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Students' Perceived Effectiveness of Artificial Intelligence in Online Learning: Evidence from Universitas Nahdlatul Ulama Lampung

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Abstract

The integration of Artificial Intelligence (AI) in online learning has increased significantly over the past decade; however, empirical evidence regarding its effectiveness in Indonesian higher education remains limited, particularly studies employing multidimensional inferential statistical analysis. This study aims to examine the effectiveness of AI in online learning at Universitas Nahdlatul Ulama Lampung. A quantitative survey design was employed involving 105 students selected from a population of 2,163 students. The research instrument consisted of a 40-item Likert-scale questionnaire encompassing four dimensions: AI usage, online learning participation, material comprehension, and challenges and concerns. Data were analyzed using descriptive statistics and a one-sample t-test at a significance level of 0.05. The findings indicate an overall mean score of 3.44, exceeding the scale midpoint of 3.00, with a statistically significant difference from the midpoint ($t = 11.18$, $p < 0.001$, Cohen's $d = 1.09$). The highest mean score was observed for material comprehension ($M = 3.55$), whereas online learning participation was relatively lower ($M = 3.38$). These findings suggest that AI plays a substantial role in supporting online learning, particularly in enhancing material comprehension and learning flexibility, although it has not yet optimally fostered active student participation. These findings provide empirical evidence for universities in designing pedagogically appropriate AI integration strategies.

Keywords: Artificial Intelligence, Higher Education, Material Comprehension, Online Learning, Student Participation

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INTRODUCTION

Digital transformation in higher education has accelerated substantially since the COVID-19 pandemic, which triggered a massive transition toward online learning modalities.(Fernández et al., 2023; Otto et al., 2023) Digital technologies have shifted from being complementary tools to becoming foundational components of higher education delivery in Indonesia.(Aripradono et al., 2024; Surjawan et al., 2025) Artificial Intelligence (AI) has emerged as one of the most prominent innovations within the digital education ecosystem due to its capacity to provide personalized learning pathways, automated feedback, learning analytics, and adaptive data-driven support. The advancement of generative AI has further expanded these functions by enabling conceptual elaboration, content summarization, academic dialogue simulation, and personalized resource recommendations.(Tlili et al., 2023) These capabilities position AI as a potential enhancer of students' self-regulated learning and cognitive efficiency in online environments.(Chen et al., 2020; Hwang & Tu, 2021)

The Indonesian context presents distinctive dynamics in educational technology adoption.(Adiwijaya et al., 2026) The Merdeka Belajar policy promotes digital integration to expand access, increase flexibility, and enhance educational quality in higher education institutions. Its implementation has accelerated the use of Learning Management Systems,(Simon et al., 2025) video conferencing platforms, and AI-based applications in academic activities.(Suhardi, 2025) National studies report increased digital technology usage among both students and lecturers during online learning periods.(Fairusy Fitria Haryani et al., 2023; Izzati et al., 2024) However, increased adoption has not been fully accompanied by rigorous empirical evaluation of AI's effectiveness in improving learning quality. Most domestic studies focus primarily on perceptions, infrastructure readiness, or technology acceptance, while inferential statistical examinations of AI's impact across multiple learning dimensions remain limited.

International literature indicates that AI positively contributes to conceptual understanding and self-regulated learning through instant feedback and adaptive explanations.(Ba et al., 2025; Banihashem et al., 2025; Luo et al., 2025) Meta-analyses of intelligent tutoring systems demonstrate moderate positive effects on cognitive learning outcomes.(Ma et al., 2014) Studies also report increased task efficiency and learning flexibility in AI-supported higher education contexts (Bond et al., 2021; Crompton & Burke, 2023). At the same time, scholarly discourse highlights potential risks, including cognitive dependency, algorithmic bias, data privacy concerns, and academic integrity challenges.(*Guidance for Generative AI in Education and Research*, 2023a; Williamson & Eynon, 2020) Intensive use of generative AI may reduce the depth of critical thinking if not pedagogically integrated.(Kasneci et al., 2023a; Rizun et al., 2026)

