Systematic review of critical thinking using artificial intelligence

[ID]Teresa Chara-De lo Rios[1]*, [ID]Beymar Solis-Trujillo[2], [ID]Jhon Perez-Ruiz[3], [ID]María Aquije-Mansilla[4]
[1,2,3,4]Cesar Vallejo University, Lima, Perú; tlosrios@ucvvirtual.edu.pe (T.C.D.L.R.) bsolist@ucvvirtual.edu.pe (B.S.T.)
jperezru@ucvvirtual.edu.pe (J.P.R.) maquije@ucvvirtual.edu.pe (MA.M.)

Abstract: In an era where technology facilitates both the generation of information and misinformation, it is crucial to equip students with critical thinking skills. This study aims to systematically review the role of artificial intelligence (AI) in fostering critical thinking, exploring its effectiveness, methodologies, and implications in educational contexts. A systematic literature review was conducted following PRISMA guidelines. Relevant peer-reviewed articles published in the last decade were sourced from databases such as Scopus, Web of Science, and IEEE Xplore. The inclusion criteria focused on studies that analyze AI-driven tools, techniques, and interventions designed to enhance critical thinking in students. The findings indicate that AI-based approaches, including machine learning algorithms, natural language processing, and intelligent tutoring systems, can support the development of critical thinking by providing personalized feedback, facilitating argument analysis, and detecting misinformation. However, challenges such as ethical concerns, biases in AI models, and accessibility issues remain significant barriers. The study provides insights for educators, policymakers, and AI developers on how to effectively integrate AI-driven tools into educational curricula. It also highlights the need for interdisciplinary collaboration to ensure that AI fosters rather than hinders critical thinking development. AI has the potential to enhance critical thinking skills in educational settings, but its implementation must be carefully designed to address ethical and technical challenges. Further research is needed to assess long-term impacts and to develop more inclusive and unbiased AI-based educational frameworks.

Keywords: Artificial intelligence, Critical thinking, Ethics, Education, Methodological strategies.

1. Introduction

1.1. The Importance of Critical Thinking in the Face of Misinformation

Technological advances have significantly transformed how information is created, consumed, and shared. Technology changes people's lives and their perspective on the worldOviedo-Trespalacios, et al. [1] and Cantero, et al. [2] when they consume information without analyzing or filtering it, or worse, when they share it without verifying its authenticity.

In a context where real facts and misinformation are intentionally mixed to create confusion, it is necessary to combat misinformation, and one way to do so is by developing critical thinking skills—that is, the ability to logically analyze and evaluate data and information collected, considering both the process and the outcome, while carefully assessing the validity and integrity of digital sources [3-6].

Intermediate-level students are the most frequent users of the internet and social media, yet they often lack essential media literacy skills and the ability to distinguish between true and false information [7]. Primary and secondary students Murillo-Ligorred, et al. [8] must learn to differentiate between reality and representations, as they struggle to distinguish real images from fake ones (deepfakes), a common form of manipulation in daily life. A deepfake is a realistic video digitally altered to show

people doing or saying things that never actually happened García-Ull [9] using neural networks that analyze extensive datasets and learn to replicate a person's facial expressions, movements, and voice.

1.2. The Need to Innovate in Teaching Methods

One of the main concerns of educators is how to encourage and cultivate critical thinking in their students through the use of artificial intelligence (AI), but also how these tools might affect the critical and analytical thinking of students and researchers [10]. This raises the need to examine both the challenges and opportunities of AI in education, ensuring that this technology fosters critical thinking rather than simply automating tasks.

Moreover, professionals and educators Pavlik [11] must be prepared to adapt to technological changes and ensure that AI is used responsibly and ethically; they must also foster collaboration in teaching practices to maximize the benefits of AI in education, such as ChatGPT Leite [12] which is designed to provide specific responses to user queries, offering an opportunity for teachers to move beyond the traditional teaching model centered on memorization, where the teacher asks the question, and the student is responsible for the answer. It is essential to develop new theories and methodologies, such as questioning their pedagogical practices in a time of hyper-complexity, diverse intelligence, architectures, and platforms, training teachers to be productive, creative, critical, and ethical users of technology [13]. As teachers and researchers, we play a crucial role in building a future where technology enhances human capabilities without compromising essential values, adopting a critical and forward-looking approach to ensure ethical and responsible integration in research.

Regarding assessments, researchers Alabidi, et al. [14] and Zhai, et al. [15] need to innovate in assessment practices by creating interactive, personalized, and engaging evaluations within the realm of scientific education, moving away from cognitively demanding tasks and toward creativity and analytical skills, reducing the negative effects of GAI on tests, and ensuring that AI promotes strong critical thinking rather than merely automating cognitive processes and innovation in assessments.

Technological advances, such as artificial intelligence, will require students to acquire additional competencies [4]. The future labor market will demand a combination of adaptable skills, with critical thinking as a key element.

1.3. Protection of Rights

Artificial intelligence La [16] must prioritize human well-being by addressing educational challenges, such as the need to innovate in teaching and learning methods to accelerate progress toward the goals set in SDG 4 on Quality Education and the right to redefine a new social contract that ensures technology benefits everyone and protects essential rights, such as privacy, security, and truthfulness in the digital realm.

Digital literacy will influence identity, rights, critical thinking skills, and emotional intelligence [6] since the digital environment has permeated nearly every aspect of daily life. According to the UNESCO Forum held in December 2020 and SDG 4 of the 2030 Agenda Vivar and Peñalvo [17] an algorithmic literacy plan should be integrated into educational programs across all areas of knowledge.

