

Critical Thinking Development among University Students in the Era of Digitalization and Artificial Intelligence

Pengembangan Berpikir Kritis di Antara Mahasiswa Universitas di Era Digitalisasi dan Kecerdasan Buatan

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ABSTRACT

Critical thinking is an essential competency for students in facing the transformation of higher education in the digital era and Artificial Intelligence (AI). However, empirical evidence regarding the factors that shape and develop these abilities is still scattered in psychological, pedagogical, and technological perspectives. This study aims to synthesize empirical findings on the antecedents and development of students' critical thinking in the context of digital and AI. The research uses a Systematic Literature Review (SLR) based on the PRISMA guidelines. Empirical literature published in 2021–2026 was searched through Google Scholar and selected based on inclusion criteria that include research on higher education students and focus on critical thinking skills or development. A total of 18 empirical articles met the criteria and were analyzed thematically. The results showed three main determinants. Psychological factors, such as self-efficacy, cognitive flexibility, and reflective thinking, contributed to students' analytical and evaluative abilities. Pedagogical strategies, including Problem-Based Learning, collaborative learning, WebQuest, and digital learning, are effective in improving critical thinking skills. Meanwhile, AI and digital technology extend critical thinking to the ability to evaluate digital information, verify AI outputs, recognize biases, and use AI reflexively and ethically. This study offers an integrative psychological–pedagogical–AI literacy framework to understand students' critical thinking transformations in the digital and AI era.

ABSTRAK

Berpikir kritis merupakan kompetensi esensial bagi mahasiswa dalam menghadapi transformasi pendidikan tinggi di era digital dan Kecerdasan Buatan (AI). Namun, bukti empiris mengenai faktor yang membentuk dan mengembangkan kemampuan tersebut masih tersebar dalam perspektif psikologis, pedagogis, dan teknologi. Studi ini bertujuan mensintesis temuan empiris tentang antecedents dan pengembangan berpikir kritis mahasiswa dalam konteks digital dan AI. Penelitian menggunakan Systematic Literature Review (SLR) berdasarkan pedoman PRISMA. Literatur empiris yang diterbitkan pada 2021–2026 ditelusuri melalui Google Scholar dan diseleksi berdasarkan kriteria inklusi yang mencakup penelitian pada mahasiswa pendidikan tinggi dan berfokus pada keterampilan atau pengembangan berpikir kritis. Sebanyak 18 artikel empiris memenuhi kriteria dan dianalisis secara tematik. Hasil menunjukkan tiga determinan utama. Faktor psikologis, seperti self-efficacy, cognitive flexibility, dan reflective thinking, berkontribusi terhadap kemampuan analitis dan evaluatif mahasiswa. Strategi pedagogis, termasuk Problem-Based Learning, collaborative learning, WebQuest, dan digital learning, efektif meningkatkan keterampilan berpikir kritis. Sementara itu, AI dan teknologi digital memperluas berpikir kritis menjadi kemampuan mengevaluasi informasi digital, memverifikasi keluaran AI, mengenali bias, serta menggunakan AI secara reflektif dan etis. Studi ini menawarkan kerangka integratif psikologis–pedagogis–AI literacy untuk memahami transformasi berpikir kritis mahasiswa di era digital dan AI.

Kata Kunci:

Kecerdasan Buatan; Berpikir Kritis;
Tinjauan Pustaka Sistematis;
Mahasiswa.

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INTRODUCTION

The rapid development of digital technology and the widespread use of Artificial Intelligence (AI) have brought significant changes to higher education in the 21st century. This transformation requires university students not only to access information quickly, but also to possess the ability to analyze, evaluate, and validate information critically before making decisions. In this context, critical thinking has become one of the primary competencies needed to address global complexity, technological disruption, and increasingly dynamic social changes. This ability is no longer viewed merely as an additional academic skill, but rather as an intellectual foundation that determines the quality of decision-making, problem-solving, and individual adaptability in the digital era (Paul & Elder, 2020).

In higher education, critical thinking plays an essential role in encouraging students to think reflectively, analytically, and logically in understanding various academic and social issues. According to Facione (2011), critical thinking is a judgment process involving interpretation, analysis, evaluation, inference, and self-reflection regarding information or problems. Meanwhile, Halpern (2014) explains that critical thinking is a higher-order thinking skill that enables individuals to use cognitive strategies effectively in achieving specific goals. Thus, critical thinking is not only related to cognitive aspects, but also involves dispositional dimensions such as open-mindedness, curiosity, and the courage to evaluate information objectively (Ennis, 2011; Facione, 2000).

Despite the increasing urgency of critical thinking skills, various studies indicate that university students' critical thinking abilities remain at a relatively low level. This condition is caused by both internal and external factors. Internal factors include low self-efficacy, limited cognitive flexibility, and insufficient reflective abilities in evaluating information. Meanwhile, external factors are associated with learning strategies that remain oriented toward memorization, limited implementation of problem-based learning, and inadequate integration of educational technologies that encourage higher-order thinking activities (Dwyer et al., 2014)(Salea, N., & Soetjningsih, 2022).

On the other hand, the development of AI and digital technology has introduced new challenges in fostering students' critical thinking skills. Students acknowledged AI's utility in enriching various facets of critical thinking, such as academic research and theory scrutiny (Darwin et al., 2024). This is congruent with the findings of Ruiz-Rojas et al. (2024), which indicate that generative artificial intelligence (AI) tools enhance university students' critical thinking and collaborative skills. The presence of AI-based technologies enables students to obtain information instantly and automatically; however, this condition also has the potential to create cognitive dependency if not balanced with adequate evaluative abilities (Chan & Colloton, 2024). Students are required not only to utilize technology, but also to possess the ability to verify, assess the accuracy, and evaluate the relevance of information generated by AI

technologies (Crompton & Burke, 2024). AI tools can potentially hinder the development of writing skills, they actually improve students' writing fluency and foster self-directed learning when carefully integrated into the curriculum (Deep & Chen, 2025). Therefore, AI literacy is increasingly regarded as an important component in the development of critical thinking skills in higher education (H. P. (Hank) Lee et al., 2025).

