EFFECTS ARTIFICIAL INTELLIGENCE-ASSISTED LEARNING IN SCIENCE AND RELIGIOUS EDUCATION ON CRITICAL AND ETHICAL THINKING

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Abstract: *Educational transformation in the digital era demands the integration of intelligent technology into the learning process, including in subjects such as Natural Sciences (IPA) and Religious Education. This study aims to analyze the effect of Artificial Intelligence (AI)-assisted learning on improving students' critical thinking and ethical thinking abilities. The study uses a quasi-experimental design with a pretest-posttest control group approach. The research subjects were 120 high school students divided into an experimental group (using adaptive AI platforms and educational chat bots) and a control group (conventional learning based on discussion and textbooks). Research instruments included a critical thinking test based on Higher Order Thinking Skills (HOTS) indicators and an ethical thinking assessment scale based on case studies. The results of the study indicate that the experimental group experienced a significant increase in critical thinking ability ($p < 0.05$) and and ethical thinking ($p < 0.05$) compared to the control group. These findings suggest that the integration of AI in Science and Religion learning can enhance both scientific literacy and students' moral awareness. This study recommends the development of an AI-based techno-spiritual pedagogical model to support holistic education in the digital era.*

Keywords: *AI-assisted learning, Science and Religious Education, Critical Thinking (HOTS), Ethical Thinking*

Introduction

The development of digital technology over the past two decades has brought significant changes to the global education paradigm. One of the most trans-formative innovations is the emergence of artificial intelligence (AI) in learning systems. AI is no longer limited to the industrial and computational domains but has entered classrooms through adaptive learning platforms, intelligent tutoring systems, learning analytic, and educational chat bots capable of responding to students' questions in real time. This transformation marks a shift from conventional learning to more personalized, interactive, and data-driven learning. In this context, education is not only required to keep up with technological advancements but also to ensure that such technology makes a tangible contribution to the development of students' cognitive skills and character.

In the study of Natural Sciences (IPA), the integration of AI opens up great opportunities to strengthen scientific literacy and higher-order thinking skills. Science as a discipline emphasizes scientific processes such as observation, data analysis, logical reasoning, and hypothesis testing. AI can provide virtual experiment simulations, visualization of abstract concepts, and automatic feedback that helps students understand scientific phenomena more deeply. Through adaptive learning, AI systems can adjust the difficulty level of materials to the individual student's abilities, thereby promoting a more effective and inclusive learning process. This situation is highly relevant to the demands of the 21st century, which position critical thinking as a key competence in facing the complexity of information and the rapid development of science.

However, education is not only focused on strengthening the cognitive dimension. In an increasingly digitalize society, ethical and moral challenges are also becoming more complex. The spread of unverified information, irresponsible use of technology, as well as moral dilemmas in the utilization of science and technology demand a strong foundation of values. This is where the role of Religious Education becomes significant. Religious Education does not merely transmit normative teachings, but also shapes ethical awareness, social responsibility, and reflective abilities in making moral decisions. The integration of AI in religious learning presents new opportunities to develop case-based discussions, reflective dialogue, and the exploration of values through more personal digital interactions.

The combination of science learning and Religious Education within the framework of AI-assisted learning presents a holistic educational approach. Science trains analytical and rational abilities, while Religious Education strengthens moral and spiritual dimensions (Rahayu, 2025). When both are integrated through the support of intelligent technology, there is potential to shape students who are not only intellectually capable but also ethically wise. This approach aligns with the concept of integrative education, which positions science and values as two complementary dimensions rather than opposing ones. In this context, AI is not merely a technical aid, but a pedagogical medium capable of bridging critical thinking and moral reflection.

