2026).

In Latin America, this process is still underway, marked by infrastructure and educational deficits (Rivas, 2025). Despite these challenges, publications from Peru have been notably significant and strategically relevant, leading regional production in research competency development with 23.6% of the Scopus-indexed publications reviewed (Marín León et al., 2026). This increase includes high-impact social projects, such as the assessment of indigenous languages and sign language through AI models (Rivas, 2025).

Given the rapid pace of these changes and the scarcity of updated local bibliographic information, it is essential to employ scientometric methods and scientific mapping techniques to understand the intellectual structure of the field (Mora Coral et al., 2025; Marín León et al., 2026). This bibliometric study aimed to analyze scientific production on artificial intelligence in education using the Scopus database for publications between 2015 and 2026. Through the application of VOSviewer software, the study sought to identify emerging trends, institutional collaboration networks, and research hotspots, thereby offering an overarching perspective to guide decisions toward equitable, ethical, and human-centered technological inclusion (Ansari & Qamari, 2025; Marín León et al., 2026; Villarroel-Molina et al., 2025).

Methodology

The research followed a deductive method, adopted a quantitative approach, maintained a descriptive scope, and employed a documentary and longitudinal study design (Hernández-Sampieri & Mendoza, 2018). The study served as a resource for collecting and analyzing publication metadata to facilitate the identification of trends, prominent organizations, and collaboration networks in scientific production on artificial intelligence (AI) in education. Regarding the technique employed, bibliometric analysis was applied, while the research instrument consisted of a structured search string with Boolean operators (TITLE-ABS-KEY ("artificial intelligence" AND "education")), designed for searching the Scopus database due to its high impact factor and academic reliability.

Consequently, the population for analysis comprised all indexed studies related to the educational field, whereas the sample was restricted to documents published between 2015 and 2026, following the selection criteria and stages of the PRISMA 2020 protocol. This selection method enabled the refinement of the document set by removing duplicates and irrelevant records, ensuring an analysis grounded in peer-reviewed, empirically supported literature.

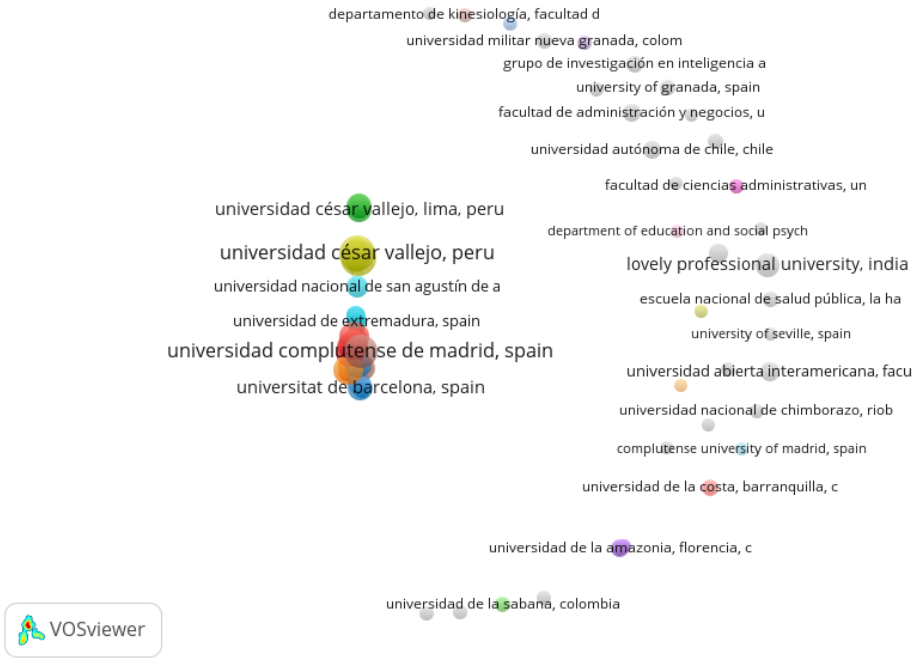
Likewise, a coding matrix was constructed in Microsoft Excel to classify essential variables, including publication year, country of origin, institutional affiliation, and citation count. For scientific mapping and network visualization, the VOSviewer application was used to perform co-occurrence analysis of keywords, co-authorship analysis, and bibliographic coupling.

Finally, descriptive statistics were employed to analyze the results, facilitating the creation of sociometric graphs and density maps representing research "hotspots" in the field, such as adaptive learning, academic ethics, and the leadership of Peruvian universities in the region. It is worth noting that strict ethical guidelines for scientific integrity were observed, ensuring recognition of original authorship through proper citation in accordance with APA 7 standards and maintaining full transparency in the handling of collected data.