Recent studies have increasingly emphasized that critical thinking skills are closely associated with digital literacy, metacognitive awareness, and students' ability to evaluate information generated through Artificial Intelligence systems. In higher education contexts, students are expected not only to consume digital information but also to critically assess the credibility, bias, and ethical implications of AI-generated content (Zhao & Watterston, 2021; Hwang et al., 2020). The integration of AI into academic learning environments has therefore shifted the orientation of critical thinking from conventional analytical reasoning toward reflective digital judgment and technological evaluation skills (Lee et al., 2023).

Furthermore, recent empirical studies demonstrate that active learning environments significantly contribute to the development of critical thinking skills among university students. Problem-Based Learning (PBL), collaborative inquiry, reflective learning, and digital-based instructional strategies have been found to improve students' analytical reasoning, argumentation, and decision-making abilities (Sulhan et al., 2023; Usiono et al., 2026). Study of Oliva-Córdova et al (2025) demonstrates that the intentional integration of structured workshops based on generative *Artificial Intelligence* aligned with clear educational goals can produce a meaningful and positive impact on enhancing university students' higher-order thinking skills, particularly in the dimensions of applying, analyzing, and evaluating. Similarly, AI-supported learning environments encourage students to engage in deeper cognitive processing when accompanied by appropriate reflective and evaluative activities (Chen, 2021).

Several recent studies also highlight the importance of psychological dimensions in strengthening critical thinking skills. Self-efficacy, cognitive flexibility, reflective thinking, and learning motivation consistently emerge as important predictors of students' analytical and evaluative performance in higher education settings (Karakuş, 2024; Salea & Soetjningsih, 2022). Essentially, when students know how to use digital tools wisely and believe in their own abilities, they become much better at analyzing information and solving problems (Leuwol et al., 2023). These findings indicate that critical thinking should be understood as a multidimensional construct influenced by cognitive, psychological, pedagogical, and technological factors simultaneously.

Previous studies have examined university students' critical thinking skills from various perspectives, such as the influence of Problem-Based Learning, collaborative learning, WebQuest, and psychological factors including self-efficacy and cognitive flexibility. However, these findings remain fragmented and generally focus only on a single dimension.

Some studies emphasize pedagogical strategies, while others focus more on psychological factors or the separate use of digital technologies. This condition indicates the limited availability of studies integrating psychological factors, pedagogical approaches, and AI literacy within a comprehensive framework for understanding university students' critical thinking skills.

In addition, Systematic Literature Review studies specifically discussing the transformation of university students' critical thinking skills in the AI era remain relatively limited. In fact, changes in digital learning patterns and the increasing use of AI in academic activities have transformed the ways students obtain, process, and evaluate information (Chassignol et al., 2018). Therefore, a research synthesis is needed to provide a comprehensive overview of research trends, determining factors, and the implications of university students' critical thinking skills within the context of modern technological development (Rothinam et al., 2025; Salido et al., 2025).

This study aims to systematically synthesize empirical evidence on university students' critical thinking skills in the digital and artificial intelligence (AI) era by identifying research trends, psychological and pedagogical determinants, and the impact of AI on the transformation of critical thinking in higher education. The study addresses a critical gap in the literature, which largely examines psychological factors, pedagogical strategies, digital literacy, and AI separately, without explaining their interrelationships. Its novelty lies in integrating these dimensions into a unified analytical framework through a Systematic Literature Review (SLR), positioning AI not merely as a learning tool but as a transformative force that reshapes information evaluation, reasoning, problem-solving, metacognition, and decision-making. The synthesis contributes theoretically by advancing a comprehensive framework for understanding critical thinking amid technological transformation and practically by informing AI-integrated curricula, pedagogical strategies, assessment, and AI literacy development that strengthen students' independent reasoning rather than foster cognitive dependence on AI. Thus, this study provides an evidence-based foundation for developing higher education that produces autonomous, reflective, and critically competent learners capable of evaluating AI-generated information and making informed decisions in an increasingly complex digital society.

RESEARCH METHODS

This study employed a Systematic Literature Review (SLR) approach to synthesize various empirical findings related to university students' critical thinking skills in the era of Artificial Intelligence (AI). The SLR approach was selected because it provides a systematic, transparent, and structured process for identifying, evaluating, and integrating relevant research findings (Faradila et al., 2026; Nabil et al., 2026; Popay et al., 2006). This study followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, which include the stages of

identification, screening, eligibility, and inclusion of articles (Page et al., 2021; Sakul et al., 2026).

This study was formulated into three research questions (RQ): (1) How are the distribution and characteristics of research on university students' critical thinking represented in the current academic literature?; (2) What psychological and pedagogical factors significantly influence these critical thinking skills?; and (3) What are the theoretical and practical implications of these studies for future research directions? These research questions served as the basis for the identification, selection, analysis, and synthesis of articles, thereby ensuring that the discussion remained systematic and focused (Turner et al., 2010).

The article search process was conducted through the Google Scholar database using keywords related to university students' critical thinking skills, such as "critical thinking," "critical thinking skills," "university students," "higher education," "Artificial Intelligence," and "digital learning." These keywords were combined using Boolean Operators (AND and OR) to obtain articles relevant to the research focus (Snyder, 2019). Several keyword combinations included "critical thinking" AND "university students," "critical thinking skills" AND "higher education," "critical thinking" AND "Artificial Intelligence," and "critical thinking" AND "digital learning." The literature search was focused on articles published between 2021 and 2026 in order to capture recent developments related to university students' critical thinking skills in the digital and AI era.

