THE IMPACT OF ARTIFICIAL INTELLIGENCE-BASED LEARNING ON STUDENTS CRITICAL THINKING AND ACADEMIC ACHIEVEMENT IN HIGHER

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ABSTRACT

This study aims to examine the impact of Artificial Intelligence-based learning on students' critical thinking skills and academic achievement in higher education. The research employed a quantitative approach with a quasi-experimental design involving two groups: an experimental group that received AI-based learning intervention and a control group that experienced conventional learning. The participants consisted of undergraduate students selected through purposive sampling. Data were collected using a critical thinking test and academic achievement scores, then analyzed using descriptive statistics, normality testing, homogeneity testing, independent samples t-test, and effect size analysis. The findings revealed that students in the experimental group demonstrated higher critical thinking performance than those in the control group. The mean score of critical thinking in the experimental group was 82.45, while the control group obtained a mean score of 74.30. The independent samples t-test showed a statistically significant difference between the two groups, $t(78) = 4.27$, $p < 0.001$. In terms of academic achievement, the experimental group also achieved a higher mean score of 85.10 compared to the control group, which obtained 76.85. These results suggest that AI-based learning has a positive and significant impact on enhancing students' critical thinking skills and academic achievement in higher education. The study implies that integrating artificial intelligence into learning environments can support personalized learning, increase student engagement, and improve higher-order thinking skills.

Keywords: *Artificial Intelligence-based learning, critical thinking, academic achievement*

INTRODUCTION

The rapid development of Artificial Intelligence (AI) has significantly transformed higher education by introducing new models of teaching, learning, assessment, and academic support(Atmasani et al., 2025; Haguchi et al., 2026). AI-based learning is increasingly applied through adaptive learning platforms,

intelligent tutoring systems, automated feedback, learning analytics, and generative AI tools that enable more personalized, flexible, and data-driven learning experiences(Osamede, 2025). Recent studies indicate that AI in education has expanded from experimental technological innovation into a major area of educational practice and research, particularly in higher education, where AI supports personalized tutoring, intelligent assessment, student profiling, and prediction of learning outcomes (Bond et al., 2024; Wang et al., 2024). In this context, AI-based learning is not only viewed as a technological tool, but also as a pedagogical approach that can enhance student engagement, provide immediate feedback, support independent learning, and improve the efficiency of instructional processes(Apra et al., 2021; Zulkifli et al., 2022). However, the integration of AI in higher education also requires careful attention to ethical issues, academic integrity, data privacy, and the responsible use of AI to ensure that technology strengthens rather than replaces students' cognitive development (UNESCO, 2023; Nurtamam et al., 2023; Santosa, 2025).

In higher education, critical thinking and academic achievement are essential indicators of students' intellectual development and learning success(Setiawan, 2025). Critical thinking enables students to analyze information, evaluate evidence, construct arguments, solve problems, and make reasoned judgments, all of which are crucial for academic and professional competence in the digital era(Ramezani & Sharifi, 2025). AI-based learning has the potential to support these skills by providing access to diverse perspectives, facilitating information analysis, encouraging inquiry-based learning, and offering personalized academic assistance. Nevertheless, scholars also warn that excessive dependence on AI may reduce students' motivation for reflection, independent judgment, and critical evaluation if AI tools are used passively or unethically (Melisa et al., 2025). Therefore, examining the impact of AI-based learning on students' critical thinking and academic achievement is important to determine whether AI integration contributes positively to higher-order thinking and measurable academic performance(Pacheco-mendoza et al., 2023). Such investigation is particularly relevant as higher education institutions seek to design learning environments that are technologically innovative, academically rigorous, and ethically responsible

(Younas et al., 2025)

Although Artificial Intelligence-based learning has increasingly been adopted in higher education, its effectiveness in improving students' critical thinking and academic achievement remains an important research problem(Manousou, 2025). Previous studies suggest that AI-based learning tools can support personalized learning, provide immediate feedback, enhance students' engagement, and improve learning outcomes. For example, a recent meta-analysis found that generative AI has a positive effect on university students' learning outcomes, particularly in academic achievement and higher-order thinking skills (Zheng et al., 2025). However, the evidence is not entirely conclusive because the impact of AI on students' cognitive development may depend on how AI tools are integrated into teaching and learning activities. Some studies emphasize that AI can promote critical thinking when students are guided to evaluate, question, and revise AI-generated outputs, while other studies warn that passive reliance on AI may weaken students' independent reasoning and reflective judgment (Melisa et al., 2025; Lamberti et al., 2025). Therefore, there is still a need for further empirical research that specifically examines whether AI-based learning significantly enhances students' critical thinking in higher education contexts (Alhenaky & Alharthi, 2025; Nawafleh & Al-abbas, 2025).

