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The Impact of Artificial Intelligence Adoption on University Students' Critical Thinking Skills in Higher Education Learning

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A B S T R A C T

The adoption of artificial intelligence in college learning is increasing, but its impact on students' critical thinking skills is still inconsistent. This study aims to analyze the influence of the level of artificial intelligence adoption on students' critical thinking skills. The research uses a quantitative approach with an explanatory design. Data were collected through questionnaires and critical thinking tests on 250 students from five selected universities using stratified random sampling. The data were analyzed by descriptive statistics and multiple linear regression. The results showed that the adoption of artificial intelligence accompanied by digital literacy and reflective use had a significant positive effect on critical thinking skills, while passive use did not show a significant effect. These findings confirm the importance of pedagogically integrating artificial intelligence to strengthen analytical, evaluative, and independent learning.

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INTRODUCTION

The development of artificial intelligence (AI), especially generative AI such as ChatGPT, Gemini, and Copilot, has changed learning patterns in colleges. Students can use AI to obtain material explanations, summarize information, generate ideas, and complete assignments more efficiently. In a global context, AI also supports personalized learning, increases student engagement, and expands access to learning resources. In Indonesia, the use of ChatGPT has grown among students and lecturers, although the level of understanding, acceptance, and ethics of its use still varies. Suryawijaya et al. (2025) found that AI helps students understand complex material and develop independent learning, while Vieriu and Petrea (2025) emphasized that these benefits are accompanied by the risk of technology dependence, information inaccuracy, and weakened student cognitive engagement. This condition shows that the adoption of AI in universities needs to be studied not only from the aspect of efficiency, but also from its influence on the quality of students' thinking processes.

Critical thinking skills are one of the main competencies that must be developed in higher education because they relate to the ability to analyze information, evaluate arguments, identify biases, draw conclusions, and make decisions based on evidence. Based on the perspective of constructivism, knowledge is not simply received passively, but is built through the process of questioning, dialogue, problem-solving, and reflecting on learning experiences. AI can serve as a cognitive scaffold when students use it to explore different perspectives, compare answers, test arguments, and verify information. On the other hand, AI can be a means of cognitive offloading if students leave the analysis and problem-solving process completely to technology. Darwin et al. (2024) show that AI can support the exploration of ideas and evaluation of information, but the results are highly dependent on students' ability to question and examine AI outputs. Therefore, AI literacy and digital literacy are prerequisites for interaction with technology to continue to encourage evaluative and reflective reasoning (Agustin et al., 2024; Salido et al., 2025).

A number of studies in Indonesia show that there is a positive relationship between the use of AI and students' cognitive skills. Hutapea and Kabatiah (2025) found a positive and significant relationship between the use of ChatGPT and students' critical thinking skills with a correlation coefficient of 0.595 and a contribution of 35.4%. Rahmawati et al. (2025) also reported that the use of ChatGPT had a positive effect on students' skills in compiling effective questions that included clarity, depth, relevance, and originality, with a determination coefficient of 77.9%. Meanwhile, Supriyadi et al. (2024) show that the simultaneous use of AI and digital literacy affects student learning outcomes. These findings indicate that AI has the potential to support high-level thinking skills if its use is accompanied by the skills of formulating questions, evaluating answers, and managing digital information appropriately.

However, the results of previous studies have not shown completely consistent conclusions. Baiquni et al. (2025) found that ChatGPT improves student efficiency, conceptual comprehension, and creativity, but can also decrease critical thinking skills and independent reading motivation when used excessively. Similar risks were discovered by Suryawijaya et al. (2025), namely technology dependence, plagiarism, and acceptance of inaccurate AI information. At the international level, Vieriu and Petrea (2025) explain that AI can improve student learning outcomes and engagement, but unstructured use can lead to decreased cognitive engagement, academic dishonesty, and weakened ability to evaluate information. These differences in results show that the influence of AI is not only determined by the frequency of use, but also by the purpose, usage patterns, digital literacy, reflective engagement, and learning design applied by lecturers.