Results

Co-authorship results – organizations

Figure 1. *Organizations with publications identified in the Scopus database from 2015 to 2026 on artificial intelligence in education.*



Note. Authors' own elaboration (2026); based on data provided by Scopus.

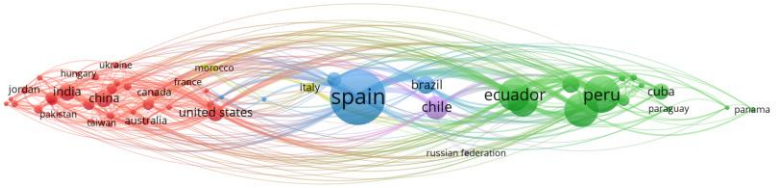
As shown in the figure, the ecosystem of scientific production on artificial intelligence (AI) in education between 2015 and 2026 is led by a consolidated core of organizations that have reached a critical research mass, exceeding a minimum of five documents and ten citations. This bibliometric map reveals a strong Asian axis, with institutions from Indonesia, such as Universitas Negeri Padang, standing out for their studies on expert systems applied to engineering education and the effectiveness of tools like ChatGPT in science teaching. In addition, a highly integrated European cluster emerges from collaboration between the University of Seville (Spain) and Bialystok University of Technology (Poland), whose publications link university maturity with technological management in smart city environments.

In Latin America, Peruvian universities have assumed a prominent and strategic role, leading regional production in research competency development and accounting for 23.6% of the Scopus-reviewed publications. Peruvian institutions such as Universidad César Vallejo and Universidad Nacional de Jaén have become key nodes in the generation of knowledge on scientific skills, while Pontificia Universidad Católica del Perú (PUCP) distinguishes itself through its focus on human rights and inclusion, as evidenced in social innovation projects such as the creation of the first bilingual dictionary of Peruvian Sign Language using AI models. These institutional centers pursue an agenda oriented toward Education 4.0, seeking to balance the efficiency of adaptive learning systems with academic integrity and ethical reflection on the use of cognitive assistants. Finally, the presence of organizations such as King Khalid University and the Chinese Academy of Sciences signals a global trend toward learning personalization and cognitive performance improvement through neural networks and predictive analytics techniques.

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Co-authorship results – countries

Figure 2. *Countries with publications identified in the Scopus database from 2015 to 2026 on artificial intelligence in education, with a minimum of 10 documents per country and 10 citations per country.*



Note. Authors' own elaboration (2026); based on data provided by Scopus.

As shown in Figure 2, the countries with the greatest participation in the scientific collaboration network are Spain, Peru, and Ecuador, with Spain standing out as the largest and most central node within the analyzed structure. This indicates that Spain concentrates substantial scientific output and maintains extensive interaction with other nations, thus constituting the primary articulator of the research network on the topic under study.

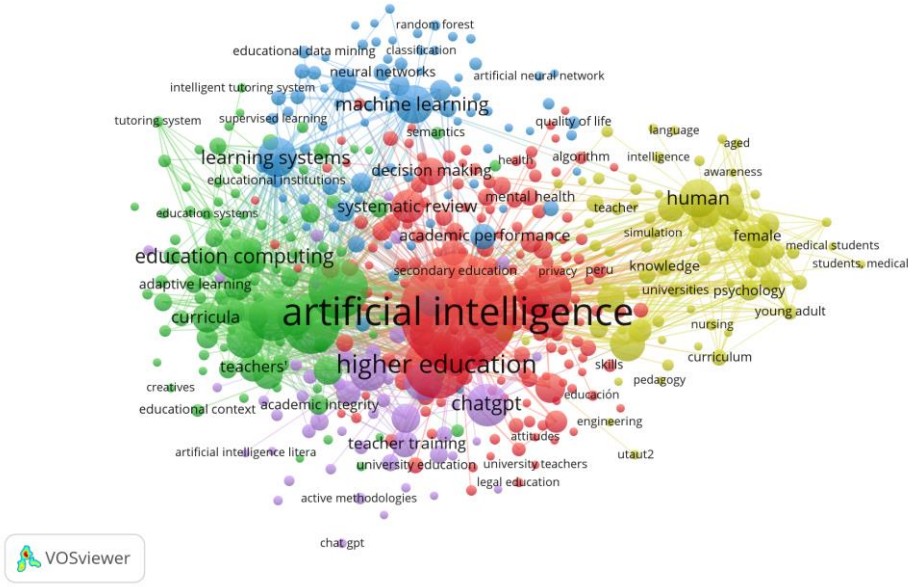
Similarly, participation from Latin American nations such as Peru, Ecuador, Cuba, Paraguay, and Panama is observed, forming a closely connected collaboration cluster with Spain. The dynamic relationship among these countries reveals the existence of an established Ibero-American scientific network, distinguished by knowledge exchange, joint research execution, and dissemination of results in international academic venues.