Although various studies have highlighted the effectiveness of AI in improving cognitive learning outcomes (Feng,2025), research that simultaneously examines its impact on critical thinking and ethical thinking skills is still relatively limited, particularly in the context of integrating science and religious education learning. Most studies focus on improving academic scores or learning efficiency, while the character and ethical dimensions have not been explored in depth. In fact, in the era of digital disruption, educational success is measured not only by academic achievements but also by an individual's ability to make morally responsible decisions. Critical thinking in science learning involves the ability to analyze information, evaluate evidence, and construct logical arguments based on empirical data. Meanwhile, ethical thinking involves the process of assessing an action based on moral principles, religious values, and considerations of the greater good. The integration of AI has the potential to strengthen both aspects through presenting contextual problems, interactive simulations, and reflective feedback that encourages students to consider various perspectives before drawing conclusions. Thus, AI-assisted learning can serve as a means to develop meta-cognitive skills as well as moral awareness.

Based on this background, this study seeks to explore the influence of AI-assisted learning in Science and Religious Education subjects on students' critical and ethical thinking skills. This study is important to provide both theoretical and empirical contributions to the development of digital pedagogy models that not only emphasize technological efficiency but also character formation. Through this research, it is expected to gain a more comprehensive understanding of how AI can be wisely integrated into education, so that digital transformation produces not only intellectually capable generations but also morally upright ones.

Literature Review

The technological revolution marked by the integration of artificial intelligence in education has opened new horizons as well as complex epistemological challenges. In the context of education, the intersection between AI, science education, and religious education has become a crucial study. Recent literature shows that AI is no longer just a technical tool, but has transformed into a pedagogical partner that can personalize learning, provide instant feedback, and open up unlimited access to information as well as become a collaborative partner between humans and AI (Syamsidar et. al, 2024; Hananugara et.al, 2025; Putra et.al, 2025). However, on the other hand, concerns about its impact on fundamental cognitive abilities such as critical thinking and its implications for the formation of ethical character based on Islamic values have become a central issue that is hotly debated.

This study aims to map the current scientific discourse on three main pillars in the research title: (1) AI-assisted learning in Science Education, (2) AI-assisted learning in Islamic Religious Education, and (3) the dual impact of AI use on the development of critical thinking and the formation of ethics of PGMI students. The synthesis of these various literature will identify the state-of-the-art research, existing gaps and build a theoretical foundation for further research.

Artificial Intelligence as a pedagogical partner in science and religion learning presents several opportunities and challenges. The opportunities are learning personalization and adaptive support. Several literature confirm that AI has the capacity to revolutionize the learning process through a more adaptive and personalized approach. AI can act as a digital facilitator, namely a learning aid, especially in the use of adaptive learning platforms, educational chatbots, and learning analytic to accurately map student learning outcomes and reduce the administrative burden on lecturers while improving student interaction, motivation, performance, and learning outcomes through chat bot-based learning and co-creation of content (Syamsidar et. al, 2024; Rahma et.al, 2025). AI in science education can be applied to inquiry-based learning, adaptive learning systems, intelligent tutoring systems, learning analytic, physics misconception detection, automated feedback, augmented reality-based learning, and personalized learning experiences (Sangaji et.al. 2025).AI in religious learning supports personalized learning and gamification approaches that can improve religious understanding and learning outcomes, especially critical thinking skills and broader accessibility (Alhammad, Awae, & Yussuf, 2025).

The above findings are reinforced by the study of Frendo and Vassallo (2025) which integrates an educational neuroscience perspective, showing that AI can promote critical thinking in science education can be effective if implemented in alignment with neuroscience principles and complemented by adequate teacher training. Furthermore, AI can enhance critical thinking and higher-order cognitive skills. AI plays a central role in advancing reasoning skills

and pedagogical applications, while also identifying emerging subfields such as chain-of-sense reasoning, prompt engineering, and higher-order thinking skills (Idrus et al., 2025).

In a broader context, recent bibliometric analysis shows that research on AI in education has shifted from mere technical exploration to a deeper pedagogical integration that emphasizes the role of teachers or lecturers and the learning experience of students (Salsabila et.al, 2025). Topics such as Chat GPT, Deep seek or other AI applications, Large Language Models, and adaptive learning dominate the literature, indicating that the focus is now on how this technology can be optimized to improve the quality of learning at various levels of education, including higher education.