Based on previous studies, there are still some research gaps. First, most of the research in Indonesia is conducted in one study program or one university with a relatively limited number of samples, so the generalization of the findings is still low. Second, some studies measure perception, productivity, learning outcomes, or intensity of ChatGPT use more than critical thinking skills through tests that include analysis, evaluation, inference, and argumentation. Third, previous research has tended to treat the use of AI as a single variable without distinguishing between reflective uses, such as verifying and comparing answers, with passive use in the form of direct copying of AI outputs. Fourth, the relationship between AI adoption, digital literacy, and critical thinking skills has not been widely tested simultaneously through cross-university quantitative design. Salido et al. (2025) also emphasized the need for empirical research that integrates pedagogical aspects, AI literacy, self-regulation, and critical evaluation in diverse higher education contexts. These gaps are an important basis for more comprehensive research and have a wider coverage of respondents.

This study aims to analyze the influence of AI adoption on students' critical thinking skills in college learning, by paying attention to digital literacy and patterns of AI use in a reflective and passive manner. Theoretically, this research is expected to expand the study of educational technology by explaining that the impact of AI on critical thinking skills is conditional and depends on the way students interact with technology. This research also develops an understanding of AI as a tool to support the construction of knowledge, not as a substitute for the human reasoning process. Practically, the results of the research can be the basis for universities and lecturers to design AI-assisted learning that emphasizes source verification, the preparation of critical questions, reflection, discussion, and assessment of AI outputs. Thus, the adoption of AI is expected to improve students' analytical, evaluative, and independent learning abilities without causing cognitive dependence.

LITERATURE REVIEW

Adoption of Artificial Intelligence in Higher Education Learning

The adoption of artificial intelligence (AI) in higher education refers to the acceptance and utilization of artificial intelligence-based technology to support information retrieval, material understanding, assignment preparation, problem-solving, and independent learning. Such adoption is determined not only by the frequency of use, but also by the purpose, competence of the user and the degree of integration in academic activities. Niyu et al. (2024) show that students and lecturers in Indonesia have used ChatGPT to obtain information, generate ideas, and help complete assignments. Suryawijaya et al. (2025) also found that the use of ChatGPT, Copilot, Blackbox AI, and Gemini helps students understand complex material, improves the efficiency of completing assignments, and strengthens motivation for independent learning. However, technology adoption does not automatically result in better learning quality because its impact depends on how students process and evaluate AI outputs (Vieriu & Petrea, 2025).

AI and Students' Critical Thinking Skills

Critical thinking skills include the ability to interpret information, analyze relationships between ideas, evaluate the credibility of sources, formulate inferences, explain arguments, and self-regulation. In the context of AI-assisted learning, technology can serve as a cognitive scaffold that provides questions, alternative perspectives, simulations, and feedback to expand the reasoning process. Darwin et al. (2024) explain that AI can support information exploration and argumentation development if students do not receive the output directly, but compare and evaluate it with other sources. Empirically, Hutapea and Kabatiah (2025) found a positive and significant relationship between the use of ChatGPT and students' critical thinking skills, with a correlation coefficient of 0.595. Rahmawati et al. (2025) also showed that the use of ChatGPT affects students' ability to formulate clear, in-depth, relevant, and original questions. Thus, AI has the potential to improve critical thinking skills when positioned as a dialogue partner, not as a substitute for student reasoning.

Digital Literacy and the Reflective Use of AI

Digital literacy is the ability to access, understand, evaluate, manage, and use digital information responsibly. In AI-based learning, digital literacy includes the ability to craft appropriate commands, recognize technological limitations, check the accuracy of answers, compare AI outputs with scientific sources, and understand academic ethics. Agustin et al. (2024) show that the use of ChatGPT accompanied by digital literacy can support students' research and information management skills. Supriyadi et al. (2024) also found that AI technology and digital literacy simultaneously have a positive effect on student learning outcomes. The findings suggest that the influence of AI on critical thinking skills is not adequately explained by the intensity of its use. Reflective use—such as testing arguments, verifying, asking follow-up questions, and refining answers—is more likely to result in cognitive engagement than the use of AI that is only geared towards quick answers.

