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The Role of Artificial Intelligence in Enhancing Critical Thinking in Education: A Systematic Literature Review

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Abstract:

The emergence of generative AI, particularly language models like ChatGPT, has revolutionized educational practices by enhancing lesson planning and fostering critical thinking. This systematic literature review investigates the application of generative AI in creating effective lesson plans and its broader role in improving the educational process. By synthesizing findings from multiple studies, this research highlights AI's ability to personalize learning, provide adaptive feedback, and simulate real-world scenarios, which collectively promote analytical and reflective thinking among students. Additionally, the integration of ethical considerations in AI-supported education fosters responsible use and critical evaluation of AI systems. Despite its potential, challenges such as ethical dilemmas, dependency on technology, and algorithmic biases remain significant. This study underscores the transformative role of generative AI in modern education, offering practical insights and recommendations for integrating AI tools effectively. The findings contribute to understanding AI's impact on pedagogy, student engagement, and the development of higher-order thinking skills, emphasizing the importance of a balanced approach that aligns AI capabilities with human.

Keywords: *Artificial Intelligence, Critical Thinking, Educational Technology, Generative AI.*

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Introduction

The development of artificial intelligence (AI) technology has greatly influenced numerous areas of life, including education. A notable innovation in this field is the application of generative language models such as ChatGPT. Within the educational context, ChatGPT is recognized for its potential to create an inclusive learning environment, enabling students to ask questions and seek help without the fear of being judged negatively (Suriano et al., 2025) This innovation offers fresh opportunities to foster cognitive engagement and strengthen students' critical thinking abilities.

Critical thinking skills are vital in the 21st century and are a key focus across many disciplines. This skill involves a structured approach to analysis, considering different viewpoints, and applying logical reasoning to make well-informed decisions (Yusuf et al., 2024). In this regard, ChatGPT can support students in assessing information, contemplating their choices, and nurturing the development of critical thinking skills (Suriano et al., 2025). Research indicates that engaging with ChatGPT not only boosts reflective thinking but also enhances students' creativity in solving problems (Bunt & Gouws, 2020).

ChatGPT also holds the potential to improve the learning process by delivering personalized adaptive feedback. When combined with feedback from teachers, ChatGPT enables students to gain a more diverse perspective, fostering deeper understanding and greater engagement in the learning experience (Lo et al., 2024). This approach emphasizes the collaboration between humans and AI, which, when applied effectively, can bring substantial benefits to both individuals and society (Vallis et al., 2024).

Despite the promising potential of ChatGPT, its implementation must consider ethical aspects, transparency, and academic integrity. These factors are crucial to ensuring that the technology not only enhances the learning process but also upholds fairness and trustworthiness in education (Tlili et al., 2023; Williams et al., 2023).

This article seeks to provide a systematic review of the existing literature on ChatGPT's role in fostering critical thinking skills and enhancing student engagement in education. While prior studies highlight the potential of generative AI to support reflective, analytical, and creative thinking, their findings remain scattered across different contexts and applications (Suriano et al., 2024; Lo et al., 2024). To address this issue, the present study synthesizes evidence from multiple studies to offer structured and comprehensive insights into the role of artificial intelligence in education.

Accordingly, this systematic literature review is guided by the following research questions:

RQ1: What are the benefits of using artificial intelligence, particularly ChatGPT, in enhancing students' critical thinking skills in education?

RQ2: What factors influence the effectiveness of artificial intelligence in supporting the development of students' critical thinking skills?

RQ3: What types of artificial intelligence applications are used to foster critical thinking skills in educational settings?

By explicitly addressing these research questions, this review aims to clarify current research trends, consolidate empirical findings, and identify key benefits, influencing factors, and application types of AI in critical thinking development. These questions also provide a clear framework for organizing the results and discussion sections, ensuring coherence between the review objectives and the synthesized findings.