The articles analyzed in this study were selected based on predetermined inclusion and exclusion criteria (Table 2). The inclusion criteria were: (1) empirical research articles discussing university students' critical thinking skills; (2) articles published between 2021 and 2026; (3) studies involving university students as research subjects; (4) articles related to higher education, learning strategies, psychological factors, or the development of AI and digital technology; (5) articles available in full text; and (6) articles published in either Indonesian or English. Meanwhile, the exclusion criteria included: (1) articles not focusing on university students or higher education; (2) opinion articles, editorials, or non-empirical literature reviews; (3) articles that did not directly discuss critical thinking skills; (4) articles with data or discussions irrelevant to the research focus; (5) articles without full-text availability; and (6) articles published before 2021.

Table 2. Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Document Type	Scientific Journal Articles (Peer-Reviewed)	Reviews, Books, Conference Proceedings, or Undergraduate/Thesis Dissertations
Time Range	Publications from 2021–2026	Publications before 2021
Research Subjects	University Students	Other than University Students

Language	Indonesian and English	Languages other than Indonesian and English
Study Focus	Discusses factors, interventions, or impacts of critical thinking skills	Does not discuss critical thinking variables as the primary focus
Accessibility	Articles available in full text	Articles available only in abstract form

The article selection stages were conducted according to the PRISMA guidelines, consisting of identification, screening, eligibility, and inclusion stages (Page et al., 2021). During the identification stage, articles were collected based on the search results using the predetermined keywords. Subsequently, the screening stage was conducted by reviewing article titles, abstracts, and the relevance of research topics. The eligibility stage involved evaluating the suitability of articles based on the established inclusion and exclusion criteria. Articles meeting all criteria were then selected as the final articles included in the study. Based on this selection process, a total of 18 empirical articles met the criteria and were used as the primary sources for analysis as shown in Figure 1.

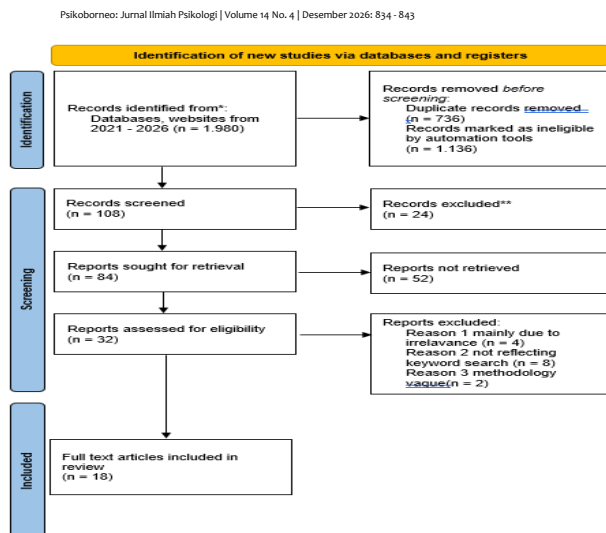


Figure 1. PRISMA Flow Chart

Data analysis was conducted using a thematic analysis approach to identify, classify, and synthesize research

findings related to university students' critical thinking skills (Braun & Clarke, 2006). This technique was chosen because it enables a systematic understanding of patterns, themes, and interrelationships among variables emerging from the analyzed studies. The analysis process involved several stages, including reading and understanding all articles that met the inclusion criteria, identifying key concepts and findings related to university students' critical thinking skills, conducting coding processes based on thematic similarities, and synthesizing the research findings to identify general patterns and conceptual implications regarding university students' critical thinking skills in the AI era.

The data analysis was structured based on the predetermined research questions. The analysis for RQ1 focused on identifying the distribution of publications, research methods, and research themes related to university students' critical thinking skills. The analysis for RQ2 focused on examining psychological and pedagogical factors influencing university students' critical thinking skills. Meanwhile, the analysis for RQ3 focused on the theoretical and practical implications of research on university students' critical thinking skills, as well as recommendations for future research.

To ensure research validity, the article selection process was conducted systematically based on the established criteria. In addition, the analysis was carried out comprehensively by comparing various research findings to obtain an objective and consistent synthesis. The use of PRISMA guidelines aimed to enhance the transparency of the review process so that the research findings could be academically accountable (Page et al., 2021). This study did not employ meta-analysis because the research focus was directed toward conceptual synthesis and the identification of major themes related to university students' critical thinking skills in the AI era.

RESEARCH RESULTS

Characteristics of Research on Critical Thinking

To facilitate a comprehensive understanding of the literature, this sub-section presents a mapping of relevant research on critical thinking. This comparative analysis aims to identify the primary findings, as well as the similarities and differences across various studies regarding pedagogical approaches and generative AI interventions on critical thinking skills.

Table 3. Comparative Analysis of Research on University Students' Critical Thinking

