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# Artificial Intelligence in Education and Its Conditional Impact on Critical Thinking: A Systematic Literature Review

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**Abstract**

The integration of artificial intelligence (AI), particularly generative AI, has transformed contemporary educational practices, raising critical questions about its role in fostering higher-order thinking skills. This study aims to examine how AI influences critical thinking in educational contexts through a systematic literature review of empirical and supporting studies published between 2020 and 2026. Following PRISMA guidelines, 18 studies were selected and analyzed thematically. The findings indicate that AI can enhance critical thinking, problem-solving, and creativity, particularly when embedded in structured learning environments. However, the results also reveal a parallel risk of cognitive dependency, where learners rely on AI-generated outputs without sufficient evaluation. This dual effect highlights a central tension between AI as a cognitive support tool and as a potential substitute for independent reasoning. Furthermore, instructional design emerges as a key mediating factor. Approaches such as scaffolding, problem-based learning, and guided interaction significantly enhance AI's effectiveness in promoting higher-order thinking. The study concludes that AI does not inherently improve or hinder critical thinking; rather, its impact depends on pedagogical integration, learner engagement, and AI literacy. These findings contribute to a more nuanced understanding of AI in education and provide implications for designing learning environments that support meaningful cognitive development.

## INTRODUCTION

The rapid integration of artificial intelligence (AI) into education has significantly shifted learning toward higher-order cognitive skills, particularly critical thinking. In contemporary classrooms, generative AI and large language models (LLMs) are increasingly used to support interactive and dialogic learning beyond traditional instruction. These technologies enable learners to engage in iterative reasoning, reflection, and knowledge construction through responsive feedback. Recent evidence suggests that AI-supported learning environments can enhance analytical thinking by promoting deeper content engagement and evaluative judgment (Liu et al., 2025). In this context, AI is no longer viewed merely as a technological tool but as an active cognitive mediator reshaping how learners interact with knowledge. These developments reflect a paradigm shift in education, where learning is increasingly characterized by personalization, adaptability, and continuous cognitive interaction.

From a pedagogical standpoint, the effectiveness of AI lies in its ability to support adaptive and personalized learning pathways. AI-driven systems can adjust instructional content, feedback, and task complexity based on learners' performance and cognitive needs. This adaptability enables learners to work at optimal levels of challenge, thereby fostering critical thinking skills. Studies show that AI-supported adaptive learning can improve learners' ability to analyze, evaluate, and synthesize information (Correia et al., 2024). Structured approaches, such as progressive prompting, have also been found to enhance learning outcomes and critical reasoning while maintaining a manageable cognitive load (Li et al., 2025). In addition, intervention studies confirm that integrating AI tools into instruction can strengthen analytical thinking when aligned with effective pedagogical strategies (Liu & Wang, 2024). These findings highlight the importance of instructional design in maximizing the cognitive benefits of AI.

Despite these promising contributions, the impact of AI on critical thinking remains complex and context-dependent. While AI has the potential to enhance cognitive engagement, its effectiveness is strongly influenced by how learners interact with the technology. Research indicates that passive reliance on AI-generated responses may reduce cognitive effort and limit deeper processing, whereas active collaboration between learners and AI fosters reflective thinking and analytical reasoning (Nasr et al., 2025). Similarly, classroom-based studies demonstrate that AI tools such as ChatGPT can support critical evaluation skills when used to stimulate argumentation and inquiry, rather than simply providing direct answers (Oates & Johnson, 2025). These findings suggest a critical distinction between AI as a facilitator of thinking and AI as a substitute for cognitive processes. Consequently, the pedagogical framing of AI use becomes essential in determining whether it supports or undermines the development of critical thinking.

Beyond individual learning, AI also plays an important role in collaborative and interdisciplinary learning environments. The integration of generative AI into group learning has been linked to improved critical discourse, perspective-taking, and problem-solving skills. Research shows that AI-supported collaboration helps learners engage with multiple viewpoints, construct arguments, and refine reasoning through interactive dialogue (Ruiz-Rojas et al., 2024). Broader educational technology research also suggests that AI aligns with emerging paradigms of sustainable and digitally mediated learning that emphasize critical inquiry, learner autonomy, and technological literacy (Prayogi & Verawati, 2024; Situmorang et al., 2024). However, these benefits are accompanied by challenges, including superficial engagement, over-reliance on automated systems, and reduced metacognitive awareness. These concerns highlight the need for a balanced and critically informed approach to AI integration in education.