Passive Use, Dependence, and Cognitive Offloading

In addition to its benefits, AI can reduce cognitive engagement if students leave the search, analysis, and decision-making process entirely to technology. This condition is related to cognitive offloading, which is the transfer of part of mental tasks to an external device. Gerlich (2025) found that increasingly intensive use of AI accompanied by a high level of trust can increase cognitive offloading and reduce involvement in critical thinking. In the Indonesian context, Baiquni et al. (2025) found that ChatGPT improves efficiency, conceptual comprehension, and creativity, but excessive use is also associated with decreased reading motivation, technology dependence, and weakened critical thinking skills. Similar risks are raised by Vieriu and Petrea (2025), especially related to inaccurate information reception, academic dishonesty, and decreased cognitive engagement. Therefore, passive use characterized by copying AI outputs without verification is not expected to have a significant or even potentially negative effect on critical thinking skills.

Literature Synthesis and Research Gap

Previous studies have shown that the relationship between AI adoption and critical thinking skills is complex. AI can improve idea exploration, questioning skills, learning efficiency, and information evaluation, but it can also lead to dependency when used passively. However, some Indonesian research is still conducted in one study program or one university with a relatively limited sample. Hutapea and Kabatiah (2025), for example, involved 58 students, while Rahmawati et al. (2025) involved 62 students. The qualitative studies of Baiquni et al. (2025) and Suryawijaya et al. (2025) involved 12 and 19 participants, respectively. In addition, previous studies have tended to measure the use of AI as a single construct and have not explicitly distinguished reflective use from passive use.

Based on these gaps, this study places the intensity of AI adoption, digital literacy, reflective use, and passive use as predictors of critical thinking skills. The study involved 250 students from five universities to provide a broader empirical scope. Conceptually, digital literacy and reflective use are estimated to have a positive effect on critical thinking skills because they encourage verification, analysis, and evaluation of information. On the other hand, passive use is not expected to have a significant effect because students are not actively involved in the reasoning process. The framework emphasizes that the quality of AI use is more important than just the frequency of its use.

Research Hypothesis

Based on the synthesis of theories and previous research results, the adoption of AI is estimated to affect students' critical thinking skills differently according to their intensity, digital literacy ability, and usage patterns. The use of AI accompanied by verification, evaluation, and reflection can increase students' cognitive engagement. On the other hand, passive use can reduce students' opportunities to analyze and reason independently. Thus, the research hypothesis is formulated as follows:

H1 : The intensity of AI adoption has a positive and significant effect on students' critical thinking skills.
H2 : Digital literacy in the use of AI has a positive and significant effect on students' critical thinking skills.
H3 : The use of AI reflectively has a positive and significant effect on students' critical thinking skills.
H4 : The passive use of AI has a negative effect on students' critical thinking skills.
H5 : The intensity of AI adoption, digital literacy, reflective use of AI, and passive use of AI simultaneously have a significant effect on students' critical thinking skills.