The social participation dimension in online learning presents inconsistent findings. AI appears more effective in supporting individual cognitive processes than in enhancing collaborative interaction or discussion engagement.(Chiu et al., 2021; Tan et al., 2022) These discrepancies suggest that AI effectiveness should be examined multidimensionally, incorporating actual usage, active participation, material comprehension, and perceived challenges(Tlili et al., 2023)

This study therefore aims to empirically examine the effectiveness of AI in online learning at Universitas Nahdlatul Ulama Lampung using a quantitative survey approach. The analysis encompasses four principal dimensions: AI usage, online learning participation, material comprehension, and perceived challenges and concerns.

The contribution of this study extends beyond the use of inferential statistical testing and the inclusion of four dimensions. Theoretically, this study conceptualizes AI effectiveness as a multidimensional learning experience that incorporates students' actual AI usage, cognitive understanding, active participation, and perceived challenges.(Baig & Yadegaridehkordi, 2024) Methodologically, the study integrates these dimensions within a single empirical framework to examine the contrasting benefits and limitations of student-initiated generative AI use in online learning.(Lo et al., 2024) From an educational-technology perspective, the study provides contextual empirical evidence regarding the role of generative AI as a supplementary learning tool and its differential contribution to cognitive understanding and active participation.(Qian, 2025) This perspective helps distinguish the cognitive benefits of AI from its more limited contribution to social participation and highlights the continuing importance of teacher guidance in AI-supported learning.(Heung & Chiu, 2025) The study therefore contributes context-specific evidence from Indonesian higher education that can inform the development of responsible and pedagogically appropriate strategies for generative AI integration.

METHODS

Research Design

This study employed a quantitative survey design to examine students' perceptions of the effectiveness of generative Artificial Intelligence (AI) in online learning at Universitas Nahdlatul Ulama Lampung. The survey was conducted within a single time frame to obtain empirical data on students' experiences and perceptions regarding AI-supported learning. The quantitative approach enabled the researchers to collect standardized responses and identify general patterns in students' use of AI, online learning participation, material comprehension, and perceived challenges and concerns(Creswell, John W, 2018; Setia, 2016)

Population and Sampling

The population consisted of 2,163 active students enrolled in 16 study programs across four faculties at Universitas Nahdlatul Ulama Lampung. The study programs included five programs in the Faculty of Teacher Training and Education, namely Primary School Teacher Education, Mathematics Education, English Education, Physical Education, Health and Recreation, and Vocational Automotive Education; four programs in the Faculty of Science and Technology, namely Informatics Engineering, Information Systems, Electrical Engineering, and Statistics; four programs in the Faculty of Agriculture, Fisheries, and Animal Husbandry, namely Agribusiness, Fisheries Product Technology, Fisheries Resource Utilization, and Animal Husbandry; and three programs in the Faculty of Economics and Business, namely Entrepreneurship, Digital Business, and Retail Management.

Considering the diversity of academic backgrounds and the potential differences in students' experiences with AI-supported learning, study programs were treated as sampling strata. A stratified sampling approach was used to obtain respondents from different academic fields. Eligibility criteria included active enrollment at the university and previous experience using AI applications in online learning activities. A total of 105 students meeting these criteria participated in the study. Respondents were recruited from the identified study-program strata, with participation based on the availability and willingness of eligible students to complete the questionnaire. This procedure was intended to capture variation in students' experiences with AI across different disciplinary contexts.(Etikan, 2017)

Research Instrument

The research instrument consisted of a 40-item closed-ended questionnaire using a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. The questionnaire was designed to examine students' experiences with generative AI in online learning and consisted of four dimensions: (A) AI usage, (B) online learning participation, (C) material comprehension, and (D) challenges and concerns.