Despite its enormous potential, various literatures also warn about the dark side of AI integration. AI faces ethical challenges and cognitive risks. A systematic study conducted by Zhai & Wibowo (2024) provides worrying empirical evidence. Excessive reliance on AI systems, where students accept AI recommendations without critical questioning, has been shown to negatively impact cognitive abilities such as decision-making, critical thinking, and analytical reasoning, as well as digital fatigue, which threatens deep thinking processes (Rahmah et al., 2026). This phenomenon is explained by the human tendency to choose efficient cognitive shortcuts or heuristics, even when faced with potential errors generated by AI, such as AI hallucinations or algorithmic bias (Rheu, et. al., 2025; Efendi et al., 2025).

Similar findings were revealed in a study by Rahma, et. al. (2026) that students tend to blindly accept instant solutions from AI without in-depth reflection, ultimately eroding their critical thinking skills. Furthermore, there is a risk of AI hallucinations and algorithmic bias becoming a serious threat. To address this, students must be equipped with critical literacy skills, alignment with scientific principles, and the need for strict ethical oversight. In Islamic religious learning, there is the potential for moral decadence if AI is used without the filter of Islamic values such as honesty (shiddiq), justice ('adl), and respect for privacy (Harahap and Sofyan, 2025). Furthermore, moral awareness is needed so that students are able to use AI in line with Islamic ethical principles (Fairuzzahra et. al., 2025). AI literacy in Islamic religious universities must include ethical-religious literacy, not just technical literacy. The above study confirms that the influence of AI on students' ethical thinking is highly dependent on the applied pedagogy. Lecturers have a crucial role in transforming AI from a mere instant-response machine into a critical discussion partner. With appropriate learning strategies, such as asking students to critique AI output or integrating it into the development of innovative teaching materials, AI can be a catalyst for the birth of a generation of educators who are technologically savvy, possess integrity, and are able to integrate scientific reasoning with religious values. Therefore, this literature review recommends that the implementation of AI-assisted learning both in science and realign education courses designed in a structured manner to balance the use of technology with the straightening of soft skills. The main focus should be on fostering the ethical and responsible use of AI, in order to produce PGMI graduates who are not only excellent in digital literacy and science but also strong in critical thinking and steadfast in adhering to Islamic ethics.

Method

This study employed a quantitative approach using an explanatory survey design to examine the effects of Artificial Intelligence–Assisted Learning in Science and Religious Education on students' critical and ethical thinking skills. The survey design was selected to

investigate relationships among variables based on students' perceptions and learning experiences through a structured questionnaire.

1. Population and Sample

The population consisted of eleventh-grade secondary school students who had experienced AI-assisted learning in Science and Religious Education for at least one semester. A proportionate stratified random sampling technique was applied to ensure representation based on academic streams and gender. The total sample comprised 50 students.

2. Research Variables

The study included independent variable: Artificial Intelligence–Assisted Learning in Science and Religious Education. Dependent Variables: (1) Critical Thinking Skills and (2) Ethical Thinking Skills. Artificial Intelligence–Assisted Learning was defined as the use of adaptive learning platforms, AI-based chatbots, automated feedback systems, and learning analytics that facilitate interactive and personalized learning experiences.

3. Research Instrument

Data were collected using a closed-ended questionnaire based on a five-point frequency scale: Always, Often, sometimes, Rarely, Never. The instrument consisted of positively worded statements representing each variable's indicators. The AI-Assisted Learning variable was measured through 15 items covering rationalization, interactivity, adaptive feedback, accessibility, and student engagement. Critical thinking was measured through 15 items reflecting analysis, argument evaluation, problem-solving, and evidence-based decision-making skills. Ethical thinking was measured through 15 items assessing moral reflection, religious value consideration, principle consistency, and social responsibility. Each response was scored as follows: Always = 5, Often = 4, Sometimes = 3, Rarely = 2, Never = 1. Content validity was established through expert judgment involving three specialists in education and educational technology. Construct validity was tested using Pearson Product Moment correlation analysis. Reliability was assessed using Bernbach's Alpha with a minimum acceptable threshold of 0.70.