1.4. Challenges in Using AI

Generative Artificial Intelligence (GAI) is a type of artificial intelligence capable of understanding, learning, and applying knowledge across a wide range of human-level activities, raising concerns in education Jose and Jose [18] such as the potential to replace human teachers, its impact on educational development, and concerns about its acceptance and naturalness.

ChatGPT offers multiple benefits in education, such as creating motivating environments [12, 17, 19, 20]. Supporting personalized learning, assisting in writing research papers, improving grammar and writing skills, promoting critical thinking, and enhancing the overall quality of learning. This allows human cognitive capacity to focus on activities related to divergent and inductive thinking, so it should be seen as an aid to teachers rather than a replacement [12]. If a balanced approach is applied Hieu

[21] that combines AI with traditional methods and adapts AI tools to the cultural and educational context, it can foster personalized and interactive student-centered learning experiences. Far from being a threat, artificial intelligence Pérez, et al. [22] will elevate critical reasoning and problem-solving skills to a higher dimension.

While generative AI (GAI) facilitates information and helps students and researchers improve the quality, efficiency, and clarity of research work, freeing them from tedious and routine tasks[10, 23, 24]. It does not always provide accurate information. Therefore, it is necessary to understand its limitations regarding accuracy, bias, and reliability. Constant exposure to uniform content, regardless of its quality Bonicalzi, et al. [25] can reduce users' ability to think critically, question their beliefs, or consider different valid arguments, making it crucial García-Ull [9] to equip students with the skills and tools to question and analyze AI-generated media messages, detect fake news, and promote more respectful online interactions. Students Zou, et al. [26] recognize its advantages and risks, as well as the importance of receiving training in this area.

Problem-solving and critical thinking are essential in decision-makingAvsec, et al. [20]; Benvenuti, et al. [27]; Dindorf, et al. [28] and Ossiannilsson, et al. [29] and are intertwined to find optimal solutions to challenges and drive innovation. Future citizens are expected to cultivate these skills.

Artificial intelligence (AI) also presents significant ethical and academic considerations, such as plagiarism and academic integrity. According to Nikolic, et al. [30] plagiarism occurs when students perceive that the benefits outweigh the risks, facilitating dishonest practices, making it important Pérez, et al. [22] to reinforce ethical behavior codes to prevent fraudulent use.

However, Santiago Jr, et al. [10] excessive use of artificial intelligence tools can hinder the development of critical thinking and creativity, in addition to presenting risks of plagiarism and incorrect recommendations that may alter the original meaning of the text.

Another risk is that it may come to be seen Cooper [31] as the primary source of knowledge, potentially leading to the belief that it is the only truth without solid evidence base or the necessary credentials to support it.

A relevant factor is the absence of specific institutional guidelines on the use of generative artificial intelligence Van den Berg [24] highlighting the need for clear guidelines and policies to ensure responsible and ethical integration in educational contexts, while it should be used carefully to protect data privacy [21, 32-34]. Due to the dependence on self-reported data, the possibility of biases, and inaccuracies, which could affect the validity of findings. Artificial intelligence Sanabria-Z and Olivo [35] presents ethical and privacy challenges that require regulatory frameworks, as without ethical boundaries Ossiannilsson, et al. [29] it can perpetuate biases and discrimination, increasing divisions and endangering human rights and freedoms.

1.5. Methodological Strategies

In the strategies applied by educational organizations to strengthen students' critical thinking, Sanabria-Z and Olivo [35] propose a model that combines participatory action research and User-Centered Design (UCD), based on Active and Transformational Learning (ATL) to create a user-centered platform that fosters critical thinking and real-world problem-solving, tutoring, and data analysis supported by AI. Implementing role-playing debates Guerrero and Forment [36] for the practical teaching of ethical theories in engineering is an effective technique that can be adapted to various fields. The Self-Regulated Learning (SRL) model, according to Kong, et al. [37] allows students to take responsibility for their learning, enabling them to develop self-regulation and critical thinking skills, using text-based generative AI tools for academic writing. Self-efficacy significantly influences motivation and critical thinking awareness, indicating that AI can transform cognitive learning, though its direct impact on critical thinking awareness should be carefully evaluated [38].

Intelligent tutoring systems Cantero, et al. [2] are an example of how artificial intelligence can be tailored to the specific needs of each student. Guerra [39] proposes applying philosophy with guiding questions that help define concepts and stimulate ethical reflections to guide appropriate decision-

making. It is also suggested Kunkolienker and Kamat [40] to use strategic games designed with clear instructions and skill evaluation criteria, along with the enjoyment of the game at different levels of applicability. Essien, et al. [41] provides a detailed overview of AI technologies based on Bloom's taxonomy and their impact on higher education, highlighting their advantages and challenges, providing a practical guide for effective and ethical implementation.

This study presents the findings of a systematic review, offering a synthesis of the strategies and methodologies that educational institutions use to implement artificial intelligence to enhance students' critical thinking. Based on this review, it seeks to answer the question: How can artificial intelligence (AI) be effectively employed to foster and develop critical thinking in students?

2. Methodology or Procedures

In this research, a systematic literature review was conducted following the PRISMA Declaration Mohan, et al. [5]; Serrano, et al. [42] and Page, et al. [43] to examine the methodological strategies that educational organizations have implemented to strengthen the critical thinking of their students using artificial intelligence (AI). This motivated the formulation of the research question that served as the basis for structuring the analysis: What are the methodological strategies that educational organizations have used to improve students' critical thinking?

To obtain more precise results, searches were conducted in indexed literature databases such as Scopus and Web of Science, focusing on the purpose of the topic and covering the period from 2020 to June 27, 2024. The search strategy first examined titles, keywords, and abstracts to identify the most relevant sources. Then, the selected documents were thoroughly reviewed to ensure they met the standards established in this systematic literature review.

