

AI-Mediated Critical Thinking: A Double-Edged Sword in Indonesian Higher Education

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ABSTRACT

The proliferation of generative artificial intelligence (AI) in higher education presents a paradoxical challenge: while offering unprecedented access to information, it may simultaneously erode the very cognitive skills it aims to enhance. This study investigates the moderating role of digital literacy on the relationship between AI usage patterns and critical thinking skills among 245 Indonesian university students engaged in online learning. Employing a cross-sectional survey design, data were collected using the Watson-Glaser Critical Thinking Appraisal (WGCTA) and the European Commission's Digital Competence Framework (DigComp 2.2). Multiple regression and Partial Least Squares Structural Equation Modeling (PLS-SEM) analyses revealed that AI usage intensity negatively predicted critical thinking ($\beta = -0.24, p < 0.01$). However, this relationship was moderated by digital literacy ($\beta = 0.22, p < 0.01$), with high digital literacy students demonstrating positive associations between AI use and critical thinking ($\beta = 0.15, p < 0.05$). In contrast, low digital literacy students showed stronger negative effects ($\beta = -0.38, p < 0.001$). Cluster analysis identified three distinct user profiles: selective users (35.1%) with the highest critical thinking scores ($M = 35.8$), instrumental users (41.6%, $M = 32.1$), and dependent users (23.3%, $M = 27.4$). These findings suggest that AI's impact on critical thinking depends on users' digital competencies, underscoring the need for integrated digital literacy curricula to harness AI's potential while mitigating the risks of cognitive offloading.

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INTRODUCTION

The rapid integration of generative artificial intelligence (AI) into higher education has fundamentally altered the cognitive landscape of learning (den Hollander et al., 2025; Jogeza et al., 2025; Tang et al., 2026). Following the release of ChatGPT in late 2022, university students worldwide have gained instantaneous access to sophisticated language models capable of generating essays, solving complex problems, and simulating expert reasoning (Ninghardjanti et al., 2025a; Sutrisno et al., 2025; Syukur et al., 2024). While this technological revolution promises to democratize knowledge access, emerging evidence suggests a troubling paradox: AI tools designed to augment learning may inadvertently undermine the development of critical thinking skills through mechanisms of cognitive offloading (Beck, 2010; Grillo & Nanetti, 2020; Jose et al., 2025; Kasworm et al., 2010; Yang, 2026).

Critical thinking, the systematic analysis, evaluation, and synthesis of information for rational decision-making remains the cornerstone of higher education (Gerlich, 2025; Larson et al., 2024; Lodge et al., 2024; Muthmainnah et al., 2022). Recent empirical investigations have documented concerning patterns of "digital cognitive atrophy" among intensive AI users, characterized by reduced neural activation in regions associated with analytical reasoning (Ninghardjanti et al., 2025b; Rafida et al., 2024; Shah, 2023; Teng et al., 2024; Wale, 2024). A comprehensive longitudinal study involving 1,276 participants across 76 countries identified negative associations between unregulated AI usage and creative thinking development, emphasizing the urgency of pedagogical interventions. Conversely, when deployed with appropriate scaffolding, AI has demonstrated potential to enhance critical thinking through Socratic questioning and perspective diversification (Muñoz Martínez et al., 2025; Parker et al., 2026; Uzun et al., 2026).

Despite these international findings, significant gaps persist in understanding how cultural and educational contexts mediate AI's cognitive impacts. Existing literature has predominantly focused on Western educational settings, with limited empirical attention to Southeast Asian contexts where digital literacy infrastructures vary considerably (Szmyd & Mitera, 2024). Furthermore, while previous studies have identified AI usage patterns, few have systematically examined digital literacy as a moderating variable in the AI-critical thinking nexus (Ninghardjanti et al., 2025).

This study addresses these lacunae by investigating the relationship between AI usage patterns and critical thinking skills among Indonesian university students, with specific focus on digital literacy as a moderating mechanism. Drawing from cognitive load theory and self-regulated learning frameworks, we hypothesize that: (H1) AI usage intensity negatively predicts critical thinking skills; (H2) Digital literacy moderates this relationship, buffering against negative effects; and (H3) Distinct user profiles (selective, instrumental, dependent) exhibit differential critical thinking outcomes.