Related Research

Numerous studies have been carried out to investigate the advantages, contributing factors, and types of artificial intelligence (AI) applications that aid in the development of students' critical thinking skills. Prior research indicates that AI tools, particularly generative language models such as ChatGPT, can foster inclusive learning environments, encourage deep cognitive engagement, and enhance reflective, analytical, and creative thinking abilities (Suriano et al., 2025). Other studies emphasize the role of adaptive feedback, ethical integration, and personalized learning systems in supporting students' critical thinking development (Lo et al., 2024; Williams et al., 2023).

Despite these findings, the existing literature remains fragmented and dispersed, with studies often examining AI-supported critical thinking in isolation or within specific contexts, such as single applications, educational levels, or learning activities. While some research highlights the effectiveness of ChatGPT in improving students' reflective and creative thinking (Suriano et al., 2025), others focus on ethical curricula or game-based AI applications without providing an integrated perspective across AI benefits, influencing factors, and application types (Bunt & Gouws, 2020; Williams et al., 2023). This fragmentation makes it difficult to draw comprehensive conclusions about how AI consistently supports critical thinking development in education.

In addition, although several studies acknowledge the promising role of AI in promoting higher-order thinking skills, there is no consolidated synthesis that systematically compares the reported benefits, supporting factors, and AI application types across studies. Findings are often scattered and vary in their conceptualization of critical thinking, limiting their practical implications for educators and policymakers (Lo et al., 2024; Yusuf et al., 2024).

Given its considerable benefits, the influence of supporting factors, and the variety of available applications, AI tools such as ChatGPT hold great promise in improving students' critical thinking skills. However, the absence of an integrated and systematic overview of existing evidence highlights a clear research gap. Therefore, this systematic literature review seeks to synthesize and consolidate prior findings to provide a comprehensive understanding of the relationship between artificial intelligence and the development of critical thinking skills in educational settings. By doing so, this review aims to clarify current trends, identify key benefits and challenges, and offer structured insights to guide future research and practice.

Research Method

This research is designed to synthesize relevant studies that explore the impact of AI technology on students' critical thinking abilities, examining its benefits, influencing factors, and the types of AI applications that aid in the development of critical thinking skills. The inclusion criteria for this review focus on studies that directly address the role of AI in education, particularly in relation to critical thinking, and that have been published within the past five

years. Studies that are not relevant to the educational context or do not align with the main theme are excluded from the analysis.

Data Collection and Search Strategy

The data collection process involved a systematic literature search conducted in multiple academic databases and search platforms, namely Scopus, Web of Science, SpringerLink (restricted to Springer journals), and Google Scholar. These sources were selected to ensure broad coverage of peer-reviewed research related to artificial intelligence and education.

The search strategy was developed based on the research questions and employed combinations of keywords related to artificial intelligence and critical thinking. The primary search terms included "artificial intelligence," "AI," "ChatGPT," "critical thinking," and "education." These terms were combined using Boolean operators to ensure consistency across databases (e.g., "AI" AND "critical thinking" AND "education," "ChatGPT" AND "critical thinking"). Searches were applied primarily to titles, abstracts, and keywords to ensure relevance.

To maintain focus on recent developments in AI-supported education, the search was limited to peer-reviewed journal articles published between 2019 and 2024. Only English-language publications were considered. Conference papers, book chapters, editorials, and non-peer-reviewed sources were excluded to maintain methodological rigor.

Screening and Study Selection

The study selection process followed the PRISMA 2020 guidelines (Page et al., 2021) and consisted of four stages: identification, screening, eligibility, and inclusion.

During the identification stage, a total of 136 records were retrieved from Scopus, Web of Science, SpringerLink (Springer journals), and Google Scholar. Duplicate records were removed prior to screening.

In the screening stage, the titles, abstracts, and keywords of the identified studies were examined to assess their relevance to the research focus on artificial intelligence and critical thinking in education. This screening was conducted using the predefined inclusion and exclusion criteria summarized in Table 1. After this initial screening process, 55 articles were retained for further evaluation.