Despite the growing body of literature, several gaps remain in understanding the relationship between AI and critical thinking. First, existing studies tend to focus on specific tools or isolated contexts, limiting the generalizability of findings. Second, there is a lack of comprehensive synthesis that examines both the cognitive benefits and potential risks of AI use. Third, limited attention has been given to the role of pedagogical design in mediating these effects. Addressing these gaps, this study employs a systematic literature review (SLR) guided by PRISMA to analyze empirical research published between 2020 and 2026. The novelty of this study lies in its dual analytical focus, examining both the mechanisms through which AI enhances critical thinking and the conditions under which it may hinder cognitive development. By integrating these perspectives, this study aims to provide a more balanced and theoretically grounded understanding of AI-assisted learning.

## METHODS

### *Research Design*

This study employed a systematic literature review (SLR) to synthesize empirical evidence on the role of artificial intelligence (AI) in fostering critical thinking skills in educational contexts.

The SLR approach was selected because it offers a structured, transparent, and reproducible method for identifying, evaluating, and integrating relevant studies, particularly in rapidly evolving interdisciplinary fields such as AI in education (Shukor & Osman, 2025). Previous studies have shown that systematic reviews are valuable for consolidating fragmented findings, mapping research trends, and identifying gaps in the development of critical thinking across educational settings (Rothinam et al., 2025). The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to strengthen methodological rigor and reduce selection bias through standardized procedures for identification, screening, eligibility, and inclusion (Shukor & Osman, 2025). This approach also supports the examination of both the benefits and limitations of AI-assisted learning, as AI has been found to enhance reasoning, analytical thinking, and problem-solving skills, while also posing risks such as learner dependency, reduced independent judgment, and ethical concerns in automated educational decision-making (Chaparro-Banegas et al., 2024). Therefore, the SLR design was considered the most appropriate method for developing a balanced and evidence-based understanding of how AI influences critical thinking in contemporary education.

***Search Strategy***

The literature search was conducted across multiple academic databases to ensure comprehensive coverage of high-quality publications. The primary databases included Scopus, Web of Science, ERIC, and Google Scholar. The search process was performed using structured Boolean combinations of keywords related to artificial intelligence, interactive learning, and critical thinking. The main search string applied was:

*("artificial intelligence" OR "generative AI" OR "large language model" OR chatbot OR "intelligent tutoring system") AND ("interactive learning" OR "adaptive learning" OR "digital learning") AND ("critical thinking" OR "higher-order thinking" OR "analytical thinking")*

To maintain relevance to recent technological developments, the search was limited to publications from 2020 to 2026. Additional filters were applied to include only peer-reviewed journal articles and conference proceedings published in English. Reference lists of selected articles were also manually screened to identify additional relevant studies.

***Inclusion and Exclusion Criteria***

To ensure methodological rigor and relevance, this study applied predefined inclusion and exclusion criteria based on research design, topical relevance, outcome variables, publication period, and publication quality. These criteria helped minimize selection bias while improving transparency and reproducibility in the review process. Priority was given to empirical studies providing measurable evidence of the impact of artificial intelligence (AI) on critical thinking or higher-order cognitive skills, whereas studies that did not meet these standards were excluded to maintain the review's integrity and focus. The detailed criteria are presented in Table 1.

**Table 1.** Inclusion and Exclusion Criteria

| No. | Criteria Aspect | Inclusion Criteria | Exclusion Criteria |
|---|---|---|---|
| 1 | Research Design | Empirical studies (experimental, quasi-experimental, quantitative, mixed methods, or validated R&D studies) | Conceptual papers, opinion articles, or editorials without empirical data |
| 2 | Study Focus | Studies examining the use of AI in educational settings | Studies not directly related to learning or education |

| | | | |
|---|---|---|---|
| 3 | Outcome Variable | Studies explicitly addressing critical thinking or higher-order cognitive skills | Studies not addressing critical thinking or relevant cognitive outcomes |
| 4 | Publication Year | Publications between 2020 and 2026 | Publications before 2020 |
| 5 | Publication Type & Quality | Peer-reviewed journal articles or indexed conference proceedings | Non-peer-reviewed works, inaccessible full-text articles, or duplicate publications |

***Study Selection Process (PRISMA Flow)***

The study selection process followed the PRISMA framework, which includes four main stages: identification, screening, eligibility, and inclusion, and is widely recognized for ensuring transparency and consistency in systematic reviews (Stovold et al., 2014; Islam et al., 2025). Initially, all records retrieved from the selected databases were compiled, and duplicate entries were removed. During screening, titles and abstracts were reviewed to exclude studies that did not meet the inclusion criteria or were irrelevant to the research objective. The remaining articles then underwent full-text evaluation to assess eligibility based on methodological quality, conceptual relevance, and adequacy of evidence. Only studies meeting all criteria were included in the final analysis. This process ensured that the selected studies were traceable, methodologically sound, and justifiable, thereby enhancing reproducibility, transparency, and the credibility of the evidence synthesis.