Authors	Title	Result	Equations	Differences
Chen (2021)	Effects of the application of webquest to technology education on business management students' critical thinking psychology and operation capability	The WebQuest method demonstrates a positive and significant impact on the psychological aspects of students' critical thinking and their operational competencies when compared to traditional learning approaches	Examines instructional methods designed to enhance students' critical thinking capabilities.	Employs the WebQuest method (excluding AI interventions) specifically for business management students, with a primary focus on measuring the psychological dimensions of critical thinking.
Warsah et al. (2021)	<i>The Impact of Collaborative Learning on Learners' Critical Thinking Skills</i>	Collaborative learning demonstrates a positive and significant impact on the enhancement and retention of students' critical thinking skills in addressing Islamic radicalism.	Investigates the enhancement of critical thinking skills. Involves students from Islamic higher education institutions in Indonesia.	Utilizes a collaborative learning experimental model as the pedagogical intervention Examines the specific context of Islamic radicalism.
Salea & Sietjiningningsih (2022a)	Hubungan Self-efficacy dengan Critical Thinking pada Mahasiswa	here is a significant positive correlation between self-efficacy and critical thinking among university students, indicating that higher levels of self-efficacy correspond to greater critical thinking capabilities	Investigates the relationship between the variables of self-efficacy and critical thinking Utilizes Peter Facione's critical thinking scale as the primary measurement instrument.	Focuses on a purely correlational study involving psychology students who are actively serving as functionaries within student organizations. Employs a relatively small sample size, comprising approximately 55 students.
Lee et al. (2023)	<i>Designs and practices using generative AI for sustainable student discourse and knowledge creation</i>	Generative AI is capable of summarizing ideas, synthesizing new information, and enhancing student discourse, despite the inherent risk of presenting invalid sources.	Examines the utilization of artificial intelligence within the higher education environment.	Focuses on the application of ChatGPT as a collaborative learning companion to support students' knowledge-building discourse on the Knowledge Forum platform
Leuwol et al. (2023)	<i>The Role of Digital Literacy and Self Efficacy in Enhancing Students' Critical Thinking in Learning in the Digital Era</i>	Digital literacy and self-efficacy demonstrate a positive and significant impact, both partially and simultaneously, on students' critical thinking skills in the digital era.	Investigates the variables of critical thinking and self-efficacy. Utilizes a quantitative survey method.	Incorporates digital literacy as the primary independent variable in the study. Employs a purposive sampling technique with a sample size of 100 students.
Sulhan et al. (2023)	<i>Improving Critical Thinking Skills Students Through Problem Based Learning E-Module</i>	The use of a Problem-Based Learning (PBL) e-module on momentum and impulse topics is proven to enhance students' critical thinking skills, falling into the moderate category (N-gain of 51.41%)..	Examines the PBL instructional model and indicators of critical thinking skills.	Develops a learning media product in the form of a PBL-based e-module (Anyflip). Utilizes a single-group design without a control class.
Chan & Colloton (2024)	<i>Generative AI in Higher Education: The ChatGPT Effect</i>	The use of Generative AI (GenAI), such as ChatGPT, exerts a transformative impact on higher education, necessitating	Examines the impact and implementation of generative artificial intelligence within the	Takes the form of a comprehensive reference book rather than an empirical article or a single experimental study

Authors	Title	Result	Equations	Differences
		the development of robust AI literacy among the academic community. Educational institutions must redesign curricula and assessment methods through human-machine partnerships, prioritize feedback, and formulate comprehensive ecological AI policies to safeguard academic integrity..	higher education environment. Analyzes the cognitive processes of learning utilizing Bloom's Taxonomy, correlating it with cognitive abilities and critical evaluation, consistent with previous studies	Offers a broad, institution-scale conceptual framework, encompassing the Dynamic AI Literacy Model (DAILM), Six Assessment Redesign Pivotal Strategies (SARPS), and guidelines for AI policy formulation.
Crompton & Burke (2024)	<i>Artificial Intelligence Applications in Higher Education</i>	AI applications are most frequently utilized for assessment and evaluation, prediction, AI assistants, and Intelligent Tutoring Systems, with a notable surge in studies observed between 2021 and 2022	Discusses the roles and trends of AI within the higher education context.	Constitutes a global-scale systematic literature review rather than a direct empirical study on students, specifically mapping the affiliation trends and geographical regions of AI research
Darwin et al. (2024)	<i>Critical thinking in the AI era: An exploration of EFL students' perceptions, benefits, and limitations</i>	AI is beneficial for research and analysis; however, it possesses limitations such as a lack of personalization, the risk of creating echo chambers, and an inability to comprehend emotional nuances	Examines students' perceptions of AI and its impact on critical thinking skills.	Focuses heavily on exploring the in-depth qualitative perspectives of English as a Foreign Language (EFL) postgraduate students in Indonesia, alongside the associated ethical challenges
Karakuş (2024)	<i>University students' cognitive flexibility and critical thinking dispositions</i>	There is a significant positive correlation between cognitive flexibility and critical thinking; cognitive flexibility predicts 40% of students' critical thinking dispositions.	Focuses on assessing students' critical thinking tendencies or dispositions	Investigates the correlation between critical thinking and cognitive flexibility (a purely psychological variable) without any association with technological or AI variables.
Ullauri & Vargaz (2024)	<i>Collaborative Working and Critical Thinking: Adoption of Generative Artificial Intelligence Tools in Higher Education</i>	The majority of students utilize generative AI tools (e.g., Canva, ChatPDF) and believe that these tools significantly enhance their critical thinking and collaborative abilities.	Discusses the interrelationship between technology (artificial intelligence), collaborative work, and critical thinking within the higher education environment.	The research focus is to evaluate the various types of AI utilized by students in virtual learning environments
Deep & Chen (2025)	<i>The Role of AI in Academic Writing: Impacts on Writing Skills, Critical Thinking, and Integrity in Higher Education</i>	AI improves writing fluency and reduces cognitive load; however, overreliance on it can impair critical thinking skills and raise academic integrity issues.	Analyzes the impact of AI on students' cognitive skills.	Focuses specifically on the domain of academic writing and highlights issues concerning academic integrity and plagiarism.
Elbigahy & Alanazi (2025a)	<i>Effect of applying six thinking hats teaching method for development through life span course on students opinion and critical thinking skills</i>	The Six Thinking Hats strategy is proven effective in enhancing students' critical thinking, problem-solving, creativity, and collaboration skills	Shares the ultimate goal of developing critical thinking skills in higher education.	Employs the Six Thinking Hats pedagogical method (without AI technological intervention), specifically applied to nursing students.

