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Integrating AI into educational methodologies to enhance critical thinking in university education: a systematic review

Integración de la IA en metodologías educativas para potenciar el pensamiento crítico en la educación universitaria: una revisión sistemática

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Abstract

The increasing incorporation of artificial intelligence (AI) in university settings offers both opportunities and challenges for the development of critical thinking, a fundamental skill in higher education. This study aimed to analyze recent scientific evidence on the integration of AI into educational methodologies aimed at enhancing critical thinking in university contexts. To this end, a systematic review was conducted in the ERIC, Web of Science, and Scielo databases, using the following search terms: "AI and educational methodologies and critical thinking," "AI and education and critical thinking," and "AI and educational methodologies." Applying the PRISMA protocol, 781 records were identified (617 in ERIC, 156 in Web of Science, and 8 in Scielo). After eliminating duplicates and applying inclusion criteria such as publications in the last five years, full access, English or Spanish languages, and a focus on higher education, technology, and education, 26 studies were selected for the final analysis. The results revealed that the most widely used methodologies are project-based learning, AI-mediated collaborative learning, and automated feedback. It was evident that AI facilitates personalized learning, stimulates metacognitive processes, and fosters student autonomy. However, challenges related to ethics, system reliability, and teacher training persist. It is concluded that the pedagogically planned integration of AI can be a valuable resource for strengthening critical thinking in higher education.

Keywords: higher education, AI, methodologies, critical thinking.

Resumen

La incorporación creciente de la inteligencia artificial (IA) en entornos universitarios ofrece tanto oportunidades como desafíos para el desarrollo del pensamiento crítico, una competencia fundamental en la formación superior. Este estudio se propuso analizar la evidencia científica reciente sobre la integración de la IA en metodologías educativas orientadas a potenciar el pensamiento crítico en contextos universitarios. Para ello, se realizó una revisión sistemática en las bases de datos ERIC, Web of Science y Scielo, utilizando las siguientes fórmulas de búsqueda: "*AI and educational methodologies and critical thinking*", "*AI and education and critical thinking*" y "*AI and educational methodologies*". Aplicando el protocolo PRISMA, se identificaron 781 registros (617 en ERIC, 156 en Web of Science y 8 en Scielo). Tras eliminar duplicados y aplicar criterios de inclusión como publicaciones en los últimos cinco años, acceso completo, idiomas inglés o español, y enfoque en educación superior, tecnología y educación, se seleccionaron 26 estudios para el análisis final. Los resultados revelaron que las metodologías

más utilizadas son el aprendizaje basado en proyectos, el aprendizaje colaborativo mediado por IA y la retroalimentación automatizada. Se evidenció que la IA facilita la personalización del aprendizaje, estimula procesos metacognitivos y fomenta la autonomía estudiantil. No obstante, persisten desafíos relacionados con la ética, la confiabilidad de los sistemas y la capacitación docente. Se concluye que la integración pedagógicamente planificada de la IA puede constituir un recurso valioso para fortalecer el pensamiento crítico en la educación superior.

Palabras clave: educación superior, IA, metodologías, pensamiento crítico.

Introduction

The emergence of artificial intelligence (AI) in the university sector represents one of the most significant phenomena in contemporary educational transformation. Over the past decade, higher education institutions have explored its potential not only as a technological tool but also as a catalyst for innovative pedagogical methodologies that place the student at the center of the educational process (Thompson et al., 2023). This transformation arises from the increasing need to prepare professionals capable of navigating complex environments, where competencies such as critical thinking are essential for informed decision-making and creative problem-solving (Trikoili et al., 2025).

Critical thinking, understood as the ability to analyze, interpret, and evaluate information reflectively, has always been a transversal objective in higher education. However, its development is often limited when traditional methods that prioritize memorization over critical reflection and argumentation prevail (Fakour & Imani, 2025). In this context, the integration of AI into methodologies such as project-based learning, inquiry-based teaching, and collaborative work mediated by digital environments opens new possibilities for stimulating metacognitive processes, promoting self-regulation, and fostering autonomous learning (Melisa et al., 2025; Nguyen, 2025).