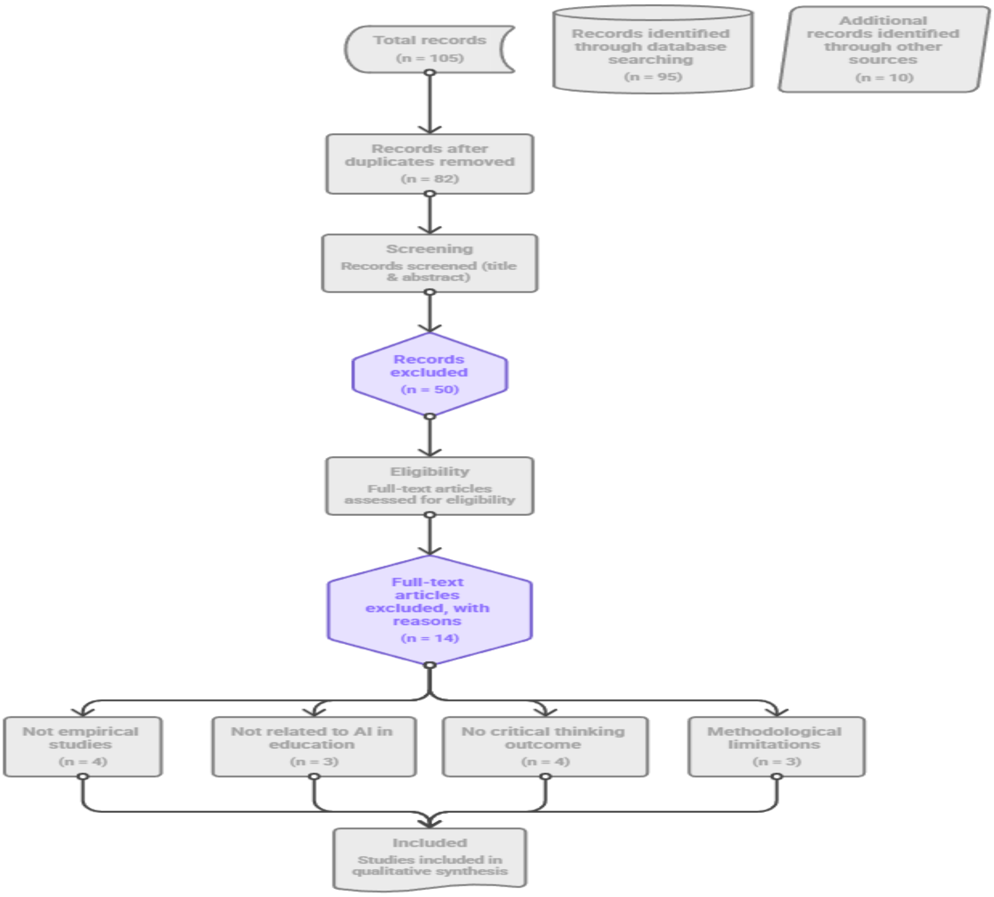


**Figure 1.** Selection Proces

***Data Extraction***

Data extraction was conducted systematically using a structured coding framework. Key variables extracted from each study included: (1) author(s) and year of publication, (2) research design, (3) sample characteristics, (4) type of AI technology used, and (5) main findings related to critical thinking outcomes. The extraction process was carried out iteratively to ensure accuracy and consistency. Only data directly relevant to the research objectives were included, while ambiguous or incomplete information was excluded to minimize bias. The characteristics of the selected studies are summarized in Table 2. The included studies vary in research design, sample characteristics, and the types of artificial intelligence (AI) tools employed. The majority of studies adopt empirical approaches, including experimental and quasi-experimental designs, indicating a growing emphasis on evidence-based investigations of AI in education. Meanwhile, several studies provide conceptual and review-based insights that enrich the theoretical understanding of the development of AI-supported critical thinking.