The methodological process followed these steps: (i) Identification of the field of study as "critical thinking in education or critical thinking using artificial intelligence." (ii) Access to full-text documents. (iii) Search for documentation that answers the research question. (iv) Selection of documentation that meets the criteria. (v) Extraction of data that aligns with the purpose.

In the effective selection of the found documentation, different inclusion criteria were considered, based on open-access articles, content aligned with the review objectives, the relevance of the topic, and publications from 2020 to June 27, 2024. Regarding exclusion criteria, duplicate documents, publications older than five years, and content that did not align with the study's objective were considered. Finally, the relevance of the documents for review was verified.

The search in Scopus was limited to articles published from 2020 to June 27, 2024. The search was limited to the subfields of Social Sciences and the languages of English, Chinese, Spanish, and Russian. A total of 476 articles were found in Scopus. In the first review, 396 articles were eliminated based on the title or abstract, which deviated from the study's purpose, leaving a total of 80 articles. In the second review, 51 articles were eliminated, leaving 29 selected articles.

The Boolean formula used in Scopus in English was: TITLE-ABS-KEY (artificial AND intelligence AND critical AND thinking AND in AND education OR critical AND thinking AND in AND education AND using AND artificial AND intelligence) AND PUBYEAR > 2019 AND PUBYEAR < 2025 AND (LIMIT-TO (SUBJAREA, "SOCI")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (EXACTKEYWORD, "Artificial Intelligence") OR LIMIT-TO (EXACTKEYWORD, "Education") OR LIMIT-TO (EXACTKEYWORD, "Critical Thinking") OR LIMIT-TO (EXACTKEYWORD, "Students") OR LIMIT-TO (EXACTKEYWORD, "Teaching")) AND (LIMIT-TO (LANGUAGE, "English") OR LIMIT-TO (LANGUAGE, "Spanish") OR LIMIT-TO (LANGUAGE, "Russian")).

In the search for articles in Web of Science, the Boolean formula used was: (ALL=(Critical thinking and artificial intelligence in education)) OR ALL=(Critical thinking in education using Artificial intelligence and Pensamiento crítico en educación usando inteligencia artificial), finding 136 open-access articles. The search was limited to English, Spanish, and Chinese languages. Then, 109 articles were

eliminated based on abstracts whose content did not correspond with the review objective, leaving a total of 27 selected articles.

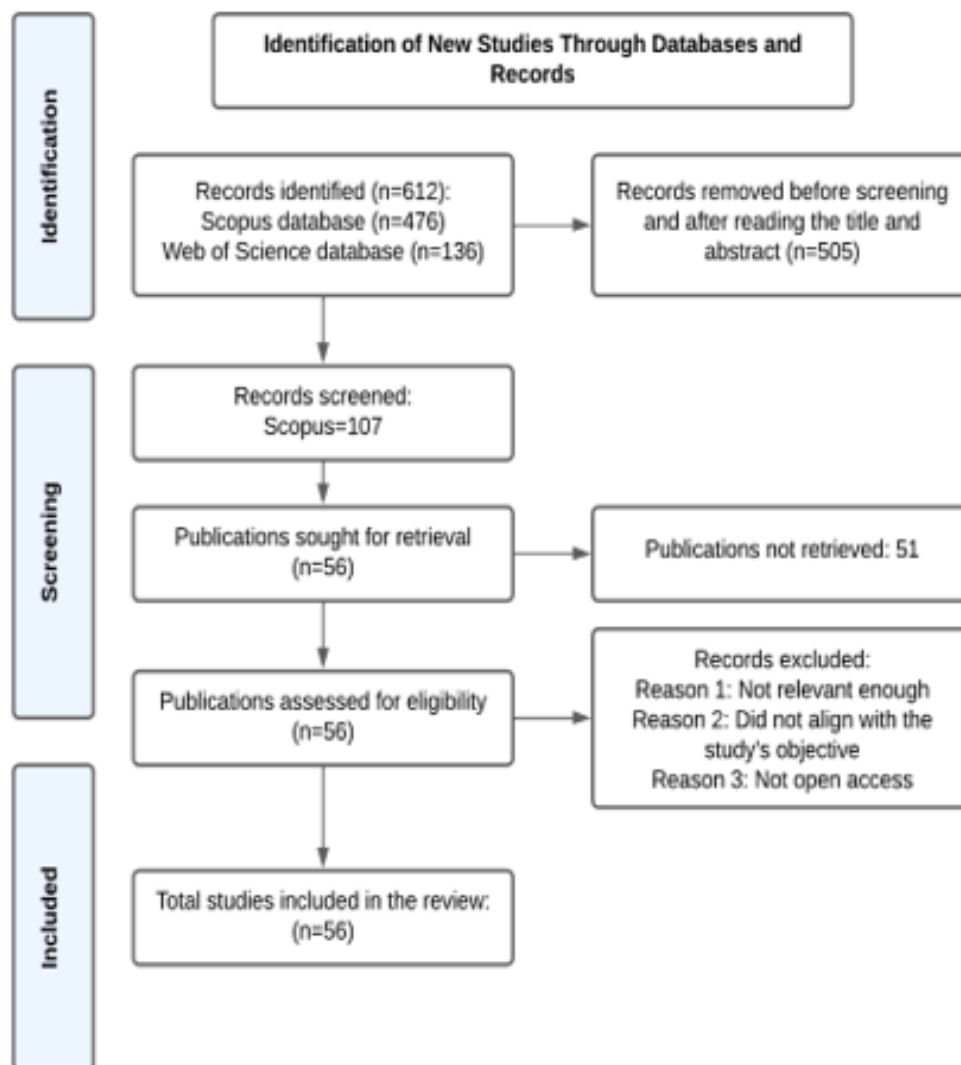Finally, 56 articles were selected, as shown in the PRISMA flow diagram, Figure 1.