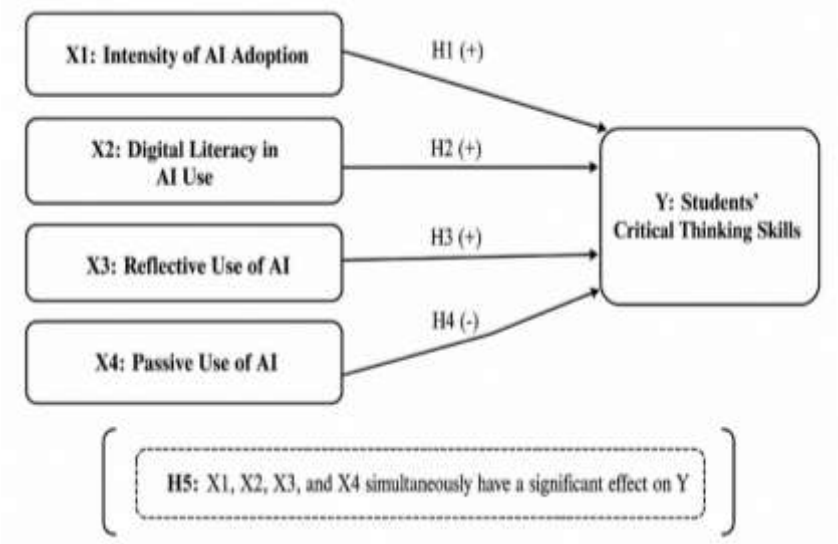

Figure 1. Framework

METHODOLOGY

Types of Research

This study uses a quantitative approach with a cross-sectional explanatory survey design to analyze the influence of artificial intelligence (AI) adoption on students' critical thinking skills. The bound variable is critical thinking skills, while the independent variable includes the intensity of AI adoption, digital literacy, reflective use of AI, and passive use of AI. Reflective use includes the activity of comparing, verifying, and evaluating AI outputs, while passive use implies the receipt or copying of AI answers without further analysis (Darwin et al., 2024; Gerlich, 2025).

Population and Sample

The research population is active students of undergraduate programs who have used AI for academic activities. The sample consisted of 250 students from five universities representing the fields of education, social-humanities, economics and business, science and technology, and health. The sample was selected using disproportionate stratified random sampling, with an allocation of 50 students from each college and grouping by year of study.

The number of samples was examined using G*Power 3.1 with four predictors, significance level 0.05, moderate effect size (f^2=0.15), and statistical power 0.95. The minimum number needed is around 129 respondents so that the sample of 250 students is considered adequate. The respondents' criteria include students in the second semester, having used AI in the last six months, and being willing to participate in the entire research process.

Research Instruments

Data was collected using AI adoption questionnaires and critical thinking skills tests. The questionnaire consists of 20 items on a five-level Likert scale that covers four dimensions: AI adoption intensity, digital literacy, reflective use, and passive use. The items are compiled based on previous research on AI adoption, digital literacy, and dependence on technology (Agustin et al., 2024; Niyu et al., 2024; Supriyadi et al., 2024).

Critical thinking skills were measured using 24 case-based questions that included interpretation, analysis, evaluation, inference, explanation, and self-regulation. The instrument consisted of 20 reasoned multiple-choice questions and four short answer questions. Test scores are converted to a scale of 0–100.

The validity of the instrument's contents was assessed by five experts using Aiken's V with a minimum limit of 0.80. The trial was conducted on 40 students outside the main sample. The validity of the questionnaire construct was tested through confirmatory factor analysis, while the reliability was tested using Cronbach's alpha and McDonald's omega with a minimum value of 0.70. The reliability of multiple-choice questions was tested using KR-20, while the suitability of short answer assessments was tested with intraclass correlation coefficients.

Data Collection Procedure

The research began with a literature review, variable formulation, instrument preparation, permit application, and ethical approval. The instrument was then validated by experts and tested on 40 students. After revision, respondents were randomly selected from each college strata and year of study.

The questionnaire was given online, while the critical thinking test was done for 40 minutes under the supervision of the researcher. Respondents were not allowed to use AI applications during the test. The data was then examined based on the completeness of the answers, processing time, response patterns, and the existence of extreme values. All respondents' identities were replaced with anonymous codes.

Data Analysis Techniques

Data were analyzed using IBM SPSS Statistics 29, R 4.4 with lavaan package, and G*Power 3.1. Descriptive analysis is used to calculate frequency, percentage, average, standard deviation, minimum value, and maximum value.

Before testing the hypothesis, residual normality, linearity, homokedasticity, residual independence, multicollinearity, and extreme values were checked. Multicollinearity was assessed based on a variance inflation factor of less than 5 and a tolerance value of more than 0.20.

The effect of the intensity of AI adoption, digital literacy, reflective use, and passive use on critical thinking skills was analyzed using multiple linear regression at a significance level of 0.05. Results were reported in the form of regression coefficients, t-values, p-values, 95% confidence intervals, F, (R^2), and adjusted (R^2) tests. Bootstrapping analysis of 5,000 samples was used to obtain a more stable estimate of the confidence interval.

RESEARCH RESULT

Respondent Characteristics

The study involved 250 active undergraduate students from five universities, with an allocation of 50 respondents each to each university. All respondents have used artificial intelligence-based applications for academic purposes in the last six months. A total of 151 respondents (60.4%) were women and 99 respondents (39.6%) were men. Based on the year of study, 92 students (36.8%) were in semesters 2–4, 96 students (38.4%) were in semesters 5–6, and 62 students (24.8%) were in semesters 7 or more.