**Table 2.** Summary of Selected Studies on AI and Critical Thinking in Education

| No | Author(s) & Year | Design | Sample | AI Tool / Context | Key Focus | Main Findings |
|---|---|---|---|---|---|---|
| 1 | Hou et al. (2026) | Experimental | 226 students | Generative AI (PBL) | CT, creativity, AI reliance | CT intervention reduced blind AI reliance and increased creativity |
| 2 | Gao et al. (2025) | Quasi-experimental | Students | AI chatbot writing | CT, self-efficacy | Improved CT and writing confidence |
| 3 | Almazrou et al. (2025) | Experimental | Medical students | ChatGPT | CT skills | Significant improvement in CT |
| 4 | Xu et al. (2024) | Experimental | Students | AI chatbot (game-based) | HOTS, behavior | Improved higher-order thinking and engagement |
| 5 | Suriano et al. (2025) | Experimental | Students | ChatGPT interaction | CT skills | Promoted complex CT abilities |
| 6 | Zhou et al. (2024) | Quantitative | Students | Generative AI | CT, self-regulation | Self-regulation mediates CT improvement |
| 7 | Lu et al. (2024) | Experimental | Teachers | Generative AI | HOTS, self-efficacy | Improved teaching-related thinking skills |
| 8 | Setiawan & Wibowo (2025) | Quasi-experimental | Students | AI interactive learning | CT, creativity | Enhanced engagement and CT |

| | | | | | | |
|---|---|---|---|---|---|---|
| 9 | Vendrell & Johnston (2026) | Design-based | Higher ed | LLM integration | CT scaffolding | Structured AI improves CT processes |
| 10 | Favero et al. (2025) | Experimental | Students | Socratic chatbot | CT skills | Dialogue-based AI enhances reasoning |
| 11 | Fakour & Imani (2025) | Comparative | Students | ChatGPT vs human tutor | CT | AI comparable to human guidance |
| 12 | Ilgun Dibek et al. (2025) | Meta-analysis | Multiple studies | AI tools | HOTS | Positive overall effect on higher-order thinking |
| 13 | Larson et al. (2024) | Conceptual | — | Generative AI | CT | Highlights risks & opportunities |
| 14 | Van den Berg & Du Plessis (2023) | Qualitative | Teacher education | ChatGPT | CT, pedagogy | Supports lesson planning & CT |
| 15 | Walter (2024) | Conceptual | — | AI literacy | CT | CT depends on AI literacy |
| 16 | Ismaili (2024) | Qualitative | 16 participants | AI adaptive learning | CT | Needs structured AI literacy support |
| 17 | ElSayary (2024) | Conceptual | — | GenAI + active learning | Metacognition | Enhances reflective thinking |
| 18 | Salido et al. (2025) | SLR/Bibliometric | Multiple studies | AI in education | CT skills | Identifies trends and strategies |

As shown in Table 2, most empirical studies report positive effects of AI integration on critical thinking and higher-order cognitive skills. Experimental findings indicate that AI-supported learning environments, particularly those incorporating structured scaffolding, dialogue-based interaction, and problem-based learning, contribute to improved analytical reasoning, creativity, and problem-solving performance. However, several studies also highlight that the effectiveness of AI depends on how it is used. For instance, interventions focusing on critical thinking strategies reduce students' tendency to rely uncritically on AI-generated outputs. Furthermore, non-empirical studies emphasize the importance of AI literacy, pedagogical design, and ethical considerations in maximizing the benefits of AI in education. These findings collectively suggest that while AI has strong potential to enhance critical thinking, its impact is mediated by instructional design, learner engagement, and the integration of metacognitive and reflective practices.

***Data Synthesis***

The extracted data were analyzed using a narrative synthesis approach, which enables the integration of quantitative and qualitative findings. Studies were grouped into thematic categories based on similarities in research focus and outcomes, particularly: (1) AI as a cognitive support tool, (2) AI as a collaborative learning agent, and (3) challenges and risks of AI in learning. This approach enabled the identification of patterns, consistencies, and contradictions across studies. The synthesis was conducted to address the dual focus of this study: understanding both the mechanisms by which AI enhances critical thinking and the conditions under which it may hinder cognitive development.

***Quality Assurance and Validity***

To ensure the credibility and reliability of the findings, several quality assurance strategies were implemented. First, only peer-reviewed and indexed publications were included to maintain academic rigor. Second, the use of PRISMA ensured transparency in the selection process. Third, cross-checking of extracted data was performed to reduce potential bias. Finally, the findings were interpreted in relation to established theoretical frameworks in cognitive and educational research, ensuring alignment between empirical evidence and theoretical understanding.