Figure 1.
PRISM Flowchart.

3. Results, Analysis, and Interpretation

Self-efficacy, along with intrinsic motivation, significantly influences students' motivation and awareness of critical thinking [38]. The ability to learn driven by curiosity and personal interest greatly enhances critical awareness.

The use of ChatGPT has the potential to strengthen critical thinking skills by allowing students to explore prospective methods and develop essential competencies such as communication and logical reasoning [44, 45]. While this can enhance educational processes, concerns have also arisen about the presence of harmful content or incorrect information and the tendency to personify the chatbot, blindly trusting its responses [46, 47]. Which could limit the development of critical thinking if not used critically and reflectively.

To assess reliability and detect misinformation, one strategy is the use of knowledge graphs and multimodal methods, which have improved the interconnection of digital information [48]. These tools are essential for students to distinguish between accurate and inaccurate information in the digital information flow.

Regarding pedagogical approaches, Problem-Based Learning (PBL) combined with Scrum, and AI has demonstrated improvements in skills such as problem-solving, critical thinking, communication, and teamwork [49]. This model offers an effective and replicable approach for future research in education.

A survey conducted with future teachers trained in historical thinking Tirado-Olivares, et al. [50] showed that they could evaluate AI-generated texts and recognize its capacity to analyze historical information, although the need to train them on the effective use of AI and the promotion of critical thinking in the digital educational environment was noted.

The SWOT analysis of ChatGPT's use in education Zhu, et al. [47] highlighted its capabilities to understand complex questions, generate reliable responses, and produce human-like texts Ülkü [51] though improvements are needed to meet academic standards. However, it also identified limitations Zhu, et al. [47] such as the inclusion of incorrect information and a lack of deep understanding. The study provides a practical guide for its ethical and effective use Lin [52] and the implementation of generative AI models in academic contexts, highlighting three key features: intellectual capacity, versatility, and ability to collaborate.

In materials created with AI Kosarieva, et al. [53] in the philological field with a neuroscientific focus in higher education institutions, they have been effective in evaluating the efficacy of critical thinking, clearly distinguishing between accurate and inaccurate information amid the continuous information flow of today's digital society.

Finally, interactive multimedia activities and peer review in CGScholar have improved content understanding and critical thinking [54]. Additionally, the use of a Virtual Learning Companion (VLC) and gamification in educational projects such as CyberScratch have proven effective in enhancing cybersecurity education and privacy management, highlighting the usefulness of interactive digital tools in distance education [46, 55].

In the following Table 1, the aspects considered for selecting the research studies are summarized, as well as the comparison of the presented work with some research articles.

Table 1.
Table of comparison of scientific articles

Aspect	Your Research Findings	Findings from Other Research Studies
Strengthening Critical Thinking	AI can strengthen critical thinking if developed in an ethical and reliable context. Students acquire the ability to question, evaluate, and detect biases.	Consistent with other studies, such as those by Kosarieva, et al. [53] which emphasize the importance of an ethical and reliable context in applying AI to develop critical thinking skills and evaluate the reliability of information.
Use of ChatGPT and AI Tools	The use of ChatGPT can strengthen critical thinking skills, but there is a risk of blindly trusting its responses if not used critically and reflectively.	Similarly, Michalon and Camacho-Zuñiga [44] and Šedlbauer, et al. [45] observe that ChatGPT enhances soft skills but warn about students' tendency to blindly trust chatbot responses, potentially limiting critical thinking.
Effective Educational Methodologies	Application of philosophy with guiding questions, integration of gamification techniques, use of multimedia, and peer review are effective in improving critical thinking.	Other studies, such as those by Essien, et al. [41] and De Barros, et al. [49] also highlight the success of methodologies like Project-Based Learning, Scrum, and LLM in enhancing critical thinking and problem-solving skills. Tobarra, et al. [55] emphasize the use of multimedia in cybersecurity education.
Challenges in AI Implementation	Challenges related to ethics, information reliability, and data privacy. Lack of clear guidelines and excessive reliance on AI may limit the development of critical thinking.	Pérez, et al. [22] and Darwin, et al. [32] and other studies address similar concerns about ethical risks, the need for regulations, and the potential for excessive AI reliance to limit creativity and critical thinking.
Visual Literacy Training	Training in visual literacy is essential for students to distinguish between real and manipulated images, such as deepfakes.	Tinmaz, et al. [6]; Murillo-Ligorred, et al. [8] and Zou, et al. [26] agree on the importance of visual literacy to equip students with the necessary tools to identify visual misinformation in a saturated digital environment.
Academic Leadership and Policies	It is necessary to examine the role of academic leadership and institutional policies to ensure proper and ethical access to technological tools in education.	Soodan, et al. [23] emphasize the importance of academic leadership in AI implementation, while Darwin et al. and Van den Berg [24] and Darwin, et al. [32] stress the need for clear policies and regulations to protect privacy and ensure ethical AI use in educational contexts.
Student Engagement and Interaction	Daily internet and social media use by students presents both opportunities and challenges, facilitating access to resources and interaction but also exposing them to misinformation.	Similar concerns are raised by Zou, et al. [26] and Aprin, et al. [46] who highlight the importance of developing creativity, critical thinking, and ethical skills to counter the risks of digital misinformation.
Impact of AI on Learning Outcomes	The use of AI, such as ChatGPT, can enhance learning outcomes by improving soft skills like communication and logical reasoning, but educators must adapt pedagogical methods to address the potential risks of over-reliance.	Research byLeite [12] and Šedlbauer, et al. [45] supports the idea that AI tools can improve educational outcomes, though there is a risk of students personifying AI tools and trusting them without question, necessitating updated pedagogical approaches.
Ethical and Responsible AI Use	Educators must be trained in the responsible use of AI and work with students to understand the consequences of improper AI use. Ethical guidelines are crucial to mitigate risks and ensure data privacy.	Pavlik [11] and Tirado-Olivares, et al. [50] emphasize the need for ethical and regulatory frameworks to manage AI use in education, echoing your findings about the importance of responsible AI