The eligibility stage involved a full-text review of the 55 remaining articles to ensure they met all inclusion criteria related to (1) the use of AI in educational contexts, (2) explicit relevance to critical thinking skills, and (3) empirical or conceptual contribution to the research questions, as detailed in Table 1. Studies that did not satisfy these criteria were excluded at this stage.

Finally, in the inclusion stage, 20 studies were identified as meeting all eligibility requirements and were selected for in-depth analysis and synthesis in this systematic literature review. The overall selection process and article flow are illustrated in the PRISMA flow diagram (Figure 1).

To enhance the rigor and transparency of the review process, article screening and eligibility assessments were conducted independently by the authors. Any discrepancies in study selection were resolved through discussion until consensus was achieved.

Table 1. Article selection criteria

Inclusion Criteria	Exclusion Criteria
A study examining the use of Artificial Intelligence (AI) in education to improve critical thinking skills.	Studies that do not involve AI as a primary focus in the context of developing critical thinking skills.
Research that provides evidence about the impact of AI on analysis, evaluation, reflection, or decision-making in learning.	Research that does not provide evidence or measurable results regarding the impact of AI on critical thinking skills in education.
An article exploring innovative applications of AI in supporting the development of critical thinking skills in educational contexts.	Articles that are not relevant to the educational context or do not discuss AI applications in learning.
Studies published in the last 5 years to ensure the most up-to-date information.	Studies published more than 5 years ago, except seminal works.

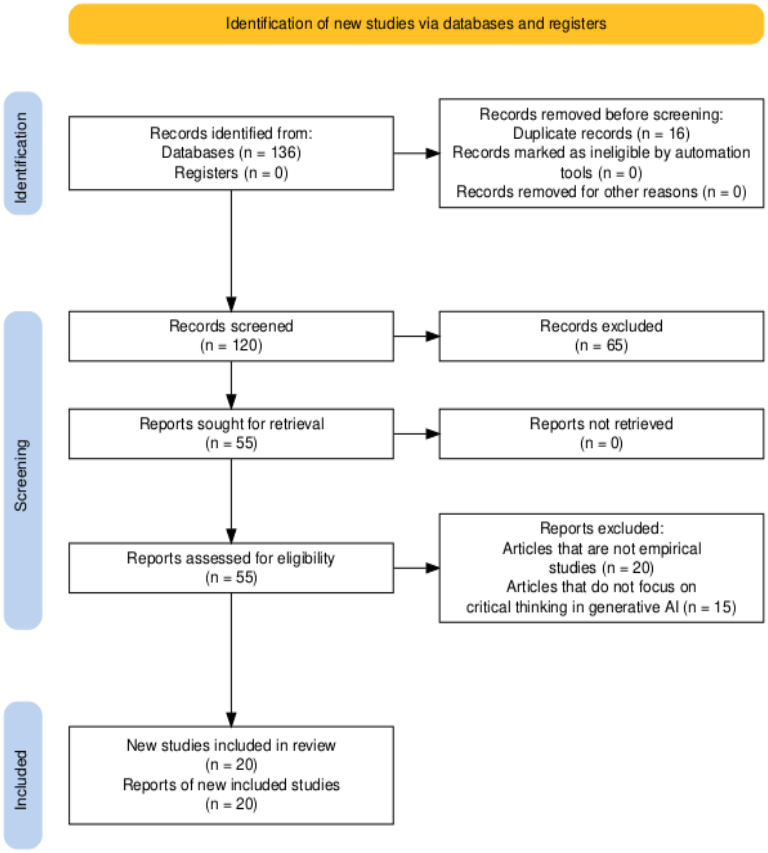

Figure 1. PRISMA flow diagram

Data Analysis

Data analysis was conducted using a thematic synthesis approach. Each included study was systematically reviewed to extract information on research design, participants, AI tools used, and key findings related to critical thinking. The findings were then coded and grouped into three overarching themes: (1) benefits of AI for critical thinking; (2) influencing factors in AI-supported critical thinking; (3) types of AI applications supporting critical thinking.