The four dimensions were theoretically and empirically informed by previous research on AI-supported learning and online education. The AI usage dimension was informed by literature emphasizing the role of AI in providing learning support, personalized assistance, and access to learning resources (Zawacki-Richter et al., 2019; Chen et al., 2020). The online learning participation dimension was informed by research examining the relationship between AI-supported learning and students' engagement in online learning activities.(Chiu et al., 2021) The material comprehension dimension was based on literature highlighting AI's capacity to provide explanations, feedback, conceptual support, and learning assistance (Hwang & Tu, 2021; Tlili et al., 2023b). The challenges and concerns dimension was developed based on documented concerns

surrounding AI use in education, including accuracy, dependence, critical thinking, and the need for appropriate pedagogical guidance (*Guidance for Generative AI in Education and Research*, 2023b; Kasneci et al., 2023b)

The AI usage dimension measured the extent to which students used generative AI applications, particularly ChatGPT, DeepSeek, and Gemini, in their learning activities. The items covered independent learning, asking questions about learning materials, completing exercises and assignments, preparing for examinations, creating summaries or notes, finding additional learning resources, and checking assignments. The online learning participation dimension measured students' engagement in online learning activities, including responding to instructors, participating in discussions, completing learning tasks, participating in group activities, and maintaining attention and motivation during online learning. The material comprehension dimension measured students' perceptions of AI support in understanding difficult concepts, receiving comprehensible explanations, obtaining relevant examples, reviewing learning materials, preparing for examinations, and learning flexibly. The challenges and concerns dimension assessed students' perceptions of the accuracy of AI-generated responses, difficulty distinguishing correct and incorrect information, potential dependence on AI, reduced thinking effort, technical limitations, contextual limitations, and the continuing need for teacher guidance.

Instrument Development and Validation

The questionnaire was developed through a systematic item-development process. First, the constructs and indicators for the four dimensions were identified from the relevant literature and aligned with the research objectives. Second, the indicators were operationalized into statements representing students' observable experiences and perceptions of generative AI use in online learning. Third, the items were reviewed for clarity, relevance, and consistency with the operational definition of each dimension. The initial questionnaire was then subjected to expert review to evaluate the relevance and clarity of the items before administration to the respondents. Items that required clarification were revised based on the experts' recommendations.

Construct validity was assessed using item-total correlation with a criterion of $r > 0.30$. All 40 items met the established criterion and were retained for the main analysis. Reliability was assessed using Cronbach's Alpha for each dimension. The reliability coefficients were $\alpha = 0.892$ for AI usage, $\alpha = 0.884$ for online learning participation, $\alpha = 0.898$ for material comprehension, and $\alpha = 0.816$ for challenges and concerns, indicating high internal consistency across the four dimensions.

Data Analysis

Data analysis was conducted in two stages. First, descriptive statistics were used to calculate item-level and dimension-level mean scores to identify patterns in students' responses to the four dimensions. The mean scores were subsequently interpreted based on the five-point Likert scale to describe the level of students' perceptions regarding AI use in online learning.

Second, a one-sample t-test was conducted to determine whether the overall mean score differed significantly from the neutral midpoint of the measurement scale. The test value was set at $\mu_0 = 3.00$, representing the midpoint of the five-point Likert scale. The null hypothesis stated that the population mean was equal to 3.00, whereas the alternative hypothesis stated that the population mean differed from 3.00. Statistical significance was determined at $\alpha = 0.05$. In addition to the t-test and p-value, Cohen's d was calculated to determine the magnitude of the difference between the observed mean and the theoretical midpoint. This effect-size measure was included to provide a more substantive interpretation of the statistical finding.