		integration and the role of educators in guiding ethical AI practices.
Technological Integration in Education	AI tools like intelligent tutoring systems and multimedia educational applications have proven effective in enhancing cybersecurity education and developing critical thinking.	This aligns with findings from Cantero, et al. [2] who discuss the success of AI-driven educational tools in personalizing learning and promoting critical thinking, as well as Guerra [39] who proposes philosophical questioning techniques in AI-enhanced educational platforms.
Limitations and Future Research	The study is limited by focusing only on Scopus and Web of Science databases, but future research should continue exploring AI's impact on education as technology rapidly evolves.	Similar limitations are acknowledged in other studies, with suggestions for broader database inclusion and continuous research to keep pace with technological advancements, as discussed by Zhu, et al. [47] and Ali Khan, et al. [48].

The daily use of the internet and social media by young people presents both opportunities and challenges in the educational field by facilitating access to a wide range of resources and enabling interaction between students and teachers [26]. However, they may also be exposed to fake news and other risks associated with digital information aimed at manipulating public opinion, which raises serious concerns [46]. Therefore, it is necessary to develop human competencies in students, such as creativity, critical thinking, and ethical skills [56].

Furthermore, implementing personalized pedagogical approaches is crucial. Michalon and Camacho-Zuñiga [44] show that the use of ChatGPT enhances methods in each area of study, boosting soft skills such as communication, logical reasoning, and students' critical thinking [45]. However, there is a risk that students may personify the chatbot, as it can answer a wide range of complex questions, leading them to blindly trust its responses. This presents a challenge for educators to review or at least question their pedagogical methods [12].

On the other hand, AI tools have popularized the production of deepfakes, creating images that entertain, educate, reinterpret, and commemorate historical figures and events from the past in imaginative and artistic ways Murillo-Ligorred, et al. [8] but they are also used for defamation and misinformation.

Particularly, high schools Demartini, et al. [57] still show doubts about the effectiveness and benefits of AI in learning and academic management, unlike universities that incorporate it without difficulty.

A significant challenge in teaching Jia and Tu [38] is that it is still unclear how to fully harness AI's capabilities to foster reflection in students and improve learning effectiveness. In this context, teachers play an essential role in adapting their pedagogical strategies to promote ethical training and develop interpersonal and critical skills among students in an environment where AI is redefining automation and promoting personalized teaching.

Therefore, when allowing students to use ChatGPT in their activities, the teacher must teach them how to select, analyze, critique, compare, evaluate, synthesize, communicate, and report information. These are complex thought processes that the mediating teacher must teach to enable students to construct their knowledge.

4. Conclusion

The systematic review shows that artificial intelligence (AI) can strengthen critical thinking in students when developed within a context of ethics and information reliability [26, 34, 56]. This approach enables students to question sources, assess reliability, and detect biases in the information they access Kosarieva, et al. [53] acquire quality knowledge, improve their educational level, make efficient decisions, and solve problems they encounter in daily life [46]—fundamental skills in an

environment saturated with misinformation [45]. Training in visual literacy is essential [6, 8, 26]. To ensure that students can distinguish between real images and representations.

Addressing misinformation García-Ull [9] involves recognizing the problem and its potential impact; only then can effective technical solutions be designed and implemented. Therefore, it is necessary Soodan, et al. [23] to examine the role of academic leadership and institutional policies in accessing these technological tools.

Successful methodological strategies that have been proven to develop critical thinking in students include applying philosophy Guerra [39] with guiding questions on a cloud-based educational platform focused on cybersecurity Tobarra, et al. [55] integrating gamification techniques from the CyberScratch project, the Virtual Learning Companion (VLC), multimedia use through the CGScholar system McMichael, et al. [54] and peer review. Project-Based Learning combined with the Scrum tool, Bloom's Taxonomy, and Large Language Models (LLMs) [41]. Problem-Based Learning (PBL) combined with the Scrum methodology and intelligent tutoring systems [49]. AI and knowledge graphs [48], fictitious prototypes, various learning environments utilizing web tools, the design and development of multimedia educational applications, discussion forums, blogs, social media chats, newsgroups, bulletin boards, online games, forms, online surveys, email, and file transfer programs [2], the Self-Regulated Learning (SRL) model Kong, et al. [37] and activities such as role-playing games with students [36].

Training educators in the responsible use of AI [11, 12, 50, 56]. Involves analyzing with students the consequences of improper use of AI platforms. Ethical and regulatory guidelines must be established Darwin, et al. [32] to mitigate risks, misinformation, and the lack of data privacy. The question is not whether we should regulate AI and convergent technologies, but how to do so effectively. Active collaboration between academic institutions, the business sector, and the constantly evolving technological environment is recommended. Universities can organize regular exhibitions of AI projects for students to share experiences and foster success [38].

In conclusion, the integration of AI tools in education presents significant potential to enhance students' critical thinking skills, ensuring an ethical and effective education that prepares students to face the challenges of today's digital environment Dumitru and Halpern [4] and the future challenges of a labor market transformed by artificial intelligence and rapid global evolutions.