On the other hand, countries such as the United States, China, and India also demonstrate significant participation within the network, though their centrality is comparatively lower than Spain's. Their presence reflects worldwide interest in the research topic and the involvement of diverse regions in the advancement of scientific knowledge. Likewise, nations such as France, Italy, Canada, Australia, Brazil, and Chile function as bridges that enhance international connectivity among different research groups.

Finally, the density of links observed in the network attests to a high level of international scientific cooperation. Spain's strategic position, together with the growing participation of Peru and Ecuador, suggests that these countries play a fundamental role in the generation and dissemination of knowledge within the analyzed field of study. Hence, collaboration among countries constitutes a key factor for strengthening scientific production and consolidating increasingly broad and dynamic research networks.

Co-occurrence results – keywords

Figure 3. *Co-occurrence of keywords in publications identified in the Scopus database from 2015 to 2026 on artificial intelligence in education, considering a minimum number of keyword occurrences of 10.*



Note. Authors' own elaboration (2026); based on data provided by Scopus.

As shown in Figure 3 on keyword co-occurrence, with a minimum threshold of 10 occurrences in Scopus publications (2015–2026), an intellectual structure organized around three fundamental pillars that define the current research agenda is identifiable. The most prominent and dense core comprises the terminology of artificial intelligence, machine learning, and deep learning, which function as technological axes driving the creation of systems capable of examining complex patterns in student behavior. From this core emerges a cluster focused on educational applications, where key terms such as adaptive learning, study personalization, intelligent tutoring systems, and learning analytics signal the progression toward Education 4.0, aiming to enhance the effectiveness of the educational process through instantaneous responses.

A third cluster, consisting of topics of considerable current relevance, particularly concerning the growth of generative AI in late 2022, encompasses notions such as ChatGPT, academic integrity, ethics in education, and neuroeducation, linking the use of cognitive assistants with concerns about authenticity in learning and the enhancement of cognitive performance based on scientific publications. Finally, the network density map shows connections with related terms such as higher education and specific areas like Latin America and Peru, where a developing landscape aimed at eliminating structural disparities through digital inclusion and the promotion of research skills is evident.

The yellow cluster brings together terms pertaining to human, psychology, knowledge, teacher, female, students, curriculum, pedagogy, and nursing, indicating that research has emphasized the human, psychological, and pedagogical aspects associated with the integration of artificial intelligence into educational settings. The inclusion of health-related and professional training terms further suggests specific applications within certain disciplines.

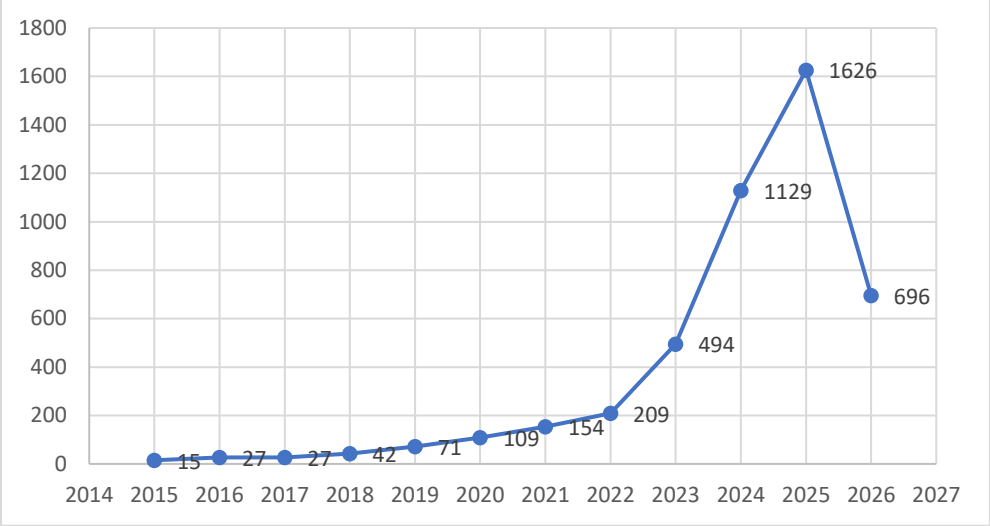
Finally, the purple cluster concentrates key terms such as teacher training, academic integrity, university education, active methodologies, and artificial intelligence literacy, which reveal growing concern about teacher education, the development of digital and ethical skills, and the teaching of artificial intelligence in higher education institutions.