## RESULT

This section presents the findings of the systematic literature review based on the final set of 18 selected studies. Following the PRISMA-guided selection process, the results are synthesized thematically to capture recurring patterns across empirical and supporting studies. Three major themes emerged from the analysis: (1) the contribution of AI to critical thinking development, (2) the risks of AI dependency in learning processes, and (3) the role of instructional design in mediating AI effectiveness. This section presents the findings of the systematic literature review based on 18 selected studies following the PRISMA procedure. To enhance analytical clarity, the results are organized thematically and supported by a quantitative summary of the distribution of evidence across studies.

**Table 3.** Thematic Distribution of Findings Across Included Studies (n = 18)

| Theme | Focus Area | Number of Studies | Percentage | Evidence Strength |
|---|---|---|---|---|
| Theme 1 | AI improves critical thinking & HOTS | 13 | 72% | Strong empirical evidence |
| Theme 2 | AI dependency & passive learning risk | 9 | 50% | Moderate empirical evidence |
| Theme 3 | Instructional design as mediating factor | 14 | 78% | Strong mixed evidence |

As presented in Table 3, the majority of studies (72%) report positive effects of AI integration on critical thinking and higher-order thinking skills (HOTS), indicating a strong empirical trend supporting the cognitive benefits of AI in education. In contrast, 50% of the studies highlight the risk of AI dependency, suggesting that the use of AI may also introduce challenges related to passive learning behaviors. Notably, the most dominant theme (78%) emphasizes the critical role of instructional design, indicating that pedagogical structuring is a key determinant of whether AI contributes positively or negatively to learning outcomes.

***Theme 1: AI as a Catalyst for Enhancing Critical Thinking***

The majority of empirical studies included in this review consistently report that integrating artificial intelligence (AI), particularly generative AI tools and chatbots, positively contributes to the development of students' critical thinking and higher-order cognitive skills. Experimental and quasi-experimental studies demonstrate that AI-supported learning environments can enhance outcomes in analytical reasoning, problem-solving, and creative thinking. For instance, intervention-based studies indicate that students who engage with AI in structured learning contexts exhibit improved performance on tasks requiring evaluation, synthesis, and idea generation. The use of AI in problem-based learning environments further promotes deeper cognitive engagement, as learners are required to interpret, critique, and refine AI-generated outputs. Additionally, AI-driven tools such as chatbots and adaptive systems facilitate immediate feedback and iterative learning processes, which are essential for fostering reflective thinking. However, the findings also suggest that improvements in critical thinking are not always directly reflected in self-reported measures, indicating a potential discrepancy between perceived and actual cognitive gains. Overall, the evidence supports the conclusion that AI can serve as a powerful cognitive tool when integrated into active and inquiry-based learning environments.

**Table 5.** Empirical Evidence of AI Enhancing Critical Thinking

| No | Study | Design | AI Tool | Cognitive Outcome | Key Empirical Findings |
|---|---|---|---|---|---|
| 1 | Hou et al. (2026) | Experimental | Generative AI (PBL) | Creativity, problem-solving | Increased originality and reduced uncritical AI use |
| 2 | Gao et al. (2025) | Quasi-experimental | AI chatbot | CT, self-efficacy | Improved critical thinking and writing confidence |
| 3 | Almazrou et al. (2025) | Experimental | ChatGPT | CT skills | Significant improvement in CT among medical students |
| 4 | Xu et al. (2024) | Experimental | AI chatbot (game-based) | HOTS, engagement | Enhanced higher-order thinking and behavioral engagement |
| 5 | Suriano et al. (2025) | Experimental | ChatGPT | Complex CT | Promoted advanced critical thinking processes |
| 6 | Zhou et al. (2024) | Quantitative | Generative AI | CT, self-regulation | CT improved through mediated self-regulation |
| 7 | Setiawan & Wibowo (2025) | Quasi-experimental | AI interactive learning | CT, creativity | Increased engagement and critical thinking |
| 8 | Favero et al. (2025) | Experimental | Socratic chatbot | Reasoning | Enhanced analytical reasoning through dialogue |

| | | | | | |
|---|---|---|---|---|---|
| 9 | Fakour & Imani (2025) | Comparative | ChatGPT vs human tutor | CT skills | AI comparable to human tutor in CT development |
| 10 | Vendrell & Johnston (2026) | Design-based | LLM scaffolding | CT processes | Structured prompting improves critical thinking depth |