Authors	Title	Result	Equations	Differences
		(yielding a 71.3% positive response).		
Lee, H.P. et al. (2025)	<i>The Impact of Generative AI on Critical Thinking: Self-Reported Reductions in Cognitive Effort and Confidence Effects From a Survey of Knowledge Workers</i>	The use of generative AI can reduce the perceived cognitive effort required for critical thinking. High confidence in AI diminishes critical thinking, whereas self-confidence enhances it.	Examines cognitive processes and activities related to Bloom's Taxonomy (analysis, evaluation, and synthesis).	The respondents in this study are professional knowledge workers, not university students. The primary focus of this study is the impact of Generative AI usage on the reduction of cognitive effort in critical thinking.
Icaza & Reyes (2025)	<i>Evaluation of Generative AI Use to Foster Critical Thinking in Higher Education</i>	The use of GenAI significantly enhances the dimensions of applying, analyzing, and evaluating within critical thinking.	Evaluates the impact of Generative AI usage on critical thinking skills.	Utilizes a questionnaire based on Bloom's Taxonomy (encompassing 6 dimensions) to map changes in critical thinking with high specificity.
Salvira et al. (2025)	<i>The Effect of Problem-Based Learning on Students' Learning Outcomes in the Topic of Matter and Its Changes</i>	The implementation of the Problem-Based Learning (PBL) model significantly improves students' learning outcomes in science subjects	Utilizes control and experimental groups to test the instructional model's impact.	The subjects in this study are junior high school students (7th grade), not university students. The primary focus of this study is to measure cognitive learning outcomes in science subjects (specifically the topic of matter and its changes).
Hanifatunnisa & Septiadi (2026)	<i>The Simultaneous Influence of AI Literacy and Prompting Skills on Students' Critical Thinking Disposition</i>	AI literacy and prompting skills, both partially and simultaneously, exert a positive and significant influence on students' critical thinking dispositions (accounting for 46.4% of the variance).	Investigates students' interactions with generative AI and its influence on critical thinking.	Examines the simultaneous correlation of two unique technical variables: AI Literacy and Prompting Skills. Employs a quantitative regression approach.
Usiono et al. (2026)	<i>Toward a pedagogical model: insights from student perspectives in learning Islamic Education Philosophy</i>	Students' interests and critical thinking experiences serve as the strongest predictors for instructional strategies, while content relevance is the primary determinant in developing the instructional model.	Discusses critical thinking capabilities	Utilizes subjects or respondents from the higher education sector (university students). Employs SEM-PLS modeling with a large-scale sample consisting of 474 students

Quality and Accreditation of Published Articles

In this sub-section, the reviewed articles are categorized based on their journal's accreditation or indexing reputation, encompassing both global databases such as Scopus and national accreditation systems like SINTA. This categorization aims to assess the quality of the literature concerning university students' critical thinking, as reflected by the accreditation status of the journals in which the studies were published.

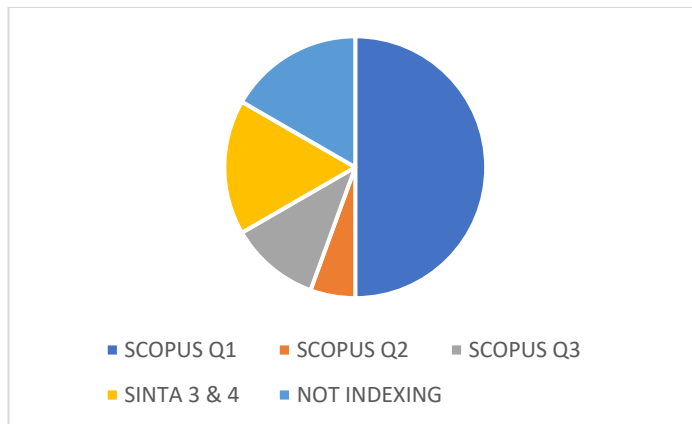


Figure 2. Quality of Research Articles Based on Journal Indexing

Based on Figure 2, it is evident that the majority of research concerning university students' critical thinking is dominated by studies published in highly reputable, internationally recognized journals. Specifically, 9 articles (50% of the total) were published in top-tier Scopus Q1 journals (Chan & Colloton, 2024; Chen, 2021; Crompton & Burke, 2024; Darwin et al., 2024; Elbilgahy & Alanazi, 2025a; Karakuş, 2024; A. V. Y. Lee et al., 2023; Ruiz-Rojas et al., 2024; Usiono et al., 2026), 1 article (6%) in a Scopus Q2 journal (Deep & Chen, 2025), 2 articles (11%) in Scopus Q3 journals (Oliva-Córdova et al., 2025; Sulhan et al., 2023), and 3 articles (17%) in nationally accredited journals, namely SINTA 3 and 4 (Hanifatunnisa & Septiadi, 2026; Leuwol et al., 2023; Salea & Soetjningsih, 2022b). The remaining 3 articles (17%) were published in non-indexed journals (H. P. (Hank) Lee et al., 2025; Salvira et al., 2025; Warsah et al., 2021).

The substantial number of publications in Scopus Q1 journals demonstrates that the integration of critical thinking skills with educational technology (particularly generative AI) is a crucial issue and a major priority within contemporary international academic discourse.

Research Impact Based on Citation Count

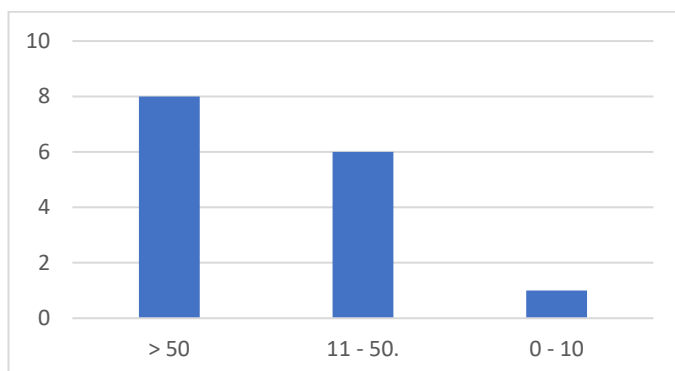


Figure 3. Categorization of Articles Based on Citation Count

Based on Figure 3, it can be concluded that the academic impact and reach of articles related to university students' critical thinking are highly significant. Eight articles (44%) garnered over 50 citations, with the highest reaching

1,335 citations in a study on the disruption of Generative AI conducted by Lee, H.P. et al. (2025) and followed by 492 citations in the research by Warsah et al. (2021).