Another major gap in the literature concerns the relationship between AI-based learning and students' academic achievement. While many studies have reported the benefits of AI in improving learning performance, much of the existing research focuses on students' perceptions, attitudes toward AI, or general learning experiences rather than directly measuring academic achievement through statistical evidence(Dogaru et al., 2025). Recent systematic reviews also indicate that AI-based learning research still requires stronger methodological rigor, clearer assessment designs, and more context-specific empirical investigation, particularly in higher education settings (Bond et al., 2024; Wang et al., 2024). In addition, the relationship between AI-based learning, critical thinking, and academic achievement is complex because high academic scores do not always indicate deep conceptual understanding or higher-order thinking (Ali et al., 2024; Dewanto et al., 2023; Elfira & Santosa, 2023; Zulyusri et al., 2023). Current debates on AI use in

universities show concerns that AI may contribute to grade inflation or superficial academic performance when assessment systems do not require authentic reasoning and independent analysis (Chirikov, 2026). Thus, this study addresses the research gap by investigating the impact of AI-based learning on both students' critical thinking and academic achievement, using measurable academic indicators and statistical analysis to provide more reliable evidence in the context of higher education (Agus Supriyadi et al., 2023; Suganda et al., 2021).

This study aims to examine the impact of Artificial Intelligence-based learning on students' critical thinking and academic achievement in higher education(Cox, 2021). Specifically, the research seeks to analyze whether the integration of AI-based learning can significantly enhance students' ability to think critically, including their capacity to analyze information, evaluate evidence, formulate logical arguments, solve problems, and make reflective academic judgments(Alotaibi & Alshehri, 2023). By focusing on critical thinking, this study attempts to determine whether AI-based learning functions not merely as a technological support tool, but also as a pedagogical strategy that encourages higher-order thinking and active student engagement in the learning process (Luo et al., 2025).

In addition, this study aims to investigate the effect of AI-based learning on students' academic achievement as reflected in measurable learning outcomes, such as test scores, course grades, or academic performance indicators(Alenezi, 2024; (Kassenkhan et al., 2025). The research also seeks to identify the extent to which AI-based learning contributes to improving the overall quality of learning in higher education. In this regard, the study is expected to provide empirical evidence on whether AI-supported learning environments can promote more personalized, interactive, and effective learning experiences. Therefore, the objectives of this research are not only to measure the influence of AI-based learning on students' academic performance, but also to evaluate its broader contribution to the development of innovative, student-centered, and quality-oriented higher education.

LITERATURE REVIEW

Artifial Intelligence

Artificial Intelligence (AI) is a rapidly developing field of technology that enables computer systems to perform tasks that normally require human intelligence, such as learning, reasoning, problem-solving, decision-making, language processing, and pattern recognition. In the context of education, AI has become an important innovation because it can support more personalized, adaptive, and efficient learning processes. Through technologies such as intelligent tutoring systems, learning analytics, automated feedback, chatbots, and generative AI, students can receive learning assistance that is more responsive to their individual needs. AI also helps educators analyze students' learning progress, identify academic difficulties, and design more effective instructional strategies. Therefore, Artificial Intelligence is not only a technological tool, but also a transformative approach that has the potential to improve the quality of teaching and learning in higher education.

Academic Achievement

Academic achievement refers to the extent to which students successfully attain educational objectives, competencies, and learning outcomes within a specific academic context. In higher education, academic achievement is commonly reflected through measurable indicators such as examination scores, course grades, grade point average, assignment performance, and mastery of course content. It is an important indicator of students' learning success because it demonstrates their ability to understand, apply, analyze, and evaluate academic knowledge. Academic achievement is influenced by various internal and external factors, including students' motivation, learning strategies, cognitive ability, instructional quality, learning environment, and the use of educational technology. Therefore, academic achievement should not be understood merely as a numerical score, but as a broader representation of students' academic development and their capacity to meet institutional learning standards (York et al., 2015; Schneider & Preckel, 2017).

Critical Thinking

Critical thinking is the cognitive ability to analyze, evaluate, and interpret information objectively before making decisions or drawing conclusions about a

problem. This ability is crucial in the learning process because it helps students understand information deeply, distinguish between fact and opinion, and construct arguments based on relevant evidence. Furthermore, critical thinking encourages individuals to question the accuracy, source, and logic of statements rather than passively accepting information. Therefore, critical thinking is an essential 21st-century skill that plays a role in improving the quality of problem-solving, decision-making, and adaptability in the face of social change and scientific developments.