RESULTS & DISCUSSION

Results

This study involved 105 students drawn from a total population of 2,163 active students at Universitas Nahdlatul Ulama Lampung. Descriptive analysis showed that the overall mean score of students' perceived effectiveness of Artificial Intelligence (AI) use in online learning was 3.44, which was higher than the midpoint of the five-point scale ($\mu_0 = 3.00$). This result indicates that students generally perceived AI-supported online learning positively, with responses tending toward the moderate-to-good category. The mean scores for each dimension are presented in Table 1.

Table 1. Mean Scores of Students' Perceived Effectiveness of AI by Dimension

Dimension	Mean	Interpretation
AI Usage	3.40	Moderate–Good
Online Learning Participation	3.38	Moderate
Material Comprehension	3.55	Good
Challenges and Concerns	3.42	Moderate–Good
Overall	**3.44**	**Moderate–Good**

The highest mean score was found in the Material Comprehension dimension (M = 3.55), whereas the lowest mean score was observed in the Online Learning Participation dimension (M = 3.38). The higher score for material comprehension indicates that students perceived AI as particularly useful for supporting individual cognitive learning processes. In contrast, the relatively lower participation score suggests that students perceived a more limited contribution of AI to active engagement in online learning.

At the item level, the highest score among learning-related indicators was obtained for the statement that AI helps students understand difficult learning materials (M = 3.78). This finding indicates that students particularly valued AI for obtaining additional explanations and assistance when encountering difficult concepts. The highest score across the entire instrument was obtained for the statement concerning the need for lecturer guidance (M = 4.32). This result indicates that, despite their positive perceptions of AI, students continued to consider lecturer guidance highly important in the learning process.

One-Sample *t*-Test

A one-sample *t*-test was conducted using a reference value of $\mu_0 = 3.00$, representing the midpoint of the five-point Likert scale. The results showed an overall mean of 3.44, which was significantly higher than the reference value, with $t = 11.18$, $p < 0.001$, and Cohen's $d = 1.09$.

These findings indicate that students' perceived effectiveness of AI-supported online learning was significantly higher than the midpoint of the measurement scale. The large effect size (Cohen's $d = 1.09$) indicates a substantial difference between the observed mean and the theoretical midpoint. However, this result should be interpreted as evidence of positive perceived effectiveness, rather than as evidence of the causal or objective effectiveness of AI. The one-sample *t*-test demonstrates that students' average perception was significantly above the scale midpoint, but it does not establish that AI directly caused improvements in academic achievement or learning outcomes.

The four dimensions also showed mean scores above the scale midpoint, with Material Comprehension obtaining the highest mean (M = 3.55) and Online Learning Participation obtaining the lowest mean (M = 3.38). This pattern suggests that students perceived AI as more beneficial for individual cognitive learning activities than for increasing active participation in online learning.

Gender-Based Difference Test

An independent samples t-test was conducted to examine differences in AI effectiveness based on gender. The analysis revealed no significant differences between male and female students ($p > 0.05$). Therefore, the effectiveness of AI use in online learning was perceived relatively equally across both groups of respondents.

Discussion

The findings indicate that students at Universitas Nahdlatul Ulama Lampung generally perceived AI-supported online learning positively. The overall mean score of 3.44 was significantly higher than the scale midpoint of 3.00, with a large effect size (Cohen's $d = 1.09$). However, the statistical result should be interpreted carefully. The one-sample *t*-test establishes that students' perceptions were significantly above the neutral midpoint, but it does not demonstrate that AI causally improves academic achievement. Therefore, the findings are more appropriately understood as evidence of students' perceived effectiveness of AI in supporting online learning.

Theoretical Interpretation: AI as Cognitive Support

The highest dimension was Material Comprehension (M = 3.55), suggesting that students perceived AI as particularly useful for supporting cognitive learning processes. In this study, students reported using generative AI applications such as ChatGPT, DeepSeek, and Gemini to obtain explanations, search for additional learning resources, summarize materials, check assignments, and assist in understanding difficult concepts.