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In other words, the network shows that scientific production on artificial intelligence in education has evolved toward a multidisciplinary approach, integrating technological, pedagogical, psychological, and organizational dimensions. The strong interconnection among keywords indicates that artificial intelligence is studied not only as an emerging technology but also as a transformative element of teaching, learning, assessment, and educational management processes.

Distribution of scientific production by publication year.

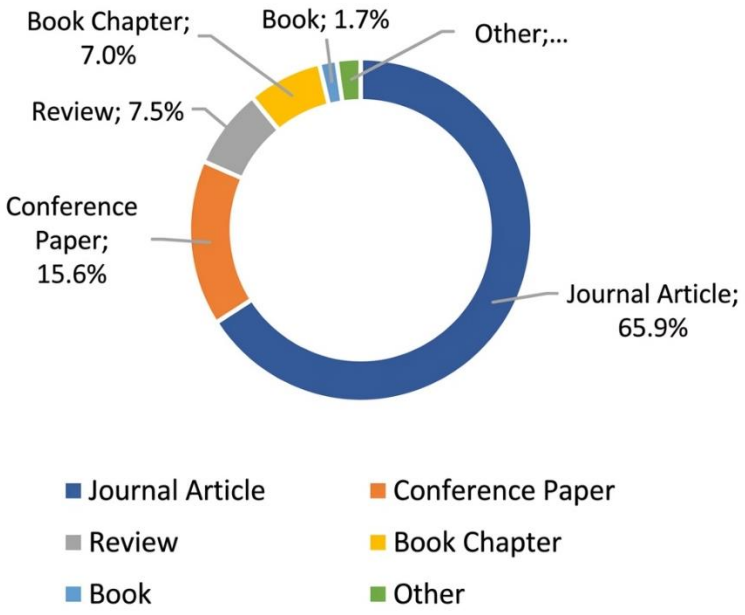
Figure 4. *Distribution of scientific production by publication year, considering the period between 2015 and 2026.*



Note. Authors' own elaboration (2026); based on data provided by Scopus.

As visualized in Figure 4, from a population of 4,599 publications on scientific production concerning artificial intelligence in education indexed in Scopus between 2015 and 2026, an exponential growth trend emerges, with a critical inflection point occurring in late 2022 following the widespread release of generative AI tools such as ChatGPT. During the initial phase from 2015 to 2021, the number of publications shows continuous but gradual growth, focused on the development of expert systems and predictive performance analysis. However, beginning in 2023, the literature experienced a sudden and unprecedented surge, reflecting a significant shift driven by the need to address the ethical, pedagogical, and academic integrity issues associated with AI. For the 2024–2026 period, the figure shows a notable increase in production, propelled by the urgent need to systematize findings on adaptive learning systems and the personalization of education within the context of Education 4.0. This quantitative growth not only signals the consolidation of AI as a technological cornerstone of the twenty-first century but also highlights the pressing need to establish clear norms and policies that guide responsible, human-centered usage in order to avoid widening existing digital divides.

Figure 5. *Type of publication document.*



Note. Authors' own elaboration (2026); based on data provided by Scopus.

As observed in Figure 5, research output on artificial intelligence (AI) in education between 2015 and 2026 is predominantly composed of research articles, which constitute 65.9% of total publications. This preeminence indicates that indexed journals are the preferred medium for disseminating empirical findings and theoretical models related to cognitive performance, learning personalization, and neuroeducation. In the second tier, conference papers, representing 15.6%, reflect active participation in the rapid dissemination of cutting-edge innovations, providing a forum for dialogue on Education 4.0 and the development of expert systems.

On the other hand, review documents, accounting for 7.5%, and book chapters, at 7.0%, indicate a substantial contribution to the organization of the literature, which is necessary for establishing ethical frameworks and academic integrity standards in response to the growth of tools such as ChatGPT. Finally, books, which reach only 1.2%, together with other documents totaling 2.0%, have a minimal presence, suggesting that research in this area prioritizes speed and impact of results within a digital system still under development. Therefore, these results demonstrate the predominance of the scientific article as a basis for guiding academic and policy decisions toward equitable technological inclusion.