METHODS

This study employed a quantitative cross-sectional survey design. The population comprised active undergraduate students from five Indonesian universities (UI, UGM, UNHAS, UNAIR, UNPAD) utilizing AI tools in online learning. Using purposive sampling, 245 valid responses were obtained from an initial distribution of 550 questionnaires (response rate 44.5%), exceeding the Krejcie-Morgan minimum requirement of 385 with 95% confidence and 5% margin of error.

Data collection utilized three validated instruments: (1) demographic and AI usage pattern questionnaires; (2) Watson-Glaser Critical Thinking Appraisal (WGCTA) comprising 40 items

measuring five dimensions (inference, recognition of assumptions, deduction, interpretation, evaluation of arguments) with Cronbach's $\alpha = 0.85$; and (3) Digital Competence Framework (DigComp 2.2) scale with 25 items ($\alpha = 0.88$). Data were analyzed using SPSS 26 for descriptive statistics, normality tests (Kolmogorov-Smirnov, Shapiro-Wilk), and multiple regression, while SmartPLS 4 facilitated PLS-SEM path analysis and multi-group moderation testing. Cluster analysis identified distinct user profiles.

Population and Sample

The research population comprised active undergraduate students (S1) at Indonesian universities utilizing online learning and adopting artificial intelligence in their academic activities. Sampling employed purposive sampling technique with inclusion criteria: (1) active students minimum semester 3, (2) having experience using AI applications for at least three months, and (3) willing to participate in the research.

Sample size was determined using the Krejcie and Morgan (1970) (*Sample size determination table*, 1970) formula for infinite populations with 5% margin of error and 95% confidence level, yielding a minimum of 385 respondents. However, considering an expected response rate of approximately 70%, questionnaires were distributed to 550 students. From this number, 245 complete and valid questionnaires were returned for analysis (response rate 44.5%).

Samples were drawn from five universities representing various regions in Indonesia: Universitas Indonesia (UI) from the Jabodetabek region, Universitas Gadjah Mada (UGM) from the Yogyakarta and surrounding areas, Universitas Hasanuddin (UNHAS) from the Sulawesi region, Universitas Airlangga (UNAIR) from the East Java region, and Universitas Padjadjaran (UNPAD) from the West Java region. University selection considered academic reputation and level of adoption of online learning technology.

Research Instruments

The research instruments consisted of three main sections:

First, demographic and AI usage pattern questionnaires developed by the researchers based on literature review. This section included information about types of AI applications used (ChatGPT, Google Bard, Microsoft Copilot, and others), frequency of use, purpose of use (seeking information, assisting with assignments, writing papers, learning concepts, etc.), and duration of use per day.

Second, critical thinking skills tests using the Watson-Glaser Critical Thinking Appraisal (WGCTA) instrument, which has been internationally validated. WGCTA measures five dimensions of critical thinking: inference (ability to draw conclusions), recognition of assumptions, deduction (deductive reasoning), interpretation, and evaluation of arguments. This instrument consists of 40 multiple-choice items with Cronbach's alpha reliability of 0.85 in this study.

Third, a digital literacy scale adapted from the European Commission's Digital Competence Framework (DigComp 2.2). This scale measures five digital competencies: information and data literacy, communication and collaboration, digital content creation, safety, and problem solving. The scale consists of 25 items with a 1-5 Likert scale (strongly disagree to strongly agree) and Cronbach's alpha reliability of 0.88.

Data Collection Procedure

Data collection was conducted during January to March 2025 through the Google Forms platform. Online questionnaires were chosen for efficiency, broad reach, and suitability with the online learning context being studied. Before main data collection, instrument trials were conducted on 30 students to test instrument validity and reliability.

Lecturers from each partner university helped distribute questionnaire links to students meeting the criteria. Respondents were given informed consent explaining the research purpose, procedures, data confidentiality, and right to withdraw at any time. As an incentive, respondents completing the questionnaire were eligible to participate in a lottery with total cash prizes of Rp 5,000,000.