Respondents came from five scientific groups, namely education, social-humanities, economics and business, science and technology, and health. ChatGPT is the most widely used AI application, followed by Gemini, Microsoft Copilot, and Blackbox AI. Since respondents can choose more than one app, the total percentage of app usage exceeds 100%.

Table 1. Characteristics of the use of AI by respondents

Features	Frequency	Percentage
Using ChatGPT	222	88,8%
Using Gemini	157	62,8%
Using Microsoft Copilot	76	30,4%
Using Blackbox AI	51	20,4%
Using AI every day	80	32,0%
Use AI 3–5 times per week	109	43,6%
Use AI 1–2 times per week	49	19,6%
Using AI less than once per week	12	4,8%

Most students use AI to find additional explanations of the course, generate initial ideas, summarize readings, check grammar, and help with assignment drafting. The use of AI to generate direct task answers was found in some respondents, but the frequency was lower than the use of AI for information search and development.

Instrument Test Results

A five-expert assessment yielded an Aiken's V value between 0.84 and 0.96. All of these values are above the acceptance limit of 0.80 so that all indicators are declared to have adequate content validity. The results *of the confirmatory factor analysis* showed that the four-factor measurement model had a good match, with a CFI value of 0.951, TLI of 0.942, RMSEA of 0.052, and SRMR of 0.046. The standardized factor charge is in the range of 0.61–0.87.

Table 2. Results of instrument validity and reliability

Constructs/instruments	Number of items	Cronbach's alpha/KR-20	McDonald's omega	Remarks
Intensity of AI adoption	5	0,82	0,83	Reliabel
Digital literacy in the use of AI	5	0,88	0,89	Reliabel
Reflective use of AI	5	0,89	0,90	Reliabel
Passive use of AI	5	0,80	0,81	Reliabel
Critical thinking test	24	0,84	–	Reliabel

The intraclass correlation *coefficient* for the assessment of four short answer questions was 0.91, which indicates excellent agreement between the two assessors. The results show that the instrument has sufficient internal validity and consistency to be used in hypothesis testing.

Description of Research Variables

The average value of the intensity of AI adoption was 3.84 on a scale of 5, which indicates that the use of AI in academic activities is in the high category. Digital literacy and reflective use are also in the high category, while passive use is in the medium category tends to be low. The average score of students' critical thinking skills is 75.68 out of a scale of 100.

Table 3. Descriptive statistics of research variables

Variabel	Minimum	Maximum	Average	Standard deviation	Category
Intensity of AI adoption	1,80	5,00	3,84	0,64	Height
Digital literacy in the use of AI	1,60	5,00	3,72	0,61	Height
Reflective use of AI	1,40	5,00	3,79	0,66	Height
Passive use of AI	1,00	4,60	2,41	0,73	Medium
Critical thinking skills	51,70	94,60	75,68	9,42	Height

Reflective use obtained high scores especially on indicators comparing AI answers with other sources, double-checking information, and correcting commands when AI answers were inadequate. In passive use, the highest score is found in the tendency to use AI answers to speed up task completion. However, the indicator of copying answers without checking obtained a comparatively lower value.

Students' Critical Thinking Skills

The measurement of critical thinking skills includes six dimensions. Interpretation gets the highest score, while self-regulation gets the lowest score. However, all dimensions are in the medium to high category.

Table 4. Critical thinking skills dimension score

Dimensions	Average	Standard deviation	Category
Interpretasi	79,20	8,21	Height
Analysis	77,60	8,74	Height
Evaluation	74,80	9,63	Height
Inference	76,30	9,05	Height
Explanation	74,20	9,81	Height
Self-regulation	72,00	10,14	Medium–high
Overall score	75,68	9,42	Height

The test results show that students are relatively able to identify key information, distinguish facts and opinions, and draw conclusions based on evidence. Lower scores on self-regulation showed that the ability to re-examine the thought process and recognize the weaknesses of one's own arguments was not evenly distributed among all respondents.

Intervariable Relationships

Pearson's correlation results show that the intensity of AI adoption, digital literacy, and reflective use have a positive relationship with critical thinking skills. Reflective use has the strongest correlation with critical thinking skills. In contrast, passive use indicates a weak and insignificant negative relationship.