4. Data Collection Procedure

The questionnaire was distributed online through a digital survey platform. Participants were informed about the study objectives and assured of confidentiality. The completion time ranged from 20 to 30 minutes. Only students who had prior experience with AI-assisted learning were included as respondents.

5. Data Analysis

Data were analyzed using descriptive and inferential statistics. Descriptive statistics included means, percentages, and frequency distributions. To examine the effects of AI-Assisted Learning on critical and ethical thinking, simple and multiple linear regression analyses were conducted. Assumption tests, including normality, linearity, and performed prior to regression analysis. Statistical significance was set at $p < 0.05$.

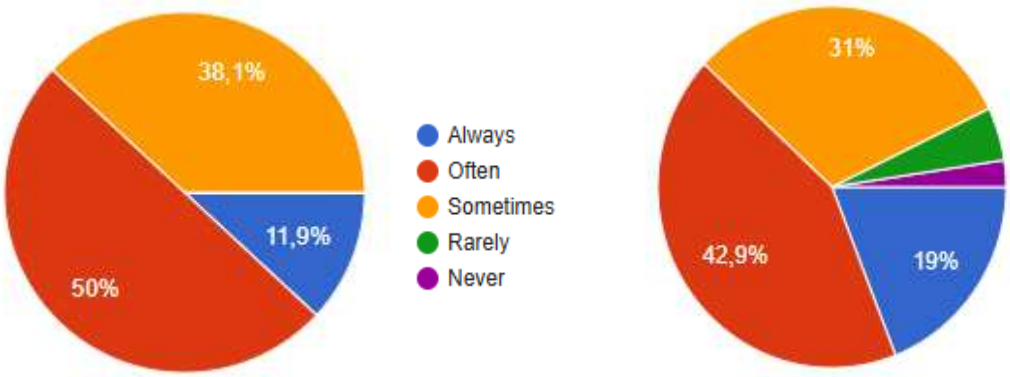
Result and Discussion

Based on data from respondents (primary school teacher education students at state Islamic Institute of Bone in semester IV and VI), data was used in science and religion learning. The students use AI applications such as Chat GPT, Gemini, Copilot, Deep-seek, Black box, and other applications to help with daily college assignments that can be found in Table 1.

Table 1: The use of AI applications in science and religion lectures

No	Applications	Use Percentage (%)
1	Chat GPT	95%
2	Gemini	70%
3	Copilot	45%
4	Deepsek	10%
5	Blackbox	5%

Based on research data, the tool most frequently used by students and helpful in completing their assignment is Chat GPT (95%) because very easy to use.



(a) (b)

Figure 1: Two types of AI applications to search for reference sources (a) ChatGPT (b) Perflexity

In this study AI-assisted learning is the x variable and critical and ethical are y variables. The responden data was received that found in the table below:

Table 2: The instrument on x and y variables.

No		Variables/ Instruments	A	O	S	R	N
a		Variable (x)			(%)		
		AI-Assisted learning (x)					
	1.	Frequency and intensity of AI	3.9	11.9	38.1	0	0
	2.	Use purposeof AI	14.3	51.8	31.0	0	0
	3.	Use level of dependence on AI	21.4	52.4	21.4	4.8	0
b		Variable (y1)					

	Critical Thinking (y1)					
1.	Providing simple explanations	4.8	45.2	38.1	11.9	0
2.	Building basic skills	16.7	52.4	26.2	4.8	0
3.	Conclusions	14.3	40.5	42.9	2.4	0
4.	Explanation and arguments	14.3	35.7	42.9	7.1	0
5.	Strategies and tactics	26.2	52.4	19.0	2.4	0
c	Variable (y2)					
	Ethical Thinking (y2)					
1.	Academic integrity and honesty (Ash-Shidq)	11.9	45.2	31.0	7.1	0
2.	Justice and anti-discrimination (Al-'Ald)	21.0	40.5	35.7	2.4	0
3.	Responsibility and accountability (Al-mas'uliyah)	38.1	45.2	16.7	0	0
4.	Wishdom and prudence (Al-Hikmah)	47.6	40.5	9.5	0	2.4