Moreover, recent studies indicate that tools such as academic chatbots, automated feedback systems, and adaptive platforms can enrich the educational experience by providing personalized guidance, expanding access to resources, and facilitating guided practice environments (Neumann et al., 2025; Walter, 2024). Nevertheless, their implementation also presents significant challenges, including the need for teacher training to ensure pedagogically sound usage and attention to ethical issues related to algorithmic transparency, equitable access, and the reliability of generated information (García, 2024; Arango et al., 2024).

Therefore, the challenge is not limited to incorporating AI into university classrooms but rather integrating it coherently with learning objectives and the demands of the educational context. A review of existing literature indicates that the best outcomes are achieved when these technologies are applied within a clear methodological framework, with teacher oversight and explicit evaluation criteria (Noroozi et al., 2024; Holmes & Tuomi, 2022). However, a knowledge gap persists regarding which approaches and practices have proven most effective in fostering critical thinking in higher education.

In light of this issue, the present study aims to synthesize and analyze the most recent research addressing the integration of AI into educational methodologies aimed at developing critical thinking in university contexts. To this end, a systematic literature review was conducted of publications from 2020 to 2025 in the ERIC, Scielo, and Web of Science databases, following the guidelines of the PRISMA protocol.

Methodology

This study was conducted through a systematic review following the PRISMA protocol guidelines, thereby ensuring methodological rigor and transparency in the selection of studies. The bibliographic search was performed in 2025, covering three high-impact academic databases: ERIC, Web of Science, and Scielo. These platforms were selected due to their extensive coverage of scientific literature related to education and their presence of recent research on the integration of artificial intelligence in university teaching.

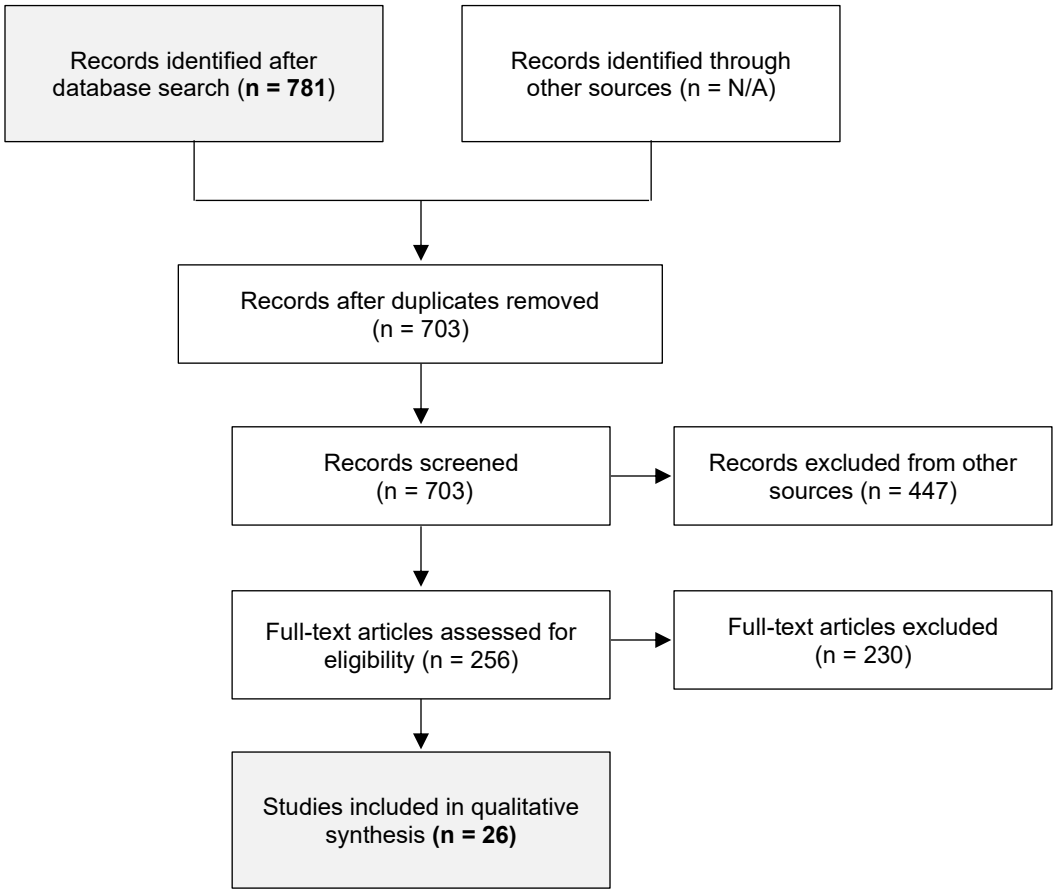
To identify relevant studies, three search formulas were designed that combined key terms with Boolean operators: “AI and educational methodologies and critical thinking,” “AI and education and critical thinking,” and “AI and educational methodologies.” This strategy generated a total of 781 records, distributed as follows: 617 from ERIC, 156 from Web of Science, and 8 from Scielo.