This approach enabled the identification of recurring patterns, relationships, and research gaps across the selected studies, providing a structured and comprehensive understanding of AI's role in fostering critical thinking in education.

Result and Discussion

The results of this systematic literature review emphasize the effect of generative AI (GenAI) on education, focusing particularly on AI for lesson planning, AI tools for learning, and the broader impact of AI in education. The findings are synthesized to answer the three research questions (RQs).

Result

What Are the Benefits of Using Artificial Intelligence in Critical Thinking?

The role of Artificial Intelligence (AI) in enhancing critical thinking in education has been examined in various contexts, with notable findings related to cognitive skill development, engagement, and academic performance. Studies indicate that when AI is approached as an area of study and applied thoughtfully, it serves as a catalyst for improving critical thinking abilities. AI promotes a more reflective and analytical approach to problem-solving and evaluating information (Suriano et al., 2025). This is further reinforced by research highlighting AI's potential to enhance broader cognitive and critical skills, especially through structured academic applications such as using ChatGPT for writing academic papers and incorporating AI into blended learning environments (Sayed et al., 2023; Suriano et al., 2025).

AI tools like ChatGPT have been shown to democratize access to educational resources, boosting creativity, efficiency, and innovation for all educators, which in turn positively impacts students' critical thinking skills (van den Berg & du Plessis, 2023). Furthermore, the collaboration between AI and humans in education has demonstrated significant

benefits, especially in areas like writing and academic research, where AI-generated content helps students evaluate the quality and credibility of information (Yusuf et al., 2024). AI-powered course and assessment software also enables instructors to customize the learning experience to meet diverse student needs, thereby enhancing critical thinking through tailored feedback (Crompton & Burke, 2023; Schroeder et al., 2022).

What Factors Influence Students' Critical Thinking Abilities with the Help of Artificial Intelligence?

The integration of Artificial Intelligence (AI) tools, particularly ChatGPT, in education has shown significant potential in enhancing critical thinking skills among students. Chatbots, such as ChatGPT, offer students a supportive and non-judgmental environment to seek help and ask questions, which encourages deeper cognitive engagement and promotes the application of critical thinking (Suriano et al., 2025). This environment encourages interactive learning experiences, allowing students to mobilize their cognitive energy and explore various perspectives, which is crucial for the development of critical thinking skills.

The combination of feedback from teachers and ChatGPT has proven to improve learning outcomes. Receiving feedback from both sources allows them to "learn more from both," which indicates that the collaboration between human feedback and AI enhances cognitive engagement and the learning experience (Lo et al., 2024). This dual feedback mechanism offers students a more comprehensive understanding of their learning progress and areas that need improvement.

AI also plays an important role in facilitating scenario-based learning, particularly in real-world case studies. ChatGPT helps teachers and prospective teachers create scenarios, such as critically evaluating lesson plans, which can encourage deeper reflection and critical thinking. Non-invasive real-world scenario simulations allow prospective teachers to reflect on their decisions and understand the potential impact on future learning outcomes (Bunt & Gouws, 2020; van den Berg & du Plessis, 2023).

The integration of AI tools in education also supports students' understanding of ethical considerations. Instilling ethics into the curriculum helps students develop a critical perspective on AI, equipping them with the skills to ethically reshape and critique the AI systems they encounter (Tlili et al., 2023; Williams et al., 2023). This aligns with the broader Responsible AI framework, which focuses on creating AI systems that are transparent, accountable, and unbiased, promoting fairness, and enhancing interpretability.