Among the study's limitations is the restriction to searching for information in only two databases, Scopus and Web of Science, as they were considered to analyze literature with the greatest scientific impact. It is recommended that future research continues to analyze this topic, as science and technology are advancing exponentially, and education must benefit from these innovations.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Copyright:

References

[1]   O. Oviedo-Trespalacios *et al.*, "The risks of using ChatGPT to obtain common safety-related information and advice," *Safety Science*, vol. 167, p. 106244, 2023. https://doi.org/10.1016/j.ssci.2023.106244

[2]   C. L. Cantero, G. B. Oviedo, W. F. Balboza, and M. V. Feria, "Tecnologías emergentes en el proceso de enseñanza-aprendizaje: Hacia el desarrollo del pensamiento crítico," *Revista electrónica interuniversitaria de formación del profesorado*, vol. 23, no. 3, 2020. https://doi.org/10.6018/reifop.435611

[3]   R. Greifeneder, M. Jaffe, E. Newman, and N. Schwarz, *The psychology of fake news: Accepting, sharing, and correcting misinformation*. London: Routledge, 2021.

[4]   D. Dumitru and D. F. Halpern, "Critical thinking: Creating job-proof skills for the future of work," *Journal of Intelligence*, vol. 11, no. 10, p. 194, 2023. https://doi.org/10.3390/jintelligence11100194

[5]   P. V. Mohan, S. Dixit, A. Gyaneshwar, U. Chadha, K. Srinivasan, and J. T. Seo, "Leveraging computational intelligence techniques for defensive deception: A review, recent advances, open problems and future directions," *Sensors*, vol. 22, no. 6, p. 2194, 2022. https://doi.org/10.3390/s22062194

[6]   H. Tinmaz, M. Fanea-Ivanovici, and H. Baber, "A snapshot of digital literacy," *Library Hi Tech News*, vol. 40, no. 1, pp. 20-23, 2023. https://doi.org/10.1108/LHTN-12-2021-0095

[7]   E. Herrero-Curiel and L. La-Rosa, "High school students and media literacy in the age of misinformation," *Comunicar: Revista Científica de Comunicación y Educación*, vol. 30, no. 73, pp. 95-106, 2022. https://doi.org/10.3916/C73-2022-08

[8]   V. Murillo-Ligorred, N. Ramos-Vallecillo, I. Covaleda, and L. Fayos, "Knowledge, integration and scope of deepfakes in arts education: The development of critical thinking in postgraduate students in primary education and master's degree in secondary education," *Education Sciences*, vol. 13, no. 11, p. 1073, 2023. https://doi.org/10.3390/educsci13111073

[9]   F. J. García-Ull, "Deepfakes: The next challenge in detecting fake news," *Anàlisi*, pp. 103-120, 2021. https://doi.org/10.5565/rev/analisi.3378

[10]   C. S. Santiago Jr *et al.*, "Utilization of writing assistance tools in research in selected higher learning institutions in the Philippines: A text mining analysis," *International Journal of Learning, Teaching and Educational Research*, vol. 22, no. 11, pp. 259-284, 2023. https://doi.org/10.26803/ijlter.22.11.14

[11]   J. V. Pavlik, "Collaborating with ChatGPT: Considering the implications of generative artificial intelligence for journalism and media education," *Journalism & Mass Communication Educator*, vol. 78, no. 1, pp. 84-93, 2023. https://doi.org/10.1177/10776958221149577

[12]   B. S. Leite, "Artificial intelligence and chemistry teaching: A propaedeutic analysis of chatgpt in chemical concepts defining br," *QUIMICA NOVA*, 2023. https://doi.org/10.21577/0100-4042.20230059

[13]   S. Mishra, R. Majumdar, A. Kothiyal, P. Pande, and J. M. Warriem, "Tracing embodied narratives of critical thinking," presented at the In International Conference on Artificial Intelligence in Education (pp. 267-272). Cham: Springer International Publishing, 2021.

[14]   S. Alabidi, K. AlArabi, N. R. Alsalhi, and M. Al Mansoori, "The dawn of ChatGPT: Transformation in science assessment," *Eurasian Journal of Educational Research*, no. 106, 2023. https://doi.org/0.14689/ejer.2023.106.019

[15]   X. Zhai, M. Nyaaba, and W. Ma, "Can generative AI and ChatGPT outperform humans on cognitive-demanding problem-solving tasks in science?," *Science & Education*, pp. 1-22, 2024. https://doi.org/10.1007/s11191-024-00496-1

[16]   C. La, "United nations educational, scientific and cultural organization, "recommendation on the ethics of artificial intelligence"," Retrieved: https://unesdoc.unesco.org/ark:/48223/pf0000381137_spa.locale=es, 2022.

[17]   J. M. F. Vivar and F. J. G. Peñalvo, "Reflections on the ethics, potential, and challenges of artificial intelligence within the framework of quality education (SDG4)," *Comunicar: Revista Científica de Comunicacion y Educacion*, vol. 74, pp. 37-47, 2023. https://doi.org/10.3916/C74-2023-03

[18]   J. Jose and B. J. Jose, "Educators' academic insights on artificial intelligence: Challenges and opportunities," *Electronic Journal of e-Learning*, vol. 22, no. 2, pp. 59-77, 2024. https://doi.org/10.34190/ejel.21.5.3272

[19]   R. AlAli and Y. Wardat, "Enhancing classroom learning: Chatgpt's integration and educational challenges," *International Journal of Religion*, vol. 5, no. 6, pp. 971-985, 2024. https://doi.org/10.61707/znwnxd43