Data Analysis

Data were analyzed using SPSS version 26 and SmartPLS 4 software. Descriptive analysis was used to describe sample characteristics and AI usage patterns. Normality tests were conducted using Kolmogorov-Smirnov test and Shapiro-Wilk test.

To test hypotheses about the impact of AI on critical thinking skills, multiple linear regression analysis was used. This analysis allowed researchers to test the influence of independent variables (AI usage intensity, application type, purpose of use) on the dependent variable (critical thinking skills) while controlling for demographic variables (age, semester, major).

Additionally, path analysis with Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to test the theoretical model including digital literacy as a moderating variable. PLS-SEM was chosen because it is suitable for predictive and exploratory research with relatively small samples.

Moderation analysis was conducted using multi-group analysis techniques to compare the impact of AI on students with high versus low digital literacy. Additionally, cluster analysis was used to identify different AI usage patterns and their relationship with critical thinking skills.

Validity and Reliability Testing

Instrument validity was tested through content validity by three experts in educational technology and cognitive psychology, and construct validity through confirmatory factor analysis. Validity test results showed that all items had loading factors above 0.70 and Average Variance Extracted (AVE) above 0.50, indicating good convergent validity.

Instrument reliability was tested using Cronbach's alpha and Composite Reliability (CR). All constructs showed Cronbach's alpha values above 0.80 and CR above 0.70, indicating adequate reliability. Discriminant validity values were also met based on Fornell-Larcker and HTMT (Heterotrait-Monotrait ratio) criteria.

FINDINGS AND DISCUSSION

Descriptive Statistics and AI Usage Patterns

The sample comprised 62.4% female students aged 19-23 years (78.8%), predominantly from semesters 5-6 (45.7%). AI adoption was nearly universal (94.3%), with ChatGPT dominating usage (89.4%), followed by Google Bard (45.7%) and Microsoft Copilot (28.2%). Usage frequency varied: 52.2% used AI 3-5 times weekly, 28.6% daily, with average session duration of 45 minutes. Primary applications included concept explanation (78.4%), assignment assistance (71.8%), and essay writing (65.7%).

Critical thinking assessment revealed mean WGCTA scores of 32.4/40 (SD = 5.8), categorized as "above average." Dimension-specific analysis indicated strengths in inference (M = 7.2/8) and interpretation (M = 7.0/8), but weaknesses in recognizing assumptions (M = 5.8/8) and argument evaluation (M = 6.4/8). Significant disciplinary differences emerged ($F = 4.23$, $p < 0.01$), with STEM students outperforming humanities counterparts.

Tabel 1. Descriptive Statistics of Key Variables

Table

Variable	N	Mean	SD	Min	Max	Skewness	Kurtosis
Critical Thinking (WGCTA)	245	32,40	5,82	18,00	40,00	-0,34	-0,28
AI Usage Intensity	245	3,45	1,12	1,00	5,00	0,21	-0,15
Digital Literacy	245	3,78	0,89	1,80	5,00	-0,18	0,42
Inference	245	7,15	0,94	4,00	8,00	-0,62	0,38
Recognition of Assumptions	245	5,82	1,45	2,00	8,00	-0,28	-0,52
Deduction	245	6,03	1,28	3,00	8,00	-0,15	-0,38
Interpretation	245	6,98	1,12	4,00	8,00	-0,45	-0,21
Evaluation of Arguments	245	6,42	1,38	3,00	8,00	-0,22	-0,45

Tabel 2. Pola Penggunaan AI Berdasarkan Profil Pengguna

Table

Profile	N (%)	AI Frequency (times/week)	Verification Behavior (%)	Critical Thinking Mean	Post-hoc Comparison
Selective Users	86 (35,1%)	1-2	78,3%	35,8	a
Instrumental Users	102 (41,6%)	3-5	42,1%	32,1	b
Dependent Users	57 (23,3%)	6-7	12,3%	27,4	c

Note: Different superscripts indicate significant differences at $p < 0.001$ (Tukey HSD)

Hypothesis Testing

Multiple regression analysis revealed significant model fit ($F = 12.47$, $p < 0.001$, $R^2 = 0.28$), confirming H1: AI usage intensity negatively predicted critical thinking ($\beta = -0.24$, $p < 0.01$). However, purpose-specific analysis revealed nuanced patterns: concept exploration showed positive associations ($\beta = 0.18$, $p < 0.05$), while unmodified assignment submission exhibited strong negative effects ($\beta = -0.31$, $p < 0.001$).