The high citation counts obtained by these studies indicate a strong interest among researchers in advancing literature related to the topics of artificial intelligence, collaboration, integration, and cognitive evaluation in the digital era.

Research Methodology Trends

This sub-section presents the trends in research methodologies utilized in previous studies concerning university students' critical thinking.

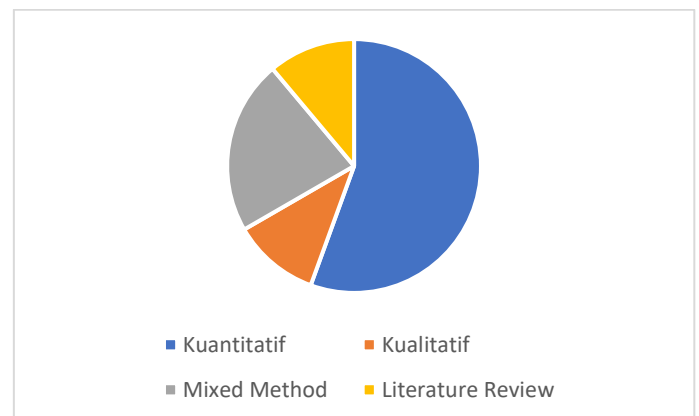


Figure 4. Research Methodology Trends in Studies on University Students' Critical Thinking

Based on Figure 4, it is evident that research concerning university students' critical thinking is predominantly conducted using quantitative methods. Specifically, 10 studies utilized quasi-experimental designs and correlational surveys aimed at measuring statistical significance (Chen, 2021; Elbilgahy & Alanazi, 2025a; Hanifatunnisa & Septiadi, 2026; Karakuş, 2024; H. P. (Hank) Lee et al., 2025; Leuwol et al., 2023; Oliva-Córdova et al., 2025; Salvira et al., 2025; Sulhan et al., 2023; Usiono et al., 2026). Furthermore, 4 studies employed a mixed-methods approach (Chan & Colloton, 2024; Oliva-Córdova et al., 2025; Ruiz-Rojas et al., 2024; Warsah et al., 2021), 2 studies utilized qualitative methods (Darwin et al., 2024; A. V. Y. Lee et al., 2023), and 2 studies conducted literature reviews adhering to the SANRA and PRISMA guidelines (Crompton & Burke, 2024; Deep & Chen, 2025).

This methodological diversity indicates that researchers aim not only to measure outcomes statistically but also to deeply explore user perceptions and experiences through qualitative approaches.

Geographical Distribution of Research

This sub-section presents the findings regarding the geographical distribution of studies on university students' critical thinking. The aim is to provide a comprehensive understanding of the demographic landscape of research concerning higher education, critical thinking, and artificial intelligence.

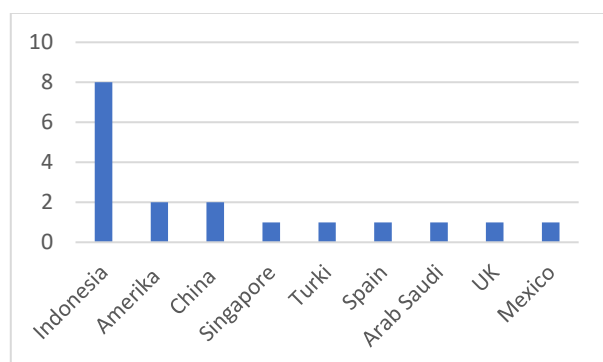


Figure 5. Geographical Distribution of Research

Based on Figure 5, it can be concluded that the geographical distribution of research on critical thinking and AI is heavily concentrated in developing countries. Notably, Indonesia accounted for the highest share, contributing 8 articles (44%) of the total studies reviewed (Darwin et al., 2024; Hanifatunnisa & Septiadi, 2026; Leuwol et al., 2023; Salea & Soetjningsih, 2022a; Salvira et al., 2025; Sulhan et al., 2023; Usiono et al., 2026; Warsah et al., 2021).

This demonstrates a robust research output in Indonesia, positioning it closely alongside similar studies conducted in developed nations such as the United States (Crompton & Burke, 2024) dan China (Chan & Colloton, 2024; Chen, 2021).

Research Publication Trends Over the Last 5 Years

Furthermore, this sub-section presents the publication trends of research concerning university students' critical thinking. The objective is to analyze the evolution of the literature based on the year of publication.

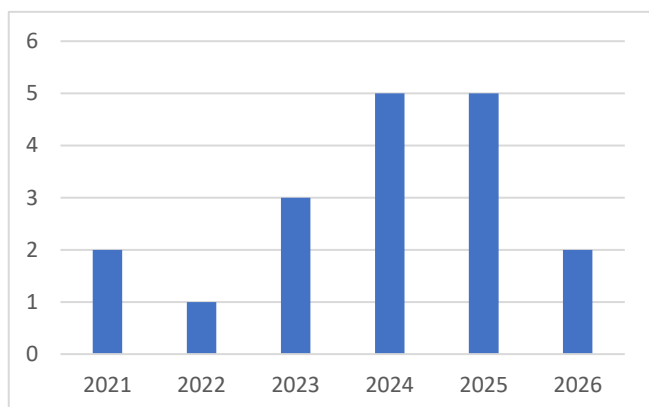


Figure 6. Distribution of Research by Publication Year

Based on Figure 6, it can be concluded that research concerning university students' critical thinking experienced a substantial surge from 2023 to 2025. This exponential growth strongly correlates with the widespread public adoption of Generative AI in late 2022 (Chan & Colloton, 2024). This phenomenon directly triggered a global wave of research aimed at evaluating the impact of artificial intelligence technologies on academic integrity and critical thinking skills within the higher education sector (Deep & Chen, 2025; H. P. (Hank) Lee et al., 2025).