Moreover, the potential of AI to personalize learning experiences, encourage collaboration, and automate assessments is clear. AI helps personalize learning by scheduling activities, providing adaptive feedback, and monitoring student progress. AI can also help predict student learning outcomes, such as the likelihood of dropping out, and facilitate knowledge construction, ultimately reducing teachers' workload while enhancing students' critical thinking and collaborative skills (Celik et al., 2022; Pan et al., 2023).

What Are the Types of AI Applications That Influence Students' Critical Thinking?

Artificial Intelligence (AI) tools have shown extraordinary potential in enhancing critical thinking in education, particularly through interactive and adaptive platforms like ChatGPT. A study among students in Ghana, which showed that interaction with ChatGPT significantly enhances students' critical, reflective, and creative thinking abilities (Suriano et al., 2025). These findings underscore the role of AI as an innovative tool for developing advanced cognitive skills.

The ability of AI to provide personalized and customized educational experiences also plays an important role in promoting self-directed learning. AI exemplified by ChatGPT creates an environment that supports self-directed learning by meeting the specific interests and needs of students. This personalized pedagogy encourages deeper cognitive engagement and reflective thinking (Murtiningsih et al., 2024).

The integration of ChatGPT into educational feedback mechanisms further enhances learning outcomes. Students benefit from receiving feedback from both teachers and ChatGPT, with many stating that this dual approach allows them to "learn more from both" (Lo et al., 2024). This highlights the value of AI-human collaboration in fostering comprehensive cognitive development.

The potential of AI in education goes beyond feedback and personalization. Exploration of AI use in interactive learning environments, such as the video game strategy "Creatures," allows students to reflect in action, understand the impact of their decisions on virtual entities like Norns, thereby encouraging critical reflection during the learning process (Bunt & Gouws, 2020). Similarly, the evaluation of students' understanding of AI concepts through final projects on block-based programming platforms demonstrates the integration of AI in developing applied critical thinking skills (Rusandi et al., 2023; Williams et al., 2023).

The application of AI in adaptive learning systems (ITS) has advanced education further by tailoring activities based on the characteristics of each student. The effectiveness of ITS in meeting unique educational needs and the use of AI in transforming electronic textbooks into interactive learning devices through the SmartStart process, which enhances accessibility and engagement (Crompton & Burke, 2023; Schroeder et al., 2022).

However, the real impact of AI tools like ChatGPT must be critically evaluated to reduce the potential for misuse. The importance of responsible integration, warning about the negative consequences of improper use of these transformative tools (Sallam, 2023).

Discussion

Benefits of AI in Critical Thinking Skills

Findings from this systematic review indicate that Artificial Intelligence (AI) can support the development of critical thinking in education; however, its impact is neither uniform nor unconditional. Several studies in the review reported improvements in specific dimensions of critical thinking, particularly analytical reasoning, reflective thinking, and evaluation of information quality, when AI tools such as ChatGPT were integrated into structured learning activities. (Salido et al., 2025; Suriano et al., 2025; Wang & Fan, 2025; Yusuf et al., 2024). For example, AI-assisted academic writing and text synthesis tasks were found to help students practice systematic analysis and critical assessment of AI-generated content rather than passively accepting it.

Nevertheless, the evidence suggests that these benefits are most pronounced when AI is embedded within pedagogically guided activities. While some studies highlighted gains in creativity and reflective engagement, others noted that improvements in higher-order skills such as independent judgment and metacognitive regulation were more limited or depended heavily on instructor scaffolding (van den Berg & du Plessis, 2023). This indicates that AI should be viewed not as a standalone driver of critical thinking, but as a complementary tool whose effectiveness depends on instructional design, learning objectives, and student readiness.

The collaborative use of AI alongside human educators emerged as a recurring theme across the literature. AI-supported feedback systems and adaptive courseware were particularly effective in enhancing critical thinking when combined with teacher guidance, enabling more personalized and targeted interventions (Crompton & Burke, 2023; Schroeder et al., 2022). However, studies also caution that without clear learning goals and reflective prompts, AI tools may encourage surface-level engagement rather than deep critical inquiry (Ekowijayanto & Ulvia, 2025).