During the initial screening phase, duplicates were eliminated, reducing the sample to 703 documents. Next, titles and abstracts were reviewed to discard those that did not meet the inclusion criteria: publications from 2020 to 2025, full access, in English or Spanish, and linked to higher education, education, or educational technology. Studies that did not directly address the relationship between AI, teaching-learning methodologies, and the development of critical thinking were also excluded.

After this preliminary evaluation, 256 articles were subjected to full-text analysis. In this phase, 230 were discarded due to thematic misalignment or lack of relevant empirical evidence, leaving 26 studies that met all established criteria. Of these, 8 were from ERIC, 1 from Scielo, and 17 from Web of Science, forming the final base for qualitative synthesis.

Regarding the procedure for selecting studies, an initial recovery of 781 records was made from the aforementioned databases. However, after applying the exclusion criteria outlined in the attached diagram, only 26 articles were considered for the analysis and discussion of results, as detailed in the following figure.

Figure 1
PRISMA flow diagram



Results

Following the filtration of information through the PRISMA analysis, a thorough examination of the sources from the selected databases was conducted. Below is a synthesis of the most relevant findings from the studies:

Table 1
Description and analysis of selected articles from the ERIC database

Author(s)	Title	Language	Approach	Key findings
Blay & Espartinez (2024)	Improving digital learning in higher education: Students' perspectives on design thinking using Q-methodology	English	Qualitative	AI-supported design thinking facilitated critical evaluation and reconfiguration of ideas.

Chadha (2024)	Transforming higher education for the digital age: Examining emerging technologies and pedagogical innovations	English	Theoretical; Document Review	AI-assisted collaborative learning enhanced the evaluation of complex problems and decision-making.
Damiano et al. (2024)	Early perceptions of teaching and learning using generative AI in higher education	English	Qualitative; Interviews	Generative AI in collaborative debates encouraged reflection and questioning of content.
Ilić et al. (2021)	Needs and performance analysis for changes in higher education and implementation of artificial intelligence, machine learning, and extended reality	English	Mixed; Exploratory Study	AI-augmented extended reality promoted critical analysis and contextualized problem-solving.
Karanjakwut & Charunsri (2025)	Transforming AI chatbots for a brainstorming teaching technique of process writing	English	Quasi-experimental	The Socratic method with chatbots strengthened questioning and critical argumentation.
Melisa et al. (2025)	Critical thinking in the age of AI: A systematic review of AI's effects on higher education	English	Systematic Review	AI-guided academic debates favored comparative analysis and the development of critical skills.
Nguyen (2025)	Project-Based Learning (PJBL) as an experiential pedagogical methodology in interdisciplinary education: A review of the literature	English	Literature Review	AI-enhanced project-based learning (PBL) fostered perspective evaluation and interdisciplinary critical thinking.
Neumann et al. (2025)	An LLM-Driven Chatbot in higher education for databases and information systems	English	Mixed; Empirical Study	Chatbot tutoring fostered critical analysis by requiring verification and contrast of information.