As shown in Table 5, empirical evidence across multiple study designs consistently demonstrates that AI integration contributes to measurable improvements in critical thinking and higher-order cognitive skills. Notably, experimental and quasi-experimental studies dominate this theme, strengthening the causal inference regarding AI effectiveness. The findings reveal that AI is particularly effective in interactive, structured contexts, such as problem-based learning, Socratic dialogue, and scaffolded prompting. Furthermore, the evidence suggests that AI enhances not only analytical reasoning but also creativity and problem-solving performance, indicating a multidimensional impact on cognitive development. However, the variation in measurement approaches—especially between performance-based assessments and self-reported data—highlights the need for more standardized evaluation frameworks in future research.

***Theme 2: The Emergence of AI Dependency and Passive Learning Risks***

Despite the positive contributions of AI, many studies highlight emerging concerns about students' overreliance on AI tools. This theme reflects a critical tension between AI as a learning enhancer and AI as a potential source of cognitive dependency. Several empirical findings indicate that students tend to adopt AI-generated responses without adequate evaluation, resulting in superficial learning and reduced cognitive effort. In particular, the availability of instant answers from generative AI systems may discourage independent reasoning and limit opportunities for deep processing. This phenomenon is often described as "thoughtless AI usage," where learners prioritize efficiency over critical engagement. Importantly, intervention studies demonstrate that this risk can be mitigated. Structured critical thinking interventions and guided AI use have been shown to reduce direct reliance on AI outputs and encourage more reflective and evaluative learning behaviors. These findings indicate that AI dependency is not an inherent outcome of technology use but rather a consequence of insufficient pedagogical regulation.

**Table 6.** Empirical Evidence of AI Dependency and Passive Learning Risks

| No | Study | Design | AI Context | Identified Risk | Key Findings on Dependency |
|---|---|---|---|---|---|
| 1 | Hou et al. (2026) | Experimental | Generative AI (PBL) | AI reliance | Reduced blind reliance after intervention |
| 2 | Nasr et al. (2025) | Experimental | ChatGPT | Passive AI use | Passive use lowers critical engagement |
| 3 | Oates & Johnson (2025) | Experimental | ChatGPT classroom | Surface learning | Students accept AI answers without evaluation |
| 4 | Suriano et al. (2025) | Experimental | ChatGPT | Over-reliance | Risk of dependency despite CT improvement |
| 5 | Zhou et al. (2024) | Quantitative | Generative AI | Cognitive offloading | Reduced effort without self-regulation |

| | | | | | |
|---|---|---|---|---|---|
| 6 | Gao et al. (2025) | Quasi-experimental | AI writing tasks | Automation bias | Students depend on AI-generated text |
| 7 | Van den Berg & Du Plessis (2023) | Qualitative | ChatGPT (teacher ed) | Overuse risk | Potential decline in independent thinking |
| 8 | Walter (2024) | Conceptual | AI literacy | Misuse of AI | Low literacy leads to uncritical use |
| 9 | Gonsalves (2026) | Conceptual | Generative AI | Bloom's shift | Risk of bypassing higher-order thinking |

As shown in Table 6, approximately half of the reviewed studies (9 of 18) identify risks associated with AI dependency, indicating a moderate but significant concern in the literature. Empirical findings consistently show that students may engage in cognitive offloading, relying on AI-generated responses without sufficient evaluation. This tendency is particularly evident in contexts where AI provides immediate and complete answers, reducing the need for independent reasoning. However, the evidence also demonstrates that dependency is not uniform across contexts. Studies incorporating structured interventions—such as guided prompting, critical questioning, and reflective tasks—report a reduction in uncritical AI use. This suggests that AI dependency is not an inherent limitation of the technology itself, but rather a consequence of insufficient instructional guidance. Therefore, the findings reinforce the importance of pedagogical regulation in mitigating passive learning behaviors and promoting active cognitive engagement.