Supporting Factors in Using AI for Critical Thinking

Several contextual and pedagogical factors influence how effectively AI supports critical thinking. One important factor is the use of AI for scenario-based and case-based learning. Studies using simulations, lesson-planning scenarios, or interactive environments demonstrated that AI can encourage students to reflect on consequences, explore alternative perspectives, and refine decision-making in a low-risk setting (Bunt & Gouws, 2020; van den Berg & du Plessis, 2023). These applications appear particularly effective for fostering reflective and evaluative aspects of critical thinking.

Ethical integration also plays a central role. Multiple studies emphasized that embedding ethics and responsible AI principles into curricula helps students develop a critical stance toward AI systems themselves, rather than viewing them as neutral or infallible tools (Tlili et al., 2023; Williams et al., 2023). Students exposed to ethical discussions were better equipped to identify potential biases, question AI outputs, and consider the societal implications of AI use. This suggests that ethical literacy is not merely a safeguard but an active contributor to critical thinking development.

Personalization and adaptive feedback were consistently identified as strengths of AI-supported learning. AI systems that tailor feedback, monitor progress, and adjust content difficulty can promote sustained engagement and self-regulated learning (Celik et al., 2022). However, several studies also noted that excessive automation may reduce opportunities for peer interaction and dialogue, which are important components of critical thinking. Thus, personalization should be balanced with collaborative and discussion-based learning approaches.

Types of AI Applications for Students' Critical Thinking

The reviewed literature highlights considerable variation in the effectiveness of different AI applications. Conversational agents such as ChatGPT were most effective when used for guided inquiry, drafting, reflection, and feedback rather than for direct answer generation (Suriano et al., 2025). Intelligent Tutoring Systems (ITS) and adaptive learning platforms showed promise in supporting analytical reasoning by adjusting instructional strategies to individual learner profiles (Crompton & Burke, 2023; Schroeder et al., 2022).

Interactive and game-based AI applications, such as simulation environments and strategy-based games, offered unique opportunities for "reflection-in-action," allowing students to observe the consequences of their decisions and revise their strategies accordingly (Bunt & Gouws, 2020). These tools were particularly effective for applied and experiential forms of critical thinking. At the same time, studies in applied domains such as machine translation and programming highlighted the importance of guiding students to critically evaluate AI performance rather than treating outputs as authoritative (Mahdi & Sahari, 2024).

Challenges, Misuse, and Limitations

Despite its potential, the literature consistently warns that the impact of AI tools like ChatGPT must be critically evaluated to avoid misuse. Misuse in this context includes over-reliance on AI-generated content, reduced opportunities for independent reasoning, plagiarism, and the uncritical acceptance of AI outputs (Kexin et al., 2020; Sallam, 2023). Algorithmic bias, lack of transparency, and uneven data quality also pose risks, particularly when students are not trained to question or verify AI-generated information (Abdallah et al., 2025; Nasr et al., 2025).

Importantly, this review has its own limitations. The analysis is restricted to peer-reviewed studies published between 2019 and 2024 and includes a relatively small sample of 20 articles. Most of the included studies focus on short-term implementations and are concentrated in higher education contexts, which limits the generalizability of the findings to K–12 education or long-term learning outcomes. Additionally, variations in research design, assessment methods, and definitions of critical thinking across studies make direct comparisons challenging.

Taken together, these limitations suggest that while AI holds promise for enhancing certain aspects of critical thinking, its effectiveness is context-dependent and requires careful pedagogical and ethical consideration. Future research should explore longitudinal impacts, diverse educational levels, and culturally varied settings to better understand when and how AI most effectively supports critical thinking development.