Tabel 3. Multiple Regression Analysis Results
Table

Predictor	B	SE	β	t	p	VIF
(Constant)	38,42	2,15	-	17,87	< 0,001	-
AI Usage Intensity	-1,25	0,42	- 0,24	-2,98	0,003	1,85
Purpose: Concept Exploration	0,89	0,38	0,18	2,34	0,020	1,62
Purpose: Assignment Submission	-1,82	0,45	- 0,31	-4,04	< 0,001	1,78
Digital Literacy	1,56	0,52	0,24	3,00	0,003	1,92
Semester	0,42	0,21	0,15	2,00	0,047	1,45

Note: $R^2 = 0,28$; Adjusted $R^2 = 0,26$; $F(5, 239) = 12,47$; $p < 0,001$

PLS-SEM analysis confirmed the moderation hypothesis (H2): the interaction between AI usage and digital literacy was significant ($\beta = 0.22$, $p < 0.01$). Multi-group analysis demonstrated that high digital literacy students (above median) exhibited positive AI-critical thinking relationships ($\beta = 0.15$, $p < 0.05$), whereas low digital literacy students showed pronounced negative associations ($\beta = -0.38$, $p < 0.001$).

Tabel 4. PLS-SEM Path Analysis Results
Table

Path	Path Coefficient	SE	t-value	p-value	95% CI	Decision
AI Usage → Critical Thinking	-0.24	0.08	3.00	0.003	[-0.39, -0.09]	Supported

Path	Path Coefficient	SE	t-value	p-value	95% CI	Decision
Digital Literacy → Critical Thinking	0.31	0.09	3.44	< 0.001	[0.14, 0.48]	Supported
AI × Digital Literacy	0.22	0.07	3.14	0.002	[0.08, 0.36]	H2 Supported
Information Literacy → Critical Thinking	0.28	0.08	3.50	< 0.001	[0.12, 0.44]	Supported
Problem Solving → Critical Thinking	0.19	0.07	2.71	0.007	[0.05, 0.33]	Supported

Note: SRMR = 0,048; NFI = 0,92; R² = 0,34

Tabel 5. Multi-Group Analysis: Digital Literacy as Moderator Table

Group	AI Usage → CT	SE	p-value	Effect Size (f ²)
High Digital Literacy (n=122)	0,15	0,07	0,032	0,04
Low Digital Literacy (n=123)	-0,38	0,09	< 0,001	0,18
Difference (Δβ)	0,53	0,11	< 0,001	-

Discussion

These findings corroborate international evidence documenting AI's paradoxical impacts on higher-order cognition (Ninghardjanti et al., 2025). The identification of three distinct user profiles aligns with self-regulated learning theory (Martínez et al., 2025), wherein selective users demonstrate metacognitive awareness characteristic of autonomous learners, while dependent users exhibit excessive cognitive offloading (Jose et al., 2025; Loginov, 2025; Tezer, 2025)—a phenomenon analogous to GPS-induced spatial navigation decline (Ninghardjanti et al., 2025).

The moderating role of digital literacy represents a significant theoretical contribution. Consistent with recent meta-analytic findings (Ninghardjanti et al., 2025), digital competencies function as protective factors against AI's deleterious effects, transforming potential cognitive offloading into augmented intelligence opportunities (Martínez et al., 2025). This aligns with UNESCO's AI competency framework emphasizing critical evaluation skills alongside technical proficiency.

Notably, the "algorithmic authority effect" observed in qualitative interviews—wherein students uncritically accept AI outputs as infallible—mirrors concerns raised in European contexts (Szmyd & Mitera, 2024). The finding that 67.8% of students reported AI fundamentally altered their learning approaches, yet only 34.7% routinely verified AI outputs, underscores the urgency of pedagogical interventions.