Table 5. Intervariable correlation matrix

Variabel	X1	X2	X3	X4	Y
X1. Intensity of AI adoption	1				
X2. Digital literacy	0,42**	1			
X3. Reflective use	0,45**	0,57**	1		
X4. Passive use	0,16*	−0,18**	−0,24**	1	
Y. Critical thinking skills	0,38**	0,52**	0,58**	−0,11	1

*Description: *p < 0.05;* *p < 0.01.**

The correlation of reflective use with critical thinking skills of 0.58 showed a relatively strong positive relationship. Digital literacy has a correlation of 0.52, while the intensity of AI adoption has a correlation of 0.38. The passive use correlation of −0.11 did not reach a significance level of 0.05.

Regression Assumption Test Results

Preliminary examination shows that the data meets the requirements of multiple linear regression. The values *of residual skewness* and *kurtosis* are in the range of −2 to +2. A *normal probability plot graph* shows that the residual follows a diagonal line, whereas the relationship between each predictor and the bound variable shows a linear pattern.

The Durbin–Watson value of 1.93 indicates that there is no autocorrelation problem. The VIF value was in the range of 1.19–1.71 and the tolerance value was in the range of 0.58–0.84, so that multicollinearity was not found. The Breusch–Pagan test yielded p = 0.312, which showed no heteroscedasticity. No observations were found with a Cook's Distance value greater than 1.

The Influence of AI Adoption on Critical Thinking Skills

The results of multiple linear regression showed that the research model was significant, with F(4.245) = 44.19 and p < 0.001. An R value of 0.647 and an R^2 of 0.419 showed that the intensity of AI adoption, digital literacy, reflective use, and passive use together explained 41.9% of students' variation in critical thinking skills. After adjusting for the number of predictors and samples, the *adjusted* value of R^2 is 0.410. Another 58.1% of the variation was explained by factors not included in the model.

Table 6. Multiple linear regression results

Predictor	B	SE	b	t	p	95% CI
Konstanta	38,62	3,86	–	10,01	<0.001	31,0246,22
Intensity of AI adoption	2,06	0,82	0,14	2,51	0,013	0,45–3,67
Digital literacy	4,02	0,91	0,26	4,42	<0.001	2,23–5,81
Reflective use of AI	5,57	0,86	0,39	6,48	<0.001	3,88–7,26
Passive use of AI	−0,77	0,61	−0,06	−1,26	0,210	−1,97–0,43

The regression equations obtained are:

[Y=38.62+2.06X_1+4.02X_2+5.57X_3-0.77X_4]

The intensity of AI adoption had a positive and significant influence on critical thinking skills with β = 0.14 and p = 0.013. Digital literacy also showed a positive and significant influence with β = 0.26 and p < 0.001. Reflective use was the strongest predictor with β = 0.39 and p < 0.001. Passive use yielded a negative coefficient, but the effect was not significant with β = −0.06 and p = 0.210.

Bootstrapping *analysis* of 5,000 samples yielded consistent results. The confidence intervals for the intensity of AI adoption, digital literacy, and reflective use did not pass zero. On the other hand, the confidence interval of passive use includes a value of zero so that the influence of these variables cannot be stated to be significant.

Score Differences Based on Reflective Usage Levels

To clarify the pattern of findings, respondents were grouped into three categories of reflective use of AI. Students with high levels of reflective use obtained the highest critical thinking scores.

Table 7. Critical thinking skills based on reflective use

Reflective usage rate	n	Average critical thinking skills	Standard deviation
Low	82	68,90	8,40
Medium	86	75,40	7,60
Height	82	82,60	7,50

The ANOVA results showed a significant difference between the three groups, $F(2.247) = 62.66$, $p < 0.001$, and $\eta^2 = 0.337$. Further tests showed that the entire group pair differed significantly. The score difference between the high and low reflective use groups reached 13.70 points.