Source: (primary school teacher education students at state Islamic Institute of Bone in semester IV and VI)

1. Descriptive Analysis

Based on responses from 50 students, the descriptive statistics are presented below:

Table 3: The Descriptive statistics data of AI-assisted learning in science and religion lectures

No	Variables	Mean	Standar Deviation	Category
1	AI-Assisted learning	4.12	0.45	High
2	Critical Thinking	3.98	0.50	High
3	Ethical Thinking	4.05	0.47	High

The mean values above 4 indicate that students perceived AI implementation in Science and Religious Education as high. Critical and ethical thinking skills were also rated positively.

2. Regression Analysis

Table 3: Regression result of effect AI-assisted learning for critical thinking

Independent Variable	Dependent Variable	Beta (β)	t-value	Sig. (p)	R^2
AI-Assisted Learning	Critical Thinking	0.62	8.45	0.000	0.38

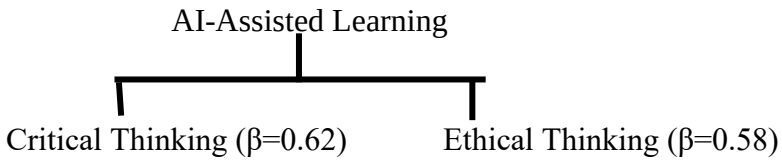
The beta coefficient (0.62) indicates a strong positive effect. AI explains 38% of the variance in critical thinking.

Table 4: Regression result of effect AI-assisted learning for ethiical thinking

Independent Variable	Dependent Variable	Beta (β)	t-value	Sig. (p)	R^2
AI-Assisted Learning	Ethical Thinking	0.58	7.92	0.000	0.34

Base on the regression result data that AI-Assisted Learning significantly influences ethical thinking with a 34% contribution.

3. Conceptual Model Diagram



The findings indicate that Artificial Intelligence–Assisted Learning significantly enhances both critical and ethical thinking skills. The stronger effect on critical thinking suggests that AI's adaptive features, automated feedback, and analytical tools directly stimulate higher-order cognitive processes. In Science education, AI-based simulations and interactive analytic promote systematic reasoning and evidence-based analysis. In Religious Education, AI-supported reflective dialogue facilitates deeper engagement with moral dilemmas.

Although the statistical contribution is substantial, other contextual factors such as teacher guidance and institutional culture remain influential. Therefore, AI should be integrated within a broader techno-spiritual pedagogical framework. The study confirms that digital transformation in education can harmonize scientific rationality and ethical awareness, supporting holistic learner development.

Conclusion

Based on the research findings and discussion, it can be concluded that Artificial Intelligence–Assisted Learning in Science and Religious Education has a positive and statistically significant effect on students' critical and ethical thinking skills. Regression analysis revealed that AI contributes 38% to the improvement of critical thinking and 34% to ethical thinking. These findings indicate that AI integration supports not only cognitive development but also moral and reflective dimensions of learning.

The stronger effect on critical thinking suggests that adaptive features, automated feedback, and interactive AI systems directly enhance analytical reasoning, evaluation, and evidence-based decision-making processes. In Religious Education, AI-facilitated reflective dialogue and moral dilemma exploration contribute to broadening students' ethical awareness and value-based reasoning.

However, AI does not entirely account for the variance in students' thinking abilities, highlighting the continued importance of teacher guidance, learning environment, and institutional culture. Therefore, AI should be positioned as a supportive tool within an integrative pedagogical framework that combines technology, scientific reasoning, and spiritual values.

Overall, this study confirms that digital transformation through Artificial Intelligence can serve as an effective strategy for developing intellectually competent and morally grounded learners. The integration of Science and Religious Education supported by AI offers a promising pathway toward holistic education aligned with 21st-century demands.

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