DISCUSSION

RQ 1: How are the distribution and characteristics of research on university students' critical thinking represented in the current academic literature?

The distribution of research on university students' critical thinking skills reveals a notable shift in the primary research focus. Prior to 2023, studies concerning critical thinking were predominantly centered on conventional pedagogical interventions and purely psychological aspects (Chen, 2021; Salea & Soetjningsih, 2022b; Warsah et al., 2021). However, a paradigm shift occurred post-2023. While earlier studies focused on pedagogical and psychological dimensions, research during this subsequent period shifted toward investigating the role of generative AI in enhancing cognitive abilities. This transition was inevitably driven by the emergence of Generative AI and its increasingly widespread adoption in the educational sector (Chan & Colloton, 2024; Crompton & Burke, 2024).

Regarding methodological characteristics, studies on university students' critical thinking skills remain dominated by quantitative and mixed-methods approaches. This indicates that researchers aim not only to statistically demonstrate the impact of artificial intelligence on cognitive abilities (such as through N-gain tests for e-module usage or Bloom's taxonomy questionnaires) but also to understand the sociological and psychological experiences of students when interacting with AI, utilizing in-depth interview approaches (Darwin et al., 2024; Ruiz-Rojas et al., 2024).

Furthermore, interestingly, Indonesia has emerged as the most dominant research epicenter in this domain, accounting for 44% of the reviewed articles concerning generative AI and university students' critical thinking. This highlights a critical urgency for educational institutions in developing countries to pedagogically adapt to global technological advancements, enabling their research trends and focuses to stand alongside those of developed nations, such as the United States and China.

RQ 2: What psychological and pedagogical factors significantly influence these critical thinking skills?

The results of the thematic analysis indicate that university students' critical thinking skills are empirically proven not to function as a singular entity; rather, they are the product of a combination of internal psychological readiness and external pedagogical factors.

1. Psychological Factors

Fundamentally, technological advancement does not automatically translate into critical thinking skills without a robust psychological foundation. Research indicates that self-efficacy and cognitive flexibility act as crucial predictors in fostering students' critical thinking dispositions (Karakuş, 2024; Leuwol et al., 2023; Salea & Soetjningsih, 2022a). Concurrently, with the evolution of generative AI, the foundational psychological aspects shaping critical

thinking have transformed into "AI Literacy" and "Prompting Skills" (Hanifatunnisa & Septiadi, 2026).

Students with high self-efficacy tend to utilize AI as a scaffolding tool for various educational needs, a practice that aligns with Vygotsky's (1978) Zone of Proximal Development (ZPD). Conversely, students with low AI literacy are highly vulnerable to overconfidence, which ultimately results in a drastic decline in their cognitive effort (H. P. (Hank) Lee et al., 2025).

2. Pedagogical Factors

Pedagogically, learning methods adopting a constructivist approach—specifically those focusing on collaboration and problem-solving—remain the primary and most effective strategies for enhancing critical thinking. This is evidenced by studies demonstrating that collaborative frameworks, such as Problem-Based Learning (PBL), WebQuests, and the Six Thinking Hats method, consistently and significantly improve students' analytical and evaluative capabilities (Chen, 2021; Elbilgahy & Alanazi, 2025b; Salvira et al., 2025; Sulhan et al., 2023; Warsah et al., 2021).

However, within the context of AI-based pedagogy, a paradox emerges regarding its integration into education. On the positive side, AI utilization is proven to improve students' writing fluency, facilitate knowledge acquisition, and enhance the application of Bloom's Taxonomy dimensions (A. V. Y. Lee et al., 2023; Oliva-Córdova et al., 2025).

On the other hand, the uncontrolled use of AI in educational activities can lead to a compromise in academic integrity and a deterioration of critical thinking due to a drastically reduced cognitive load (Deep & Chen, 2025). This phenomenon aligns with Sweller's (2020) Cognitive Load Theory, suggesting that the presence of AI prematurely takes over the "intrinsic cognitive load"—an element that is fundamentally essential for students' cognitive development in critically analyzing complex information.

RQ 3: What are the theoretical and practical implications of these studies for future research directions?

The synthesis of the existing literature generated several important implications.

1. Theoretical Implications

Theoretically, the findings from previous studies indicate the need to reconceptualize the definitions of "independent learning" and "critical thinking." Critical thinking can no longer be understood merely as an individual's conventional evaluative ability; rather, it has evolved into a multidimensional competency that integrates cognitive, metacognitive, psychological, and technological aspects.

Furthermore, traditional cognitive frameworks such as Bloom's Taxonomy are currently facing significant challenges. This is because contemporary technologies like generative AI are now capable of performing advanced cognitive tasks, ranging from analyzing to creating (Chan & Colloton, 2024).

Consequently, critical thinking in this era requires a new dimension to evaluate, validate, and utilize acquired information effectively. This aligns with Lee et al. (2025), who stated that critical thinking skills play a highly significant role in students' ability to utilize AI technology. Hanifatunnisa and Septiadi (2026) added that another equally important factor for critical thinking in the current generative AI era involves AI literacy and prompting skills.

Based on these findings, it can be concluded that critical thinking skills heavily influence and are inextricably linked to digital literacy and the ability to evaluate current technological outputs. Individuals with strong critical thinking skills will be able to operate and utilize AI effectively and responsibly, encompassing evaluation, validation, prompt generation, and the application of retrieved information.

From a broader perspective, 21st-century learning theories must accommodate the concept of human-machine partnership. In this era, human cognition no longer stands alone; instead, individuals must be capable of collaborating with and proficiently using generative AI (Chan & Colloton, 2024; Ruiz-Rojas et al., 2024; Zhao & Watterston, 2021).

This indicates that the development of university students' critical thinking skills can no longer rely solely on conventional instructional methods. Educators must devise adaptive strategies capable of responding to technological advancements and the culture of digital learning.