Table 2
Description and analysis of selected article from the Scielo database

Author(s)	Title	Language	Approach	Key findings
Castillejos (2022)	Artificial intelligence and personal learning environments: attending to the appropriate use of technological resources by university students	Spanish	Qualitative	The intrusion of AI in higher education diminishes creativity and criticality in students.

Table 3
Description and analysis of selected articles from the Web of Science database

Author(s)	Title	Language	Approach	Key findings
Abrams (2024)	(R)evolutions of thought: Artificial intelligence and education futures	English	Qualitative	Integrated AI in PBL and design thinking facilitated complex problem resolution.
Alier, García-Peñalvo & Camba (2024)	Generative artificial intelligence in education: From deceptive to disruptive	English	Qualitative	Generative AI applied to design thinking accelerated ideation and prototyping.

Aldulaijan & Almalki (2025)	The impact of generative AI tools on postgraduate students' learning experiences	English	Empirical Study	AI in PBL personalized scenarios and enhanced critical analysis.
Amofa et al. (2025)	Navigating the complexity of generative artificial intelligence in higher education	English	Systematic Review	AI in PBL and collaborative work favored hypothesis formulation and solutions.
Arango et al. (2024)	Philosophical, ethical and pedagogical implications of AI in education	English	Qualitative	AI-assisted Socratic method promoted critical dialogues.
Butson & Spronken-Smith (2024)	AI and its implications for research in higher education	English	Critical Essay	AI complemented dialogic and Socratic learning strategies.
Fakour & Imani (2025)	Socratic wisdom in the age of AI	English	Comparative Study	AI supported the Socratic method in argumentation and critical reasoning.
Farrelly & Baker (2023)	Artificial intelligence: Implications for higher education	English	Qualitative	AI applied to PBL simulated scenarios for decision-making.
García Pérez (2024)	Educating in the era of artificial intelligence	Spanish	Qualitative	AI integrated into design thinking and collaborative learning enhanced critical reflection.
Holmes & Tuomi (2022)	State of the art and practice in AI in education	English	State of the Art	AI in adaptive tutoring reinforced PBL and question formulation.
Jose & Jayaron (2024)	Educators' academic insights on AI	English	Quantitative	AI in PBL increased motivation and critical reflection.
Mateo & Fernández (2024)	Towards improved teaching of questioning	Spanish	Mixed	AI improved question formulation in the Socratic method.
Noroozi et al. (2024)	Generative AI in education	English	Qualitative	AI in PBL and debates expanded analytical perspectives.
Su & Yang (2023)	Unlocking the power of ChatGPT	English	Qualitative	ChatGPT facilitated structuring and analysis in PBL.
Thompson et al. (2023)	AI in tertiary education	English	Mixed	AI applied to PBL and dialogic learning strengthened intellectual autonomy.
Trikoili et al. (2025)	Critical Thinking Assessment in Higher Education	English	Mixed	AI supported rubrics and feedback in PBL.
Walter (2024)	Embracing the future of AI in the classroom	English	Qualitative	AI and prompt design reinforced the Socratic method and design thinking.

The temporal distribution of the analyzed studies showed that the highest production concentrated in the last two years, with 12 articles published in 2024 and 8 in 2025. In contrast, 2023 accounted for 3 publications, while 2022 and 2021 recorded 2 and 1, respectively. Regarding language, 23 works were written in English, compared to only 3 in Spanish, reflecting a clear predominance of Anglo-Saxon literature in this field.

Methodologically, the sample included various types of studies: empirical research of qualitative, quantitative, and mixed nature, as well as systematic reviews and theoretical essays. Empirical studies focused on exploring concrete experiences related to the integration of AI in university environments, while conceptual works addressed the challenges, opportunities, and pedagogical orientations for implementing these technologies.