[20]   S. Avsec, M. Jagiełło-Kowalczyk, and A. Żabicka, "Enhancing transformative learning and innovation skills using remote learning for sustainable architecture design," *Sustainability*, vol. 14, no. 7, p. 3928, 2022. https://doi.org/10.3390/su14073928

[21]   H. H. Hieu, "Exploring the impact of AI in language education: Vietnamese EFL teachers' views on using ChatGPT for fairy tale retelling tasks," *International Journal of Learning, Teaching and Educational Research*, vol. 23, no. 3, pp. 486-503, 2024. https://doi.org/10.26803/ijlter.23.3.24

[22]   V. R. Pérez, J. L. G. Soidán, A. S. Özdemir, and R. L. Rodríguez, "ChatGPT has arrived. What do we do now? Creativity, our last refuge," *Revista de Investigación en Educación*, vol. 21, no. 3, pp. 320-334, 2023. https://doi.org/10.35869/reined.v21i3.4973

[23]   V. Soodan, A. Rana, A. Jain, and D. Sharma, "AI chatbot adoption in Academia: Task fit, usefulness and collegial ties," *Journal of Information Technology Education. Innovations in Practice*, vol. 23, p. 1, 2024. https://doi.org/10.28945/5260

[24]   G. Van den Berg, "Generative AI and educators: Partnering in using open digital content for transforming education," *Open Praxis*, vol. 16, no. 2, pp. 130-141, 2024. https://doi.org/10.55982/openpraxis.16.2.640

[25]   S. Bonicalzi, M. De Caro, and B. Giovanola, "Artificial intelligence and autonomy: On the ethical dimension of recommender systems," *Topoi*, vol. 42, no. 3, pp. 819-832, 2023. https://doi.org/10.1007/s11245-023-09922-5

[26]   X. Zou, P. Su, L. Li, and P. Fu, "AI-generated content tools and students' critical thinking: Insights from a Chinese university," *IFLA Journal*, vol. 50, no. 2, pp. 228-241, 2024. https://doi.org/10.1177/03400352231214963

[27]   M. Benvenuti *et al.*, "Artificial intelligence and human behavioral development: A perspective on new skills and competences acquisition for the educational context," *Computers in Human Behavior*, vol. 148, p. 107903, 2023. https://doi.org/10.1016/j.chb.2023.107903

[28] C. Dindorf *et al.*, "Exploring decision-making competence in sugar-substitute choices: A cross-disciplinary investigation among chemistry and sports and health students," *Education Sciences*, vol. 14, no. 5, p. 531, 2024. https://doi.org/10.3390/educsci14050531

[29] E. Ossiannilsson, R. L. U. Cazarez, C. Goode, C. Mansour, and C. M. G. D. Gusmao, "Artificial intelligence use to empower the implementation of OER and the UNESCO OER recommendation," *Open Praxis*, vol. 16, no. 2, pp. 137-157, 2024. https://doi.org/10.55982/openpraxis.16.2.650

[30] S. Nikolic *et al.*, "ChatGPT versus engineering education assessment: A multidisciplinary and multi-institutional benchmarking and analysis of this generative artificial intelligence tool to investigate assessment integrity," *European Journal of Engineering Education*, vol. 48, no. 4, pp. 559-614, 2023. https://doi.org/10.1080/03043797.2023.2213169

[31] G. Cooper, "Examining science education in ChatGPT: An exploratory study of generative artificial intelligence," *Journal of Science Education and Technology*, vol. 32, no. 3, pp. 444-452, 2023. https://doi.org/10.1007/s10956-023-10039-y

[32] Darwin, D. Rusdin, N. Mukminatien, N. Suryati, E. D. Laksmi, and Marzuki, "Critical thinking in the AI era: An exploration of EFL students' perceptions, benefits, and limitations," *Cogent Education*, vol. 11, no. 1, p. 2290342, 2024. https://doi.org/10.1080/2331186X.2023.2290342

[33] W. Tam, T. Huynh, A. Tang, S. Luong, Y. Khatri, and W. Zhou, "Nursing education in the age of artificial intelligence powered Chatbots (AI-Chatbots): Are we ready yet?," *Nurse Education Today*, vol. 129, p. 105917, 2023. https://doi.org/10.1016/j.nedt.2023.105917

[34] Y. Qawqzeh, "Exploring the influence of student interaction with ChatGPT on critical thinking, problem solving, and creativity," *International Journal of Information and Education Technology*, vol. 14, no. 4, pp. 596-601, 2024. https://doi.org/10.18178/ijiet.2024.14.4.2082

[35] J. Sanabria-Z and P. G. Olivo, "AI platform model on 4IR megatrend challenges: Complex thinking by active and transformational learning," *Interactive Technology and Smart Education*, vol. 21, no. 4, pp. 571-587, 2024. https://doi.org/10.1108/ITSE-07-2023-0145

[36] M. J. C. Guerrero and M. A. Forment, "Case studies about moral dilemas to apply ethical theories in engineering education," *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje*, vol. 19, pp. 1-6, 2024. https://doi.org/10.1109/RITA.2024.3368609

[37] S.-C. Kong, J. C.-K. Lee, and O. Tsang, "A pedagogical design for self-regulated learning in academic writing using text-based generative artificial intelligence tools: 6-P pedagogy of plan, prompt, preview, produce, peer-review, portfolio-tracking," *Research & Practice in Technology Enhanced Learning*, vol. 19, 2024. https://doi.org/10.58459/rptel.2024.19030

[38] X.-H. Jia and J.-C. Tu, "Towards a new conceptual model of AI-enhanced learning for college students: The roles of artificial intelligence capabilities, general self-efficacy, learning motivation, and critical thinking awareness," *Systems*, vol. 12, no. 3, p. 74, 2024. https://doi.org/10.3390/systems12030074