From a theoretical perspective, these findings support the conceptualization of AI as a form of cognitive support or scaffolding in online learning. Generative AI can provide alternative explanations, contextual examples, summaries, and immediate responses when students encounter learning difficulties. Such functions can support students' self-regulated learning by allowing them to seek additional explanations according to their individual learning needs.

This finding is consistent with previous research indicating that AI can support conceptual understanding and self-regulated learning through personalized explanations and rapid feedback.(Chen et al., 2020; Hwang & Tu, 2021; Tlili et al., 2023) Meta-analytic evidence concerning intelligent tutoring systems has also demonstrated positive effects on cognitive learning outcomes.(Ma et al., 2014)

However, the present study differs from research that evaluates AI through objective learning outcomes because it measures students' perceptions rather than actual changes in academic achievement. Therefore, the high score for material comprehension indicates that students perceived AI as helpful for understanding learning materials, but it does not demonstrate that AI objectively increased their academic performance.

Why Did Online Learning Participation Remain Relatively Low?

An important finding was that Online Learning Participation obtained the lowest mean score among the four dimensions (M = 3.38), although the score remained above the midpoint. This finding suggests that students perceived AI as less effective in promoting active participation than in supporting individual understanding.

This result is consistent with previous studies indicating that AI may be more effective in supporting individual cognitive processes than collaborative interaction and social engagement.(Chiu et al., 2021; Tan et al., 2022) At the same time, the finding may appear unexpected because digital technologies are often expected to increase student engagement in online learning.

Several factors may explain why participation remained relatively low. First, the use of AI in this study was primarily oriented toward individual activities, such as finding

learning resources, summarizing materials, understanding difficult concepts, checking assignments, and completing academic tasks. These activities may improve individual learning efficiency without necessarily increasing interaction with lecturers or peers.

Second, the immediate availability of AI-generated responses may reduce students' need to ask questions or participate in online discussions. When students can obtain an explanation independently through AI, they may be less likely to engage in collaborative discussion or seek clarification through classroom interaction.

Third, active participation depends not only on technology availability but also on pedagogical design. AI cannot automatically create meaningful interaction, collaboration, or discussion. These forms of participation require instructional strategies that intentionally engage students in collaborative activities, discussion, reflection, and problem-solving.

Therefore, the relatively lower participation score should not necessarily be interpreted as a weakness of AI. Rather, it suggests a distinction between individual cognitive support and social participation. AI may effectively support students when learning independently, while active participation remains strongly dependent on instructional design and lecturer facilitation.

AI and the Continuing Importance of Lecturer Guidance

Another important finding was the highest score across the entire questionnaire for the statement concerning the need for lecturer guidance (M = 4.32). This result indicates that students continue to perceive lecturers as an essential component of the learning process despite their positive perceptions of AI.

This finding does not necessarily contradict the positive perception of AI. Students may simultaneously perceive AI as useful for obtaining explanations and completing learning activities while recognizing that AI cannot fully replace human pedagogical guidance. AI-generated information may require verification, contextual interpretation, and ethical consideration.

The result is particularly relevant given concerns regarding inaccurate AI-generated information, cognitive dependency, algorithmic bias, data privacy, and academic integrity. (*Guidance for Generative AI in Education and Research*, 2023b; Williamson & Eynon, 2020) The potential for generative AI to reduce deeper critical thinking when used without appropriate pedagogical integration has also been highlighted in previous research.(Kasneci et al., 2023b; Rizun et al., 2026)

Thus, the high need for lecturer guidance indicates that students perceive AI primarily as a supplementary learning tool rather than a replacement for lecturers. Lecturers remain important for validating information, providing pedagogical direction, facilitating interaction, supporting academic ethics, and developing students' critical and reflective capacities.

Challenges and Concerns in AI-Supported Learning

The Challenges and Concerns dimension obtained a mean score of 3.42, indicating that students recognized both the benefits and limitations of AI. Students expressed concerns about the accuracy of AI-generated answers, the possibility of becoming less active in thinking, technical limitations, and the ability of AI to understand particular contexts.