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The thematic analysis revealed that artificial intelligence was predominantly integrated into active methodologies focused on developing critical thinking. Among the most notable were Problem-Based Learning and Project-Based Learning, where generative AI enabled the creation of scenarios, content personalization, and immediate feedback, facilitating students' evaluation of alternatives and justification of their decisions (Amofa et al., 2025; Aldulaijan & Almalki, 2025). Additionally, AI-supported design thinking accelerated ideation and prototyping, promoting iteration and critical reflection (Blay & Espartinez, 2024; Alier et al., 2024). Some studies also reported the use of conversational tools in dynamics based on the Socratic method, which favored question formulation and argumentative debate; however, the importance of teacher mediation was emphasized to achieve greater conceptual depth (Fakour & Imani, 2025; Mateo & Fernández, 2024).

Discussion

Firstly, the findings indicate that the integration of artificial intelligence into methodologies oriented toward critical thinking has ceased to be an emerging trend and has consolidated as a fundamental axis in university innovation. In this regard, Holmes and Tuomi (2022) highlight that the implementation of intelligent systems not only optimizes learning personalization but also redefines academic interaction dynamics, promoting deeper analyses. Complementarily, Thompson, Corrin and Lodge (2023) show that this transformation reflects in the diversification of resources and environments, allowing university students to engage in more rigorous evaluation and reflection processes.

Secondly, the pedagogical transformations derived from AI transcend mere technical implementation, implying a comprehensive redesign of teaching strategies. Abrams (2024) argues that the adoption of AI creates flexible learning environments, in which critical thinking is strengthened through the exploration of multiple perspectives. Similarly, Damiano et al. (2024) demonstrate that the early incorporation of generative AI in collaborative activities increases students' ability to question established ideas and contrast information from diverse theoretical frameworks.

Among the methodologies that have benefited the most is design thinking, presented as a key tool for integrating creativity and critical reasoning. Blay and Espartinez (2024) conclude that its application with AI support facilitates systematic evaluation and reconfiguration of ideas, significantly improving the quality of proposed solutions. In line with this, Walter (2024) observes that combining AI literacy with prompt engineering strategies allows students to generate innovative proposals that are subject to rigorous critical scrutiny.

Furthermore, Project-Based Learning (PBL) has been strengthened through the use of AI, especially in interdisciplinary contexts. Nguyen (2025) explains that the complexity of problems incorporated in these environments requires advanced analytical skills to design viable solutions. Simultaneously, Amofa et al. (2025) highlight that AI-driven simulations and predictive tools favor informed decision-making by integrating logical reasoning with risk and opportunity evaluation in real scenarios.

Regarding the Socratic method, traditionally centered on reflective dialogue, AI has expanded its reach. Fakour and Imani (2025) document that chatbots designed to sustain Socratic dialogues stimulate systematic questioning, deepening reasoning. Karanjakwut and Charunsri (2025) report that in teaching process writing, the incorporation of AI promotes continuous argument review, improving the coherence and solidity of texts produced by university students.

In terms of assessment, AI has become a significant ally in strengthening critical thinking. Trikoili et al. (2025) argue that combining human and automated evaluations produces more comprehensive feedback, favoring self-regulated learning. Complementarily, Neumann et al. (2025) demonstrate that tutoring with chatbots based on advanced language models stimulates data verification and source contrast, essential practices for developing robust critical thinking.

From the perspective of synthesis and pedagogical planning, Melisa et al. (2025) identified that the most effective strategies for integrating AI and critical thinking combine structured debate dynamics with comparative analysis. In this sense, Su and Yang (2023) proposed an application framework to ensure that technology is utilized in alignment with clear educational objectives, avoiding superficial approaches that do not impact students' critical formation.