Hypothesis Testing Results

Table 8. Hypothesis testing summary

Hipotesis	Statement	Results
H1	The intensity of AI adoption has a positive and significant effect on critical thinking skills	Supported
H2	Digital literacy in the use of AI has a positive and significant effect on critical thinking skills	Supported
H3	The reflective use of AI has a positive and significant effect on critical thinking skills	Supported
H4	The passive use of AI has a negative and significant effect on critical thinking skills	Not supported
H5	The four variables simultaneously had a significant effect on critical thinking skills	Supported

H1, H2, H3, and H5 are accepted. H4 is not supported because the direction of the passive use coefficient is negative, but the effect does not reach the level of statistical significance. Thus, the main results of the study show that critical thinking skills are stronger with regard to the quality of AI use, specifically digital literacy and reflective use, than passive use of AI.

DISCUSSION

The results showed that the intensity of AI adoption, digital literacy, reflective use of AI, and passive use of AI simultaneously explained 41.9% of students' variation in critical thinking skills. These findings show that the use of AI has a strong relationship with students' ability to analyze information, evaluate arguments, formulate inferences, and make decisions based on evidence. However, the influence of AI on critical thinking skills is not automatic, but depends on students' ability to understand the limitations of technology and process AI outputs critically. This is in line with Vieriu and Petrea (2025), who explain that AI can increase engagement and learning outcomes, but it can also decrease cognitive engagement if used without a targeted pedagogical strategy.

The intensity of AI adoption has a positive and significant effect on students' critical thinking skills with a coefficient of $\beta = 0.14$ so that H1 is supported. The more intensive use of AI allows students to obtain alternative explanations, feedback, examples, and sources of information that can expand their understanding of the learning material. These findings are in line with Hutapea and Kabatiah (2025), who found a positive relationship between the use of ChatGPT and students' critical thinking skills. Niyu et al. (2024) also show that students and lecturers in Indonesia have used ChatGPT to obtain information, develop ideas, and support the completion of academic assignments. However, the coefficient of the influence of usage intensity in this study was lower than that of digital literacy and reflective use. These results show that the frequency of AI use is not the most decisive factor. Frequent but only quick-response oriented use does not necessarily result in a deep thought process.

Digital literacy in the use of AI has a positive and significant effect on critical thinking skills with $\beta = 0.26$ so that H2 is supported. Students who are able to check the credibility of sources, recognize possible biases and inaccuracies, understand the limitations of technology, and use digital information ethically have higher critical thinking skills. Digital literacy serves as an evaluative mechanism that prevents students from accepting AI outputs as always correct information. These findings support the research of Amin et al. (2023), which shows that digital literacy contributes to critical thinking skills. Agustin et al. (2024) also found that the use of ChatGPT accompanied by digital literacy can improve students' skills in managing information and conducting research. In addition, Supriyadi et al. (2024) show that the simultaneous use of AI and digital literacy affects learning outcomes. This study expands on these findings by showing that digital literacy also plays a role in improving students' ability to analyze, evaluate, and draw conclusions.

The use of AI reflexively was the most powerful predictor of critical thinking skills with $\beta = 0.39$ so H3 was supported. Students who compared AI answers to scientific sources, asked follow-up questions, examined arguments flaws, and improved AI outputs earned higher critical thinking scores. The difference in score of 13.70 points between the high and low reflective use groups shows that the quality of interaction with AI is more important than just the intensity of its use. This finding can be explained through the concept of cognitive scaffolding, where AI is used as a tool to provide initial information, alternative

perspectives, and feedback that students then process through the reflection process. Darwin et al. (2024) explain that AI can help information exploration and argument development if students evaluate and compare their outputs with other sources. Suryawijaya et al. (2025) also show that AI supports students' learning competencies and motivation when used consciously and responsibly.

The passive use of AI had a negative influence direction, but not significant, with $\beta = -0.06$ and $p = 0.210$. Thus, H4 is not supported. The direction of the coefficient shows a tendency that students who receive or copy AI outputs without evaluation have lower critical thinking skills. However, this influence is not statistically strong enough. These results differ from Gerlich (2025), who found that reliance on AI can increase cognitive offloading and decrease critical thinking engagement. Baiquni et al. (2025) also showed that excessive use of ChatGPT can decrease reading motivation and increase technology dependence. The difference may be due to the level of passive use of respondents who are only in the medium category, so the variation is not large enough to produce a significant influence.