This finding is consistent with the broader literature emphasizing that the educational benefits of AI must be considered alongside potential risks, including dependency, algorithmic bias, privacy issues, and academic integrity concerns.(*Guidance for Generative AI in Education and Research*, 2023b; Kasneci et al., 2023b; Rizun et al., 2026; Williamson & Eynon, 2020)

The findings also suggest that students do not necessarily perceive AI-generated information as unquestionably correct. Instead, the high score for the need for lecturer guidance indicates that students recognize the importance of human validation. This provides an important educational implication: AI literacy should not focus solely on how to operate AI tools but should also develop students' ability to evaluate, verify, and critically interpret AI-generated information.

Understanding the Difference Between Comprehension and Academic Achievement

A noteworthy finding was the difference between students' perceptions of AI's contribution to understanding materials and its perceived contribution to academic achievement. The statement that AI helps students understand difficult materials obtained a relatively high score (M = 3.78), whereas the indicator related to improvement in academic grades obtained a lower score (M = 3.10).

This finding suggests that support for the learning process does not automatically translate into measurable academic achievement. AI may help students obtain explanations, clarify concepts, and complete learning activities more efficiently, but academic achievement is influenced by multiple factors, including prior knowledge, motivation, learning strategies, assessment characteristics, and students' ability to apply knowledge independently.

Therefore, AI should be viewed as a facilitator of learning processes rather than as a single determinant of academic performance. The distinction is important because the present study measures perceived effectiveness rather than objective academic outcomes.

Comparison with Previous and Contradictory Findings

The findings of this study provide a more nuanced interpretation of previous research. On the one hand, previous studies have reported positive contributions of AI to conceptual understanding, learning flexibility, and task efficiency.(Bond et al., 2021; Crompton & Burke, 2023; Ma et al., 2014) On the other hand, other studies have highlighted concerns regarding cognitive dependency, reduced critical thinking, bias, and academic integrity. (*Guidance for Generative AI in Education and Research*, 2023b; Kasneci et al., 2023b; Rizun et al., 2026; Williamson & Eynon, 2020)

The present findings suggest that these apparently contrasting perspectives can coexist. Students may perceive AI as useful for understanding learning materials while simultaneously recognizing its limitations and risks. This suggests that the educational value of AI is not determined simply by whether students use AI, but by how AI is used, for what learning purposes it is used, and how students evaluate the information generated by AI.

The relatively lower participation score further demonstrates that the benefits of AI are not uniform across learning dimensions. AI may provide stronger support for individual cognitive activities than for social interaction. This finding extends previous discussions of AI-supported learning by highlighting the importance of distinguishing cognitive support from active social participation.

Educational Implications

The findings have several implications for higher education. First, universities should not limit AI integration to providing access to AI technologies. AI implementation should be accompanied by AI literacy programs that teach students how to formulate appropriate prompts, evaluate AI-generated information, identify potential inaccuracies, and use AI ethically.

Second, lecturers should design learning activities that require students to critically engage with AI-generated content rather than simply reproduce it. For example, students

can be asked to compare AI-generated answers with academic sources, identify errors, provide evidence for their judgments, and reflect on the limitations of AI-generated responses.

Third, the relatively low participation score indicates that AI should be integrated into collaborative and interactive learning designs. Lecturers can use AI as a starting point for group discussions, peer evaluation, critical analysis, and reflective activities rather than using it solely as an individual task-completion tool.

Fourth, the high score for the need for lecturer guidance indicates that human pedagogical involvement remains essential. AI integration should therefore follow a human-guided and pedagogically appropriate approach, in which AI augments rather than replaces lecturer expertise and student interaction.

Theoretical and Educational Contribution

The findings contribute theoretically by supporting a multidimensional understanding of perceived AI effectiveness in online learning. AI should not be evaluated solely according to its ability to provide information or assist task completion. Its contribution should also be considered in relation to cognitive understanding, active participation, and the challenges experienced by learners.