Discussion

This bibliometric analysis reveals a significant increase in scientific production on AI in education, reaching a decisive turning point at the end of 2022. This development coincides with the emergence and widespread use of generative AI, particularly ChatGPT, which prompted a shift from an experimental phase to common adoption of these tools as part of higher education. Similar to the arguments put forward by Villarroel-Molina et al. (2025), this increase is not merely quantitative but also signifies a transition toward the new Education 4.0, wherein AI is reshaping conceptions of institutional management, teaching methods, and assessment approaches.

Regarding intellectual distribution by area, the thematic clusters identified demonstrate a shift in research from purely technical cores concerned with machine learning and deep learning toward educational applications focused on adaptive learning. These findings align with those observed by

Aparicio-Gómez and Aparicio-Gómez (2024), who indicate that AI-supported systems offer the possibility of personalizing the educational experience by analyzing large datasets and adapting to individuals' cognitive profiles. However, this technical progress gives rise to an emerging and notably important cluster centered on the academic integrity implications of AI. Studies such as Hasham (2026) indicate that, given that 92% of university students use these digital tools, institutions must update their integrity frameworks, moving from a results-centered approach toward one focused on the learning process.

The leadership in AI research across geographic and institutional domains shows shared dominance by centers of excellence located in Asia and Europe, while simultaneously highlighting the strategic positioning of Peruvian universities within Latin America. According to Marín León et al. (2026), Peru leads Latin American production in terms of advances in research skills, accounting for 23.6% of the publications examined. This finding is significant because, although the country is considered a developing ecosystem with infrastructure still needing improvement, the results point to a robust academic agenda focused on professionalization and social innovation, such as the creation and development of AI-based bilingual dictionaries for persons with disabilities.

Regarding document classification, the high proportion of original articles, representing 65.9%, underscores the preference for peer review to validate new empirical discoveries in a rapidly changing field. Nevertheless, the existence of obstacles such as the scarcity of specialized teacher training (73%) in certain contexts and concern about the loss of human connection in education (76%) among educators indicates that technological progress outpaces the training that institutions provide to teachers.

With respect to ethical challenges, the results highlight a significant cluster related to AI academic integrity. The studies of Hasham (2026) suggest that institutions should adapt their principles toward approaches that prioritize process rather than focusing exclusively on final outcomes. This concern is also corroborated by Acosta-Enriquez et al. (2024), who point to a lack of ethical understanding among university students regarding the use of generative models.

Finally, the results support the notion that AI is not meant to replace the teacher but rather to transform their role toward the design of new learning experiences. This aligns with the recommendations of UNESCO (2024) and Villarroel-Molina et al. (2025), which indicate that the success of AI integration depends on the establishment of human-centered regulatory frameworks that ensure equity, prevent algorithmic bias, and promote inclusion.

Conclusions

Based on the bibliometric study conducted in this research, it can be concluded that, within the Latin American context, Peru has emerged as a fundamental, strategic, and leading country in regional production for the development of research skills, accounting for 23.6% of the publications reviewed in the Scopus database. Scientific output related to artificial intelligence (AI) in education experienced remarkable growth during the 2015–2026 period, with a critical inflection point at the end of 2022 following the introduction of generative tools such as ChatGPT. This quantitative growth underscores the need to systematize findings in order to establish benchmarks that promote responsible and effective implementation in students' cognitive performance.

Artificial intelligence in education constitutes the technological foundation that has given rise to what is known as Education 4.0; although its principles were developed several decades ago, a major breakthrough occurred in 2022, transforming AI into a tool for adapting the learning process and improving institutional management. This advancement imposes demands characteristic of the digital age, such as the need for advanced digital skills and continuous teacher training. During this period, tensions related to academic ethics and the risk of dehumanizing the educational process have emerged, as 76% of teachers in Latin America express concern about students' excessive dependence on these intelligent systems. This directly influences the role of the teacher, who is not being replaced but rather transformed into that of a critical facilitator and creator of meaningful learning experiences.

All the foregoing allows this article to conclude by emphasizing the importance of establishing human-centered regulations and teaching methods that ensure equity, data protection, and student well-being. It is essential that the incorporation of AI goes beyond merely considering its practical use and instead fosters social inclusion and equity in knowledge, especially in regions such as Latin America where development is still perceived as a work in progress. For this reason, the need for research such as that presented here is underscored, studies that examine the academic corpus to provide readers with a broad perspective on the current state of the literature on scientific production in artificial intelligence in education, both globally and regionally.

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