The insignificance of passive use can also be influenced by the relatively high digital literacy and reflective use ability in most respondents. Students may use AI passively in some specific assignments, but still verify and evaluate other academic activities. Additionally, passive use measurements using self-report questionnaires can lead to social desire bias because respondents may not fully acknowledge the practice of copying or accepting AI answers without examination. Therefore, the insignificance of these results cannot be interpreted as the passive use of AI does not have a risk to the development of students' thinking skills.

The acceptance of H5 showed that the four variables simultaneously had a significant effect on critical thinking skills. These findings confirm that the relationship between AI and critical thinking abilities is multidimensional. The impact of AI is not adequately explained through the frequency of use, but it is necessary to consider digital literacy, reflective usage patterns, and passive usage trends. Theoretically, this research reinforces the view that AI can function as a cognitive scaffold when supporting the processes of analysis, evaluation, and reflection. On the other hand, AI has the potential to be a means of cognitive offloading when students leave the thought process entirely to technology. The separation of the four dimensions provides a more specific explanation than research that places the use of AI as a common variable.

Practically, universities need to integrate AI literacy and digital literacy into the learning process. It is not enough for lecturers to only allow or prohibit the use of AI, but it is necessary to design activities that require students to examine sources, identify errors in AI outputs, compare multiple answers, and defend their arguments through discussion or presentation. Students may also be asked to include a history of prompts, explain changes made to AI outputs, and provide reflections on the strengths and weaknesses of the information generated. Learning assessment needs to emphasize the reasoning process more than just evaluating the final product so that AI is used as a learning aid, not as a substitute for students' intellectual responsibility.

This research has several limitations. Cross-sectional designs only measure variables in one period so that they cannot definitively prove cause-and-effect relationships. Measuring the use of AI through self-reports also has the potential to generate response bias. In addition, the sample came from five universities with the same number of respondents at each institution so that it did not fully describe the composition of students nationally. The research model only explained 41.9% of the variation in critical thinking skills, while the other 58.1% were likely to be influenced by early academic ability, metacognition, self-regulation, learning motivation, learning design, field of study, and lecturer competence.

Further research is suggested using longitudinal or experimental designs to compare changes in critical thinking skills before and after the implementation of AI-assisted learning. Data collection also needs to be complemented by observations, interviews, interaction recordings, and analysis of prompt history so that reflective and passive usage patterns can be measured more objectively. The next study can test metacognition and self-regulation as mediation variables, as well as the field of study, academic year, and lecturer guidance as the moderation variable. A multilevel analysis across universities is also needed to distinguish the influence of individual student characteristics and institutional policies on critical thinking skills.

CONCLUSIONS AND RECOMMENDATIONS

This study concludes that the adoption of artificial intelligence has a significant effect on students' critical thinking skills when its use is supported by digital literacy and reflective engagement. The research model explains 41.9% variation in critical thinking skills. The use of AI is reflective to be the strongest predictor, followed by digital literacy and the intensity of AI adoption. In contrast, passive use of AI indicates the direction of negative influences, but not significantly. These findings confirm that the benefits of AI in higher education are determined more by the quality of students' interactions with technology than simply the frequency of its use. AI can serve as a support for the process of analysis, evaluation, and reflection, but it should not replace student self-reasoning.

Colleges are advised to integrate AI literacy and digital literacy into the curriculum as well as design learning that encourages students to verify sources, compare AI outputs, identify errors, and defend arguments academically. Lecturers need to assess the thought process, not just the final product, through the inclusion of prompt history, reflection on the use of AI, discussions, and presentations. AI use policies also need to emphasize academic ethics, transparency, and intellectual responsibility so that technology is used as a learning tool that reinforces, not weakens, critical thinking skills.

ADVANCED RESEARCH

Follow-up research is recommended using longitudinal or experimental designs to test the cause-and-effect relationship between the use of AI and the development of critical thinking skills. The next study can also include metacognition, self-regulation, learning motivation, learning design, and lecturer competence as mediation or moderation variables. The use of observations, interviews, interaction recordings, and prompt history analysis is needed to measure AI usage patterns more objectively in the broader population and college.

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