Methodologically, the study demonstrates the value of examining these dimensions within a single empirical framework while explicitly distinguishing perceived effectiveness from causal effectiveness. The use of a one-sample *t*-test and effect size provides evidence that students' perceptions are substantially above the scale midpoint, while the interpretation remains appropriately limited to perceived effectiveness.

From an educational-technology perspective, the findings indicate that generative AI functions primarily as a supplementary cognitive learning tool in the context studied. Its perceived contribution is stronger for understanding materials than for promoting active social participation. This distinction provides an important basis for designing AI-supported learning environments in which technological assistance is combined with lecturer guidance, critical thinking, and collaborative learning.

Limitations and Future Research

This study has several limitations. First, the data were obtained through a self-report questionnaire and therefore may be influenced by students' subjective perceptions and response bias. Second, the cross-sectional design provides information about students' perceptions at a single point in time and does not permit causal conclusions regarding the effects of AI on academic achievement.

Third, the study was conducted at a single institution, and therefore the findings should be generalized to other higher education contexts with caution. Fourth, the study measures perceived effectiveness rather than objective learning outcomes. Future studies should employ longitudinal or experimental designs and incorporate objective indicators such as academic achievement, task performance, learning analytics, and actual participation. Such studies would provide stronger evidence regarding whether the perceived benefits of AI translate into measurable improvements in learning outcomes.

Overall, the findings indicate that students at Universitas Nahdlatul Ulama Lampung perceive generative AI positively, particularly as a tool for supporting material comprehension and flexible individual learning. However, its perceived contribution to active participation remains relatively limited. The findings therefore suggest that AI is most appropriately implemented as a supportive and augmentative technology within a lecturer-guided pedagogical framework, rather than as a substitute for human teaching and interaction.

CONCLUSION

This study aimed to examine students' perceived effectiveness of Artificial Intelligence (AI) in online learning at Universitas Nahdlatul Ulama Lampung using a quantitative survey approach. The findings indicate that students perceived AI to be effective in supporting online learning**,** with an overall mean score of 3.44, which was significantly higher than the scale midpoint of 3.00 ($t = 11.18$, $p < 0.001$, Cohen's $d = 1.09$). The highest perceived contribution was found in the material comprehension dimension (M = 3.55), particularly in helping students understand difficult learning materials. In contrast, online learning participation obtained the lowest mean score (M = 3.38), indicating that AI was perceived as less effective in promoting active social participation and interaction. These findings suggest that generative AI functions primarily as a supplementary learning tool that supports students' individual cognitive processes rather than as a substitute for lecturer guidance.

The contribution of this study lies in providing context-specific empirical evidence on students' perceived effectiveness of generative AI in Indonesian higher education through a multidimensional framework encompassing AI usage, online learning participation, material comprehension, and challenges and concerns. The findings highlight an important distinction between AI's perceived contribution to individual cognitive understanding and its relatively limited contribution to active social participation. This distinction provides a basis for understanding that the educational value of AI depends not only on access to the technology but also on how it is pedagogically integrated and guided by lecturers.

The findings have practical implications for higher education institutions seeking to integrate generative AI responsibly into online learning. Universities should support AI integration through appropriate AI literacy, critical evaluation of AI-generated information, academic integrity guidance, and lecturer-led learning activities that promote discussion and collaboration. AI should therefore be positioned as an augmentative and pedagogically guided technology, rather than as a substitute for human teaching and interaction.

Future research should employ longitudinal or experimental designs to examine whether students' positive perceptions of AI translate into measurable improvements in objective academic achievement and sustained participation. Future studies may also incorporate mixed-methods approaches and actual learning-performance data to provide a more comprehensive understanding of the pedagogical, cognitive, social, and ethical implications of generative AI use in higher education.

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