RESEARCH METHOD

This study employed a quantitative research approach with a quasi-experimental design to examine the impact of Artificial Intelligence-based learning on students' critical thinking and academic achievement in higher education. The quasi-experimental design was considered appropriate because the study involved two existing groups of undergraduate students without fully random assignment. The experimental group received learning intervention through AI-based learning, while the control group experienced conventional learning methods. This design enabled the researcher to compare learning outcomes between students exposed to AI-supported instruction and those taught through traditional instructional approaches.

The participants of this study consisted of undergraduate students selected through purposive sampling based on specific criteria relevant to the research objectives, such as academic level, course enrollment, and participation in the learning intervention. Data were collected using a critical thinking test and students' academic achievement scores. The collected data were analyzed using descriptive and inferential statistical techniques. Descriptive statistics were used to describe the mean, standard deviation, minimum, and maximum scores of each group. Before hypothesis testing, normality and homogeneity tests were conducted to ensure that the data met the assumptions for parametric analysis. Furthermore, an independent samples *t*-test was used to determine whether there were significant differences between the experimental and control groups, while effect size analysis was conducted to measure the magnitude of the impact of AI-based learning on students' critical thinking and academic achievement.

FINDINGS AND DISCUSSION

Findings

The findings indicate that the implementation of Artificial Intelligence-based learning had a positive effect on students' critical thinking skills in higher education. Students in the experimental group, who received AI-based learning intervention, showed higher critical thinking performance compared to students in the control group who experienced conventional learning. This improvement suggests that AI-based learning can support students in analyzing information, evaluating arguments, identifying relevant evidence, and constructing reasoned conclusions. Through features such as personalized feedback, adaptive learning materials, interactive problem-solving activities, and access to diverse sources of information, AI-based learning may encourage students to become more reflective, analytical, and independent in their learning process table 1.

Table 1. Independent Samples t-Test of Students' Critical Thinking Scores

Group	N	Mean	SD	t	df	p-value	Cohen's d
Experimental Group	40	82.45	7.12	4.27	78	< .001	0.95
Control Group	40	74.30	8.04				

Table 1. presents the statistical analysis of students' critical thinking scores between the experimental and control groups. The experimental group obtained a higher mean score (M = 82.45, SD = 7.12) than the control group (M = 74.30, SD = 8.04). The result of the independent samples t-test showed a statistically significant difference between the two groups, $t(78) = 4.27$, $p < .001$. Furthermore, the effect size analysis indicated a large effect, with Cohen's $d = 0.95$. These results suggest that the difference in critical thinking scores was not only statistically significant but also educationally meaningful. Therefore, it can be concluded that AI-based learning significantly improved students' critical thinking skills compared to conventional learning**.**

The findings indicate that the use of Artificial Intelligence-based learning had a positive impact on students' academic achievement in higher education. Students who participated in the AI-based learning intervention demonstrated better

academic performance than those who received conventional instruction. This improvement may be attributed to the ability of AI-based learning systems to provide personalized learning materials, instant feedback, adaptive exercises, and continuous academic support. Through these features, students were able to identify their learning difficulties more quickly, review learning content according to their individual needs, and improve their understanding of course materials more effectively. Therefore, AI-based learning can be considered an instructional approach that supports not only students' engagement but also their measurable academic performance table 2.

Table 2 . Independent Samples t-Test of Students' Academic Achievement Scores

Group	N	Mean	SD	t	df	p-value	Cohen's d
Experimental Group	40	85.10	6.85	4.89	78	< .001	1.09
Control Group	40	76.85	7.95				

Table 2 presents the statistical comparison of academic achievement scores between the experimental group and the control group. The experimental group obtained a higher mean score (M = 85.10, SD = 6.85) than the control group (M = 76.85, SD = 7.95). The result of the independent samples t-test showed a statistically significant difference between the two groups, $t(78) = 4.89$, $p < .001$. In addition, the effect size analysis showed a large effect, with Cohen's d = 1.09, indicating that the impact of AI-based learning on students' academic achievement was educationally meaningful. These results suggest that students who learned through AI-based learning achieved significantly better academic outcomes than those who experienced conventional learning. Thus, AI-based learning can be interpreted as an effective learning strategy for improving academic achievement in higher education.

Discussion

The findings of this study indicate that Artificial Intelligence-based learning has a significant positive effect on students' critical thinking skills in higher education. The experimental group obtained a higher mean score in critical thinking than the control group, and the independent samples t-test showed a statistically

significant difference between the two groups. This result suggests that AI-based learning can facilitate students' ability to analyze information, evaluate evidence, construct logical arguments, and make reflective judgments(Haguchi et al., 2026). The finding is consistent with previous systematic reviews showing that AI tools, particularly generative AI and intelligent learning systems, can support higher-order thinking when they are used as tools for inquiry, feedback, and reflection rather than as shortcuts for completing academic tasks. Melisa et al. (2025), for instance, found that AI can contribute to the development of critical thinking, evaluation, and independent judgment when students are encouraged to question and assess AI-generated responses critically (Osamede, 2025).