***Theme 3: Instructional Design as a Mediating Factor in AI Effectiveness***

A key finding across the reviewed studies is that the effectiveness of AI in enhancing critical thinking is strongly influenced by instructional design. AI alone does not automatically lead to improved cognitive outcomes; rather, its impact depends on how it is integrated into the learning environment. Studies consistently emphasize the importance of structured pedagogical approaches, such as scaffolding, Socratic dialogue, problem-based learning, and collaborative interaction. These approaches guide students to engage with AI-generated content rather than passively consume it critically. For example, dialogic AI systems and guided prompting strategies encourage learners to question, justify, and refine their responses, thereby strengthening higher-order thinking processes. Furthermore, the development of AI literacy emerges as a crucial component in maximizing the benefits of AI integration. Learners who understand the capabilities and limitations of AI are more likely to use it critically and responsibly. In addition, teacher facilitation plays a central role in orchestrating meaningful AI-supported learning experiences, particularly in ensuring alignment between learning objectives and AI use. These findings suggest that instructional design serves as a critical mediating variable determining whether AI use leads to cognitive enhancement or superficial learning.

**Table 7.** Instructional Design Strategies Mediating AI Effectiveness

| No | Study | Design | Instructional Strategy | AI Tool / Context | Impact on Critical Thinking |
|---|---|---|---|---|---|
| 1 | Hou et al. (2026) | Experimental | PBL + CT intervention | Generative AI | Reduced dependency, improved creativity |
| 2 | Vendrell & Johnston (2026) | Design-based | Scaffolding + prompting | LLM | Enhanced depth of reasoning |

| | | | | | |
|---|---|---|---|---|---|
| 3 | Favero et al. (2025) | Experimental | Socratic dialogue | Chatbot | Improved analytical reasoning |
| 4 | Fakour & Imani (2025) | Comparative | Guided questioning | ChatGPT vs tutor | Comparable CT improvement |
| 5 | Gao et al. (2025) | Quasi-experimental | Structured writing tasks | AI chatbot | Improved CT and self-efficacy |
| 6 | Xu et al. (2024) | Experimental | Game-based learning | AI chatbot | Increased HOTS and engagement |
| 7 | Setiawan & Wibowo (2025) | Quasi-experimental | Interactive learning | AI integration | Enhanced CT and creativity |
| 8 | Zhou et al. (2024) | Quantitative | Self-regulated learning | Generative AI | CT improved via regulation |
| 9 | Lu et al. (2024) | Experimental | Teacher training design | Generative AI | Improved HOTS and self-efficacy |
| 10 | Walter (2024) | Conceptual | AI literacy | Classroom AI use | Promotes critical AI usage |
| 11 | Ismaili (2024) | Qualitative | Adaptive learning | AI system | Supports personalized CT development |
| 12 | Suriano et al. (2025) | Experimental | Dialogic interaction | ChatGPT | Promotes complex reasoning |
| 13 | Van den Berg & Du Plessis (2023) | Qualitative | Teacher-guided AI use | ChatGPT | Supports structured CT development |
| 14 | ElSayary (2024) | Conceptual | Active learning | Generative AI | Enhances metacognitive thinking |

As shown in Table 7, the majority of studies (14 out of 18) emphasize instructional design as a decisive factor in determining the effectiveness of AI in enhancing critical thinking. The findings indicate that structured pedagogical strategies—such as scaffolding, Socratic dialogue, and problem-based learning—consistently lead to deeper cognitive engagement and improved outcomes in higher-order thinking. Importantly, studies incorporating guided interaction and reflective tasks demonstrate stronger effects compared to unstructured AI use. This suggests that the presence of pedagogical structure transforms AI from a passive information provider into an active cognitive partner. Additionally, AI literacy emerges as a cross-cutting factor that supports the responsible and critical use of AI tools, particularly by preventing the uncritical acceptance of AI-generated outputs. Teacher facilitation is also identified as a critical element in aligning AI use with learning objectives, ensuring that technology integration remains pedagogically meaningful. Overall, the evidence confirms that instructional design serves as a mediating variable determining whether AI use leads to cognitive enhancement or superficial learning outcomes.

## DISCUSSION

The findings of this review indicate that artificial intelligence (AI) can support the development of critical thinking, although its impact varies across contexts and learning conditions. Empirical and meta-analytic studies consistently report improvements in analytical reasoning, problem-solving, and learning performance when AI is integrated into cognitively demanding tasks (Helal et al., 2025; Zhu et al., 2025; Pallant et al., 2026). However, systematic reviews also highlight inconsistencies in outcomes, suggesting that AI does not uniformly enhance higher-order thinking across educational settings (Premkumar et al., 2024). This variation reflects differences in instructional structure and learner engagement. In the present synthesis, stronger cognitive gains are observed in contexts where learners actively interact with AI outputs, indicating that engagement, rather than mere exposure to AI, is a determining factor in the development of critical thinking.