Conclusion

The findings of this systematic review emphasize the transformative potential of Artificial Intelligence (AI) in promoting critical thinking within education. AI tools such as intelligent tutoring systems, adaptive learning platforms, and conversational agents like ChatGPT have proven effective in enhancing cognitive engagement, fostering reflective practices, and supporting personalized learning experiences. By offering instant feedback, simulating real-world scenarios, and encouraging ethical reflections, AI addresses crucial aspects of critical thinking, such as analysis, evaluation, and decision-making. Moreover, the integration of AI into educational settings aligns with constructivist learning principles, which focus on active participation and the development of higher-order thinking skills.

While AI contributes to significant progress in enhancing critical thinking, challenges persist in its practical implementation. Over-reliance on AI tools may unintentionally diminish human interaction, which could impact the development of interpersonal and collaborative skills. Ethical concerns, such as bias in AI algorithms and accountability for AI-generated content, must be carefully addressed to ensure its fair and responsible use. Educators need to be prepared to help students critically evaluate AI outputs and apply them in meaningful ways that strike a balance between innovation and ethical considerations.

The implications of this work go beyond conventional educational settings. The potential of AI to enhance critical thinking can be applied to various interdisciplinary fields such as healthcare, engineering, and business, where analytical reasoning and problem-solving are essential. For instance, AI-driven simulations and decision support systems can be utilized to train professionals in addressing complex real-world challenges while also promoting reflective and adaptive thinking.

Future research should examine the long-term effects of AI across various educational and professional settings, assessing its effectiveness within different cultural and technological contexts. Moreover, studies should focus on creating a pedagogical framework that incorporates AI in a balanced way, ensuring that human-centered teaching and learning methods remain central. This review highlights AI's transformative role in advancing critical thinking, opening the door to innovative educational practices that equip students to navigate the challenges of a rapidly changing world.

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References

Bunt, B., & Gouws, G. (2020). Using an artificial life simulation to enhance reflective critical thinking among student teachers. *Smart Learning Environments*, *7*(1), 12. https://doi.org/10.1186/s40561-020-00119-6

Celik, I., Dindar, M., Muukkonen, H., & Järvelä, S. (2022). The promises and challenges of artificial intelligence for teachers: A systematic review of research. *TechTrends*, *66*(4), 616–630. https://doi.org/10.1007/s11528-022-00715-y

Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: The state of the field. *International Journal of Educational Technology in Higher Education*, *20*(1), 22. https://doi.org/10.1186/s41239-023-00392-8

Ekowijayanto, M., & Ulvia, A. L. (2025). Impact of ChatGPT on students' learning strategies and critical thinking development. *Journal of Innovation in Educational and Cultural Research*, *6*(4), 755–765. https://doi.org/10.46843/jiecr.v6i4.2400

Kexin, L., Yi, Q., Xiaoou, S., & Yan, L. (2020). Future education trend learned from the Covid-19 pandemic: Take "Artificial Intelligence" online course as an example. *2020 International Conference on Artificial Intelligence and Education (ICAIE)*, 108–111. https://doi.org/10.1109/ICAIE50891.2020.00032

Lo, C. K., Hew, K. F., & Jong, M. S. (2024). The influence of ChatGPT on student engagement: A systematic review and future research agenda. *Computers & Education*, *219*, 105100. https://doi.org/10.1016/j.compedu.2024.105100

Mahdi, H. S., & Sahari, Y. M. (2024). Exploring the relationship between critical thinking, attitude, and anxiety in shaping the adoption of artificial intelligence in translation among Saudi translators. *Journal of Pedagogical Research*, *8*(2), 81–94. https://doi.org/10.33902/JPR.202423345

Murtiningsih, S., Sujito, A., & Khin Soe, K. (2024). Challenges of using ChatGPT in education: A digital pedagogy analysis. *International Journal of Evaluation and Research in Education (IJERE)*, *13*(5), 3466–3475. https://doi.org/10.11591/ijere.v13i5.29467

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. https://doi.org/10.1136/bmj.n71