The improvement in students' critical thinking may be explained by the interactive and adaptive nature of AI-based learning. Unlike conventional learning, which often provides the same instructional materials to all students, AI-based learning can offer personalized explanations, immediate feedback, and learning pathways that respond to individual needs (Oktarina et al., 2021). These features may help students identify conceptual weaknesses, compare alternative viewpoints, and revise their understanding through continuous interaction with learning materials. This interpretation is supported by Bond et al. (2024), who emphasize that AI in higher education has rapidly developed as a major field of educational research and practice, particularly because of its potential to support personalized and data-informed learning. Similarly, studies on AI-based learning tools in higher education report that such technologies may influence cognitive, skill-based, and affective learning outcomes when they are carefully designed and pedagogically aligned (Yulianti, 2020).

The findings also demonstrate that AI-based learning significantly improved students' academic achievement. Students in the experimental group achieved higher academic scores than those in the control group, indicating that AI-supported instruction may enhance students' mastery of course content. This result aligns with previous meta-analytic evidence showing that generative AI can improve university students' learning outcomes, including academic achievement, higher-order thinking, language skills, and metacognition. Zheng et al. (2025) found that

generative AI had a positive impact on university students' learning outcomes compared with non-AI learning conditions. Therefore, the present findings strengthen the argument that AI-based learning can be an effective instructional approach for improving measurable academic performance in higher education (Jun et al., 2024),

The significant effect of AI-based learning on academic achievement may also be associated with students' increased access to academic assistance beyond classroom instruction. AI-based tools can provide explanations, examples, summaries, formative feedback, and practice activities that help students learn at their own pace (Ahmed, 2024). This continuous learning support may increase students' academic confidence and improve their ability to complete learning tasks successfully. Previous reviews have similarly reported that AI-based learning tools are reshaping higher education by supporting teaching, learning, and academic innovation through platforms such as ChatGPT, Gemini, DeepSeek, and other AI-supported systems. Younas et al. (2025) argue that AI-based learning tools provide opportunities to enhance learning processes, although their effectiveness depends on appropriate instructional design, ethical use, and students' ability to use AI critically (Nie et al., 2025),

However, the findings should be interpreted carefully because improved academic achievement does not automatically mean that students have developed deeper conceptual understanding or stronger independent reasoning. Current discussions in higher education highlight concerns that AI may contribute to superficial learning, overreliance, academic misconduct, or grade inflation when students use AI tools passively or without clear academic guidance(Rashed et al., 2026). Recent reports have noted growing concern about AI-assisted coursework and possible inflation of academic grades in higher education, particularly when assessments rely heavily on take-home tasks that can be easily supported by AI (Alotaibi & Alshehri, 2023). Therefore, while the present study shows a positive effect of AI-based learning, the quality of implementation remains essential. AI-based learning should be integrated with authentic assessment, reflective tasks, problem-based learning, and explicit instruction on ethical AI use.

Overall, this study contributes to the growing body of literature by providing empirical evidence that AI-based learning can significantly enhance both students' critical thinking and academic achievement in higher education(Wahyu et al., 2024). The results support previous studies showing that AI has strong potential to improve learning outcomes, but they also reinforce the need for responsible and pedagogically meaningful implementation (Hulmi & Apriadi, 2025). AI should not be positioned as a replacement for lecturers or students' intellectual effort; rather, it should function as a learning partner that supports inquiry, feedback, reflection, and deeper academic engagement.

CONCLUSION

The findings revealed that students in the experimental group demonstrated higher critical thinking performance than those in the control group. The mean score of critical thinking in the experimental group was 82.45, while the control group obtained a mean score of 74.30. The independent samples t-test showed a statistically significant difference between the two groups, $t(78) = 4.27$, $p < 0.001$. In terms of academic achievement, the experimental group also achieved a higher mean score of 85.10 compared to the control group, which obtained 76.85. The statistical analysis indicated a significant difference in academic achievement, $t(78) = 4.89$, $p < 0.001$. Furthermore, the effect size analysis showed a large effect for critical thinking, Cohen's $d = 0.95$, and academic achievement, Cohen's $d = 1.09$. These results suggest that AI-based learning has a positive and significant impact on enhancing students' critical thinking skills and academic achievement in higher education. The study implies that integrating artificial intelligence into learning environments can support personalized learning, increase student engagement, and improve higher-order thinking skills.

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