[39] E. Guerra, "The contribution of critical thinking to STEM disciplines at the time of generative intelligence," *STEM Education*, vol. 4, no. 1, pp. 71-81, 2024. https://doi.org/10.3934/steme.2024005

[40] K. Kunkolienker and M. V. Kamat, "Priority based brainvita: A philosophical perspective of critical thinking for algorithm generation using game-based approach," *Journal of Engineering Education Transformations*, vol. 37, no. 2, pp. 225-233, 2024. https://doi.org/10.16920/jeet/2024/v37is2/24044

[41] A. Essien, O. T. Bukoye, X. O'Dea, and M. Kremantzis, "The influence of AI text generators on critical thinking skills in UK business schools," *Studies in Higher Education*, vol. 49, no. 5, pp. 865-882, 2024. https://doi.org/10.1080/03075079.2024.2316881

[42] S. S. Serrano, I. P. Navarro, and M. D. González, "How to conduct a systematic review following the PRISMA protocol: Fundamental uses and strategies for its application in the educational field through a practical case.," *Bordón: Revista de pedagogía*, vol. 74, no. 3, pp. 51-66, 2022. https://doi.org/10.13042/Bordon.2022.95090

[43] M. J. Page *et al.*, "PRISMA 2020 statement: An updated guide to the publication of systematic reviews," *Revista Española de Cardiología*, vol. 74, no. 9, pp. 790-799, 2021. https://doi.org/10.1016/j.recesp.2021.06.016

[44] B. Michalon and C. Camacho-Zuñiga, "ChatGPT, a brand-new tool to strengthen timeless competencies," in *Frontiers in Education*, 2023, vol. 8, p. 1251163, doi: https://doi.org/10.3389/feduc.2023.1251163.

[45] J. Šedlbauer, J. Činčera, M. Slavík, and A. Hartlová, "Students' reflections on their experience with ChatGPT," *Journal of Computer Assisted Learning*, vol. 40, no. 4, pp. 1526-1534, 2024. https://doi.org/10.1111/jcal.12967

[46] F. Aprin, P. Peters, and H. U. Hoppe, "The effectiveness of a virtual learning companion for supporting the critical judgment of social media content," *Education and Information Technologies*, vol. 29, no. 10, pp. 12797-12830, 2024. https://doi.org/10.1007/s10639-023-12275-6

[47] C. Zhu, M. Sun, J. Luo, T. Li, and M. Wang, "How to harness the potential of chatgpt in education?," *Knowledge Management & E-Learning*, vol. 15, no. 2, pp. 133-152, 2023. https://doi.org/10.34105/j.kmel.2023.15.008

[48] U. Ali Khan, J. Kauttonen, L. Aunimo, and A. V Alamäki, "A system to ensure information trustworthiness in artificial intelligence enhanced higher education," *Journal of Information Technology Education: Research*, vol. 23, p. 013, 2024. https://doi.org/10.28945/5295

[49] V. A. M. De Barros, H. M. Paiva, and V. T. Hayashi, "Using PBL and agile to teach artificial intelligence to undergraduate computing students," *IEEE Access*, vol. 11, pp. 77737-77749, 2023. https://doi.org/10.1109/ACCESS.2023.3298294

[50] S. Tirado-Olivares, M. Navío-Inglés, P. O'Connor-Jiménez, and R. Cózar-Gutiérrez, "From human to machine: Investigating the effectiveness of the conversational AI ChatGPT in historical thinking," *Education Sciences*, vol. 13, no. 8, p. 803, 2023. https://doi.org/10.3390/educsci13080803

[51] A. Ülkü, "Artificial intelligence-based large language models and integrity of exams and assignments in higher education: the case of tourism courses," *Tourism & Management Studies*, vol. 19, no. 4, pp. 21-34, 2023. https://doi.org/10.18089/tms.2023.190402

[52] Z. Lin, "Why and how to embrace AI such as ChatGPT in your academic life," *Royal Society Open Science*, vol. 10, no. 8, p. 230658, 2023. https://doi.org/10.1098/rsos.230658

[53] H. Kosarieva, O. Vasylenko, N. Breslavets, I. Tamozhska, I. Anikina, and N. Mordovtseva, "Methods of critical thinking in classes of philological disciplines in higher education institutions: Neuroscientific approach," *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, vol. 13, no. 4, pp. 459-470, 2022. https://doi.org/10.18662/brain/13.4/399

[54] M. A. McMichael *et al.*, "Use of a multimodal, peer-to-peer learning management system for introduction of critical clinical thinking to first-year veterinary students," *Journal of Veterinary Medical Education*, vol. 48, no. 2, pp. 170-180, 2021. https://doi.org/10.3138/jvme.2019-0029

[55] L. Tobarra, A. Utrilla, A. Robles-Gómez, R. Pastor-Vargas, and R. Hernández, "A cloud game-based educative platform architecture: The cyberscratch project," *Applied Sciences*, vol. 11, no. 2, p. 807, 2021. https://doi.org/10.3390/app11020807

[56] C. Candido de Azambuja and G. Ferreira da Silva, "Novos desafios para a educação na Era da Inteligência Artificial," *Filosofia Unisinos*, vol. 25, no. 1, pp. 1-16, 2024. https://doi.org/10.4013/fsu.2024.251.07

[57] C. G. Demartini, L. Sciascia, A. Bosso, and F. Manuri, "Artificial intelligence bringing improvements to adaptive learning in education: A case study," *Sustainability*, vol. 16, no. 3, p. 1347, 2024. https://doi.org/10.3390/su16031347