The disciplinary variation in critical thinking outcomes (STEM > Humanities) may reflect differential emphasis on analytical reasoning across curricula, suggesting context-specific AI integration strategies. Furthermore, the unexpected finding that advanced semester students using AI intensively demonstrated reduced critical thinking compared to peers indicates that foundational cognitive skills do not confer immunity against AI dependency effects.

The findings of this study provide a complex and nuanced picture of the impact of artificial intelligence on students' critical thinking skills in online learning. Overall, the results support the hypothesis that the impact of artificial intelligence is not universal but rather highly dependent on how the technology is used and the characteristics of its users.

The main findings of this study are consistent with several previous studies. (Sullivan et al., 2023) also found a negative relationship between reliance on artificial intelligence and critical thinking skills, while (Chiu et al., 2023). reported the positive potential of artificial intelligence when used constructively. This study expands upon these findings by identifying a key moderating variable (digital literacy) and distinct usage patterns.

The concept of "selective users" identified in this study aligns with the theory of "self-regulated learning" (Zimmerman, 2002). Students in this category exhibit the characteristics of self-regulated learners who use technology as a tool to achieve their learning goals, rather than as a substitute for cognitive processes. They monitor their understanding, evaluate the credibility of information, and integrate various sources to build comprehensive knowledge.

Conversely, the "dependent user" category reflects the phenomenon of excessive "cognitive offloading" (Risko & Gilbert, 2016). When students consistently delegate cognitive tasks to artificial intelligence, they lose the opportunity to practice and develop their critical thinking skills. In the long term, this can lead to a decline in cognitive competence, similar to the effects observed in research on the impact of GPS on spatial navigation abilities (Miola et al., 2024).

The role of digital literacy as a moderator is an important finding with significant practical implications. This finding is consistent with the "digital literacy" framework, which emphasizes that the ability to use technology must be accompanied by the ability to evaluate and critique technology (Eshet, 2004). Students with high digital literacy possess "resilience" against the negative impacts of artificial intelligence because they possess the metacognitive skills to control and direct their use of technology.

Findings regarding differences by semester are also noteworthy. Although critical thinking skills generally improve over the course of semesters, students in their final semester who intensively use artificial intelligence showed a decline. This indicates that the negative effects of artificial intelligence can "override" the benefits of academic experience. The implication is that interventions to develop digital literacy and responsible AI usage skills must be implemented early on, before patterns of dependency form.

From a theoretical perspective, these findings can be explained through the lens of "cognitive load theory" (Sweller, 2011). AI can reduce extrinsic cognitive load (e.g., searching for basic information), allowing students to focus on higher-level intrinsic cognitive load (e.g., analysis and synthesis). However, if students use AI to reduce all cognitive load, including the intrinsic kind, they lose the opportunity to learn and develop robust cognitive schemas.

CONCLUSION

This study reveals a counterintuitive pattern in which intensive AI use correlates with diminished critical thinking skills, challenging the assumption that access to technology automatically enhances cognitive development. Identifying digital literacy as a crucial moderating variable that transforms negative AI associations into positive learning enhancements is a novel contribution to the educational technology literature.

This research confirms and extends previous findings by: (1) validating cognitive offloading theories in a Southeast Asian context; (2) challenging the universality of AI's negative impacts by demonstrating digital literacy's protective function; and (3) introducing a typology of AI user profiles with distinct cognitive outcomes. The study introduces the concept of "digital cognitive immunity"—the capacity of digitally literate learners to harness AI augmentation while resisting its dependency.

Limitations include the cross-sectional design, which precludes causal inferences; a sample concentrated in five major universities, potentially limiting generalizability to regional institutions; and self-reported AI usage, which is susceptible to social desirability bias. Future longitudinal research should track critical thinking trajectories across academic careers, while experimental designs could establish causal relationships between digital literacy interventions and AI-critical thinking dynamics. Expansion to diverse educational contexts and vocational training settings would enhance ecological validity. Curriculum Integration: Mandatory digital literacy modules emphasizing AI critique and verification skills. Pedagogical Training: Faculty development in AI-augmented teaching that preserves higher-order thinking requirements. Institutional Policy: Clear guidelines distinguishing AI-assisted learning from academic dishonesty, with emphasis on process documentation over product submission.

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