Regarding the ethical and philosophical aspects related to the integration of AI in education, Arango et al. (2024) caution that inappropriate use can affect intellectual autonomy and foster technological dependence. Complementarily, García Pérez (2024) warns that overexposure to automated resources could dilute the role of human judgment, diminishing the value of academic deliberation processes.

Moreover, the limitations and risks associated with this integration cannot be overlooked. Farrelly and Baker (2023) point out that implementation lacking rigorous planning can compromise essential cognitive skills,

while Castillejos (2022) warns that excessive automation can undermine students' creativity and capacity for autonomous analysis, thus highlighting the need to balance innovation and critical training in higher education.

The role of the teacher appears fundamental in this process. Jose and Jayaron (2024) emphasize that teacher training must consider competencies to integrate AI in a critically and pedagogically meaningful way. In line with this, Butson and Spronken-Smith (2024) stress that this training should include constant reflection on how technologies transform not only teaching dynamics but also the ways of evaluating and fostering critical thinking.

From a theoretical and comparative perspective, Noroozi et al. (2024) argue that AI should be incorporated based on solid pedagogical frameworks to ensure its positive impact. Aldulaijan and Almalki (2025) show that in postgraduate contexts, generative tools promote self-reflection and self-management as long as their use is articulated with clearly defined educational objectives.

Finally, an integrative view of the results suggests that AI, strategically applied to methodologies such as design thinking, PBL, and the Socratic method, can substantially enhance the development of critical thinking in higher education. Holmes and Tuomi (2022) remind us that the central objective is not to replace human cognitive processes but to enrich them. In this sense, Mateo and Fernández (2024) demonstrate that AI, even in situations of communicative misunderstandings, contributes to clarifying and improving academic discourse, strengthening students' critical competencies.

Conclusion

The integration of artificial intelligence into pedagogical methodologies such as design thinking, Project-Based Learning, and the Socratic method has proven to be an effective strategy for enhancing the development of critical thinking in the university context. These methodological combinations, supported by intelligent tools, not only facilitate the generation of ideas and creative solutions but also promote their systematic and substantiated evaluation. This strengthens students' ability to tackle complex problems, argue solidly, and rigorously contrast perspectives.

The benefits of using AI in higher education are fully realized when its implementation is framed within a solid instructional design, grounded in clear objectives and the mediation of teachers with consolidated technopedagogical competencies. This approach ensures that technology serves as a facilitator of critical learning rather than a substitute for human reasoning, thereby preventing risks related to excessive dependence, superficial analysis, or a reduction in creativity and intellectual autonomy.

On the other hand, higher education institutions face the challenge and opportunity to establish policies and programs that strategically incorporate AI, ensuring that technological innovation aligns with 21st-century educational objectives. To this end, it is necessary to develop ethical frameworks for its use, promote ongoing teacher training, and ensure that the methodologies employed directly contribute to building a solid and transferable critical thinking skill set across various professional and social contexts. In this way, the role of the university as a space for comprehensive training and a driver of social transformation is strengthened.

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AUTHORSHIP CONTRIBUTION

The authors declare that the conceptualization, data curation, formal analysis, investigation, methodology, project management, resources, validation, and manuscript writing—proofreading and editing—were carried out with the necessary attention to detail to ensure that the research maintains the appropriate rigor.

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CONFLICT OF INTERESTS DECLARATION

The authors declare that there are no conflicts of interest, either financial or personal, that could have improperly influenced the elaboration, analysis, interpretation, or presentation of the results of this study.

STATEMENT ON THE USE OF ARTIFICIAL INTELLIGENCE

The authors declare that, during the process of writing this manuscript, generative artificial intelligence tools were employed solely as support for linguistic tasks, such as style enhancement, syntactic organization, and grammatical correction. Under no circumstances were these technologies used to generate original scientific content, interpret results, or substitute the academic and ethical judgment of the authors. Full responsibility for the integrity, validity, and originality of the manuscript rests solely with the authors, in accordance with recognized editorial best practices and international ethical principles of scientific publication.