Pan, Q., Zhou, J., Yang, D., Shi, D., Wang, D., Chen, X., & Liu, J. (2023). Mapping knowledge domain analysis in deep learning research of global education. *Sustainability*, *15*(4), 3097. https://doi.org/10.3390/su15043097

Rusandi, M. A., Ahman, Saripah, I., Khairun, D. Y., & Mutmainnah. (2023). No worries with ChatGPT: Building bridges between artificial intelligence and education with critical thinking soft skills. *Journal of Public Health*, *45*(3), e602–e603. https://doi.org/10.1093/pubmed/fdad049

Salido, A., Syarif, I., Sitepu, M. S., Suparjan, Wana, P. R., Taufika, R., & Melisa, R. (2025). Integrating critical thinking and artificial intelligence in higher education: A bibliometric and systematic review of skills and strategies. *Social Sciences & Humanities Open*, *12*, 101924. https://doi.org/10.1016/j.ssaho.2025.101924

Sallam, M. (2023). ChatGPT utility in healthcare education, research, and practice: Systematic review on the promising perspectives and valid concerns. *Healthcare*, *11*(6), 887. https://doi.org/10.3390/healthcare11060887

Sayed, W. S., Noeman, A. M., Abdellatif, A., Abdelrazek, M., Badawy, M. G., Hamed, A., & El-Tantawy, S. (2023). AI-based adaptive personalized content presentation and exercises navigation for an effective and engaging E-learning platform. *Multimedia Tools and Applications*, *82*(3), 3303–3333. https://doi.org/10.1007/s11042-022-13076-8

Schroeder, K. T., Hubertz, M., Van Campenhout, R., & Johnson, B. G. (2022). Teaching and learning with AI-generated courseware: Lessons from the classroom. *Online Learning*, *26*(3), 73–87. https://doi.org/10.24059/olj.v26i3.3370

Suriano, R., Plebe, A., Acciai, A., & Fabio, R. A. (2025). Student interaction with ChatGPT can promote complex critical thinking skills. *Learning and Instruction*, *95*, 102011. https://doi.org/10.1016/j.learninstruc.2024.102011

Tlili, A., Shehata, B., Adarkwah, M. A., Bozkurt, A., Hickey, D. T., Huang, R., & Agyemang, B. (2023). What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education. *Smart Learning Environments*, *10*(1), 15. https://doi.org/10.1186/s40561-023-00237-x

Vallis, C., Wilson, S., Gozman, D., & Buchanan, J. (2024). Student perceptions of AI-generated avatars in teaching business ethics: We might not be impressed. *Postdigital Science and Education*, *6*(2), 537–555. https://doi.org/10.1007/s42438-023-00407-7

van den Berg, G., & du Plessis, E. (2023). ChatGPT and Generative AI: Possibilities for its contribution to lesson planning, critical thinking and openness in teacher education. *Education Sciences*, *13*(10), 998. https://doi.org/10.3390/educsci13100998

Wang, J., & Fan, W. (2025). The effect of ChatGPT on students' learning performance, learning perception, and higher-order thinking: Insights from a meta-analysis. *Humanities and Social Sciences Communications*, *12*(1), 621. https://doi.org/10.1057/s41599-025-04787-y

Williams, R., Ali, S., Devasia, N., DiPaola, D., Hong, J., Kaputsos, S. P., Jordan, B., & Breazeal, C. (2023). AI + ethics curricula for middle school youth: Lessons learned from three project-based curricula. *International Journal of Artificial Intelligence in Education*, *33*(2), 325–383. https://doi.org/10.1007/s40593-022-00298-y

Yusuf, A., Bello, S., Pervin, N., & Tukur, A. K. (2024). Implementing a proposed framework for enhancing critical thinking skills in synthesizing AI-generated texts. *Thinking Skills and Creativity*, *53*, 101619. https://doi.org/10.1016/j.tsc.2024.101619