2. Practical Implications

Practically, the findings of this study suggest that higher education institutions must redesign their curricula, instructional strategies, and assessment methods to better adapt to technological advancements and digital learning cultures. Conventional learning methods that prioritize memorization are no longer considered effective for enhancing higher-order critical thinking skills. Therefore, educational institutions are expected to develop instructional strategies that integrate active learning, collaborative problem-solving, and AI literacy to foster analytical and reflective learning activities.

Furthermore, educational institutions must update their assessment systems. Educators can no longer evaluate solely the final output of the learning process, as AI can now easily manipulate these results (Deep & Chen, 2025). Consequently, educators must

shift assessments from a focus on final products to evaluating the learning "process," such as assessing how critically students verify AI-generated data, synthesize prompts, and reflect on the outputs provided by the machine (Chan & Colloton, 2024).

To facilitate this transformation, higher education institutions must formulate ecological AI literacy policies. Rather than restricting or prohibiting the use of technology, these policies should regulate its ethical application and guide students to use AI responsibly as a supportive tool within their academic activities (Chan & Colloton, 2024; Darwin et al., 2024).

3. Implications for Future Research

Based on the analysis of the 18 articles reviewed in this study, a research gap is evident regarding the role of AI in university students' critical thinking skills: generally, research on this topic remains cross-sectional and is limited to short-term experimental trials. Therefore, future studies should focus on longitudinal designs aimed at observing the long-term impact of generative AI usage on students' memory retention and critical thinking capabilities throughout their four-year academic journey in higher education.

The findings of this study also indicate a need for more in-depth research concerning the relationship between critical thinking aspects and AI development within the higher education context. Future research on this topic should focus on developing integrative models that cohesively connect psychological factors, pedagogical strategies, and AI literacy within a comprehensive conceptual framework.

In addition, future research is expected to focus on the development of specific curricula that seamlessly integrate AI literacy with academic ethics. This aims to prevent mass cognitive degradation. Curriculum development must no longer focus purely on cognitive aspects; it must also encompass students' adaptive capabilities in responding to future digital and technological advancements.

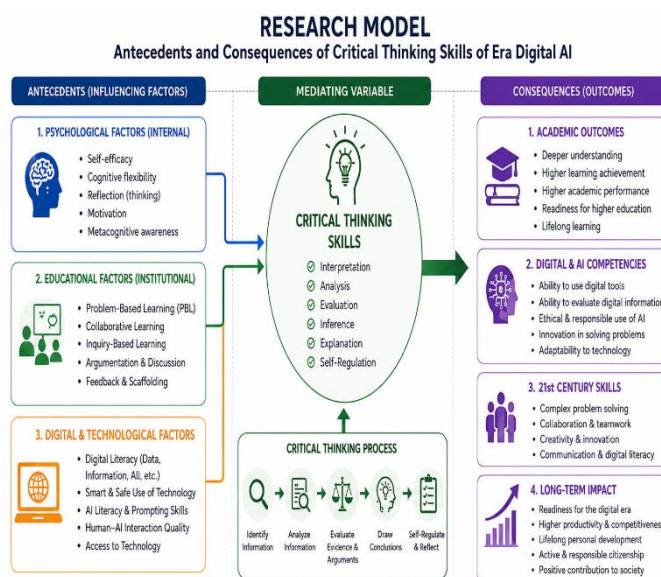


Figure 7. Integrated Model of Antecedents and Consequences of University Students' Critical Thinking in the Digital and AI Era

CONCLUSION

Based on the analysis of 18 empirical articles, the findings indicate that studies on university students' critical thinking skills have experienced significant development in recent years, particularly alongside digital transformation and the advancement of Artificial Intelligence (AI) in higher education. Research on university students' critical thinking remains dominated by quantitative approaches, with primary emphasis on pedagogical strategies and psychological factors. The findings demonstrate that psychological factors such as self-efficacy, cognitive flexibility, reflective thinking, and learning-to-learn abilities significantly influence university students' critical thinking skills. In addition, pedagogical strategies such as Problem-Based Learning (PBL), collaborative learning, WebQuest, Six Thinking Hats, and the use of digital learning media have proven effective in enhancing students' critical thinking skills through more active, reflective, and problem-solving-oriented learning activities.

On the other hand, the development of AI has expanded the concept of critical thinking into a multidimensional competency closely associated with digital literacy and technological evaluation abilities. University students are required not only to understand and analyze information logically, but also to critically and reflectively evaluate the validity, relevance, and accuracy of information generated by AI technologies. Theoretically, this study reinforces the understanding that critical thinking skills are the result of interactions among psychological factors, pedagogical strategies, and the development of digital technology. Practically, the findings highlight the importance of developing active, collaborative, and digitally integrated learning strategies in higher education. Future research is recommended to develop integrative models concerning the relationship between critical thinking skills, AI literacy, and

digital learning transformation in order to generate a more comprehensive understanding of the development of university students' critical thinking skills in the technological era.

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ETHICAL APPROVAL

This research applies the principles of research ethics involving human participants. All respondents provided informed consent after obtaining information about the purpose, voluntariness, confidentiality, and anonymity of the data. The respondent has the right to resign at any time without consequence. This research did not obtain formal ethical approval from the institution's ethics committee.

DECLARATION OF INTEREST

This study does not have a conflict of interest from anyone and the author states that the analysis is delivered in accordance with the analysis approach and techniques used.

TRANSPARANCY OF DATA

The data used is sourced from literature available through open access and can be accessed by anyone.

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AUTHOR'S CONTRIBUTIONS

This study has two authors from the same institution. The role of the first author is in the form of research conceptualization, data engineering and analysis, interpretation of results, and manuscript authorship. The second author plays a role in ensuring that the research methodology can run well so that the analysis and interpretation of the results are in accordance with the methods presented.

AI USAGE STATEMENT

This research was entirely conceived and developed by the authors, with AI used only as an optional supporting tool for writing assistance when necessary

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