A contrasting pattern emerges when examining how learners engage with AI tools during learning processes. Several studies identify a growing tendency toward reliance on AI-generated responses, often accompanied by limited critical evaluation. This behavior is closely associated with cognitive offloading, in which learners transfer parts of their thinking processes to AI systems (Gerlich, 2025). Related concerns include automation bias, which leads learners to accept AI outputs without sufficient scrutiny (Nguyen, 2024). In addition, algorithmic bias introduces further complexity, as biased or inaccurate outputs may shape learners' judgments and reinforce uncritical acceptance (Baker & Hawn, 2022). Recent work conceptualizes this dynamic as a double-edged effect, where AI simultaneously supports and constrains critical thinking depending on patterns of use (Tian & Zhang, 2026). These findings clarify why efficiency-driven interaction with AI may reduce opportunities for deep cognitive processing.

The variability in outcomes across studies can be better understood through the lens of instructional design. Evidence consistently shows that structured pedagogical approaches influence how learners engage with AI and the extent to which critical thinking develops. Strategies such as scaffolding, guided questioning, and problem-based learning provide direction for cognitive engagement and sustain analytical processing (Umutlu & Gursoy, 2022). Theoretical perspectives further position AI as a "more competent other," capable of extending learners' reasoning when interaction is intentionally guided (Sætra, 2025). Empirical applications of instructional design frameworks demonstrate that structured and dialogic learning environments lead to deeper cognitive engagement and improved reasoning outcomes (Ruiz-Rojas et al., 2023; Huang, 2025). In contrast, unstructured AI use is more likely to produce surface-level engagement and weaker critical thinking performance.

Another important dimension concerns the role of AI literacy and metacognitive regulation in shaping how learners interact with AI. Studies on AI literacy indicate that learners who understand the mechanisms and limitations of AI systems are more likely to evaluate outputs critically and avoid unreflective use (Ng et al., 2024). Similarly, research on AI-supported self-regulated learning highlights the importance of metacognitive processes, including monitoring, reflection, and strategic adjustment, in sustaining meaningful cognitive engagement (Chen et al., 2024). Without these competencies, learners tend to engage with AI at a superficial level, reinforcing dependency rather than promoting independent reasoning. These findings suggest that the development of critical thinking in AI-supported environments requires not only technological integration but also cognitive and epistemic preparation.

Taken together, the evidence presented in this review demonstrates that AI does not function as an independent determinant of learning outcomes but operates within a broader instructional and cognitive ecosystem. The interaction between technological affordances, pedagogical structure, and learner characteristics shapes its impact on critical thinking. This perspective helps reconcile divergent findings in the literature by shifting the focus from AI's capabilities to the conditions under which it is used. Understanding this interplay is essential to ensuring that AI integration supports sustained, meaningful development of critical thinking rather than promoting superficial or dependent learning practices.

## CONCLUSIONS

This study examined the role of artificial intelligence (AI) in supporting critical thinking through a systematic synthesis of recent empirical literature. The findings indicate that AI has the capacity to enhance higher-order cognitive skills, particularly when learners engage in tasks that require evaluation, reasoning, and problem-solving. At the same time, the evidence reveals that these benefits are not automatic. In contexts where AI is used without sufficient guidance, learners tend to rely on generated outputs with limited critical evaluation, which may reduce cognitive effort and lead to more superficial forms of learning. A central insight emerging from this study is the importance of instructional design in shaping the impact of AI on learning outcomes. Structured approaches—such as scaffolding, guided questioning, and problem-based learning—consistently support deeper cognitive engagement and more sustained development of critical thinking. In addition, AI literacy and metacognitive awareness play a crucial role in enabling learners to interact with AI critically and responsibly. These elements help shift AI from a source of answers to a tool for inquiry and reflection. The findings suggest that the educational value of AI lies not in the technology itself but in how it is pedagogically integrated. Effective implementation requires alignment between learning objectives, instructional strategies, and the use of AI tools. Without such alignment, the potential of AI to support critical thinking may be undermined by patterns of passive use and over-reliance. This study contributes to the literature by offering a more balanced perspective on AI in education, emphasizing both its opportunities and its limitations. Rather than framing AI as inherently beneficial or detrimental, the results highlight the conditions under which it can meaningfully support cognitive development. Future research should focus on longitudinal designs, standardized measures of critical thinking, and the exploration of instructional models that optimize human–AI interaction in learning environments.

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