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Research Article

Role of AI in Enhancing Critical Thinking in Science Education: Challenges and Opportunities for Science Instructor

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ABSTRACT

The integration of artificial intelligence (AI) in education has the potential to revolutionize teaching and learning, particularly in the development of students' critical thinking skills. This study explores science instructors' familiarity, perceptions, and experiences with using AI to enhance students' critical thinking skills, as well as the level of institutional support for AI integration in teaching. A quantitative survey was conducted among 20 science instructors from higher education institutions in Isabela, Philippines. The findings reveal that while instructors acknowledge AI's potential to improve educational outcomes, there is a significant gap in formal AI training and literacy among educators. Positive correlations were found between AI literacy, AI integration, and critical thinking development, suggesting that as AI literacy increases, AI integration and enhancement of critical thinking skills also increase. Regression analysis identified AI integration as a significant predictor of critical thinking development. Challenges remain in the effective implementation of AI, including concerns about overreliance on AI-generated responses and the need for clear assessment guidelines. Interestingly, years of teaching experience did not significantly influence participants' AI literacy, perceptions, or integration. This study highlights the importance of developing comprehensive AI literacy programs for educators and integrating AI into curriculum structures to balance AI-enhanced learning with human-centered pedagogy. These findings emphasize the need for thoughtful implementation and ongoing research to effectively leverage AI in promoting critical thinking skills in science education.

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Introduction

AI technologies are fundamentally transforming education by reshaping teaching and learning across various disciplines and have notably impacted science. AI offers personalized learning experiences, enables adaptive learning environments, and enhances knowledge management. In science education, AI applications such as chatbots like ChatGPT provide instant feedback and support critical inquiry, fostering deeper engagement between students and scientific concepts (Dogan et al., 2023; (王梦倩) and (郭文革), 2023). AI-powered simulations allow students to interact with complex scientific models, providing experiential learning opportunities that promote critical thinking and critical thinking skills (Ruano-Borbalán 2025). Additionally, AI facilitates knowledge management through intelligent tutoring systems that adapt to individual learning paces, ensuring that students receive customized educational content tailored to their needs (Gaitantzi & Kazanidis, 2025; Petrea & Vieriu, 2025). These technologies contribute to improved academic outcomes, although challenges such as data privacy concerns and the risk of overreliance on AI remain unresolved (Vieriu and Petrea, 2025). Research has shown that AI-assisted tools, particularly ChatGPT, significantly improve critical thinking, self-directed learning, and academic writing. For instance, one study explored the use of ChatGPT in research supervision and found that it enhanced critical thinking among postgraduate students, accelerated research progress, and improved their scholarly development and professional skills. This suggests an evolving model of research supervision in which students become more autonomous, fostering their independence and confidence (Dai et al., 2023). Similarly, a study focusing on self-directed learning evaluated a course named "I Learn with Prompt Engineering," which integrated generative AI tools to foster self-directed learning and enhance academic English proficiency. The results indicated significant improvements in students' autonomous learning abilities and language skills (Mzwri and Turcsányi-Szabo, 2025). Another study highlighted the potential of AI tools to enhance academic writing, pointing out the opportunities and threats posed by technologies such as ChatGPT in terms of the efficiency and authenticity of academic work (Dergaa et al., 2023). However, concerns remain regarding the potential overreliance on AI tools, which could hinder creativity and critical thinking among students. Students and educators are concerned about the quality and bias of AI-generated content, the risk of plagiarism, and the maintenance of academic integrity (Ali et al., 2024; Dergaa et al., 2023). Overreliance on AI could limit the development of essential skills if not complemented by human oversight and creativity (Fawaz et al., 2025). Regarding the research gap among science instructors, there remains a paucity of studies on how instructors perceive, adopt, and implement AI to develop critical thinking skills in science education. A comprehensive investigation is necessary to understand instructors' attitudes and practices regarding AI in educational settings, which could lead to more effective integration strategies and enhanced educational outcomes. The integration of educational technology (EdTech) into Philippine universities has been a growing trend, significantly influenced by initiatives from the Commission on Higher Education (CHED). Post-pandemic, there has been a rapid adoption and adaptation of digital education methods. The pandemic highlighted the need for enhanced digital capabilities as institutions abruptly shifted to online education (Ramos and I, 2022). CHED has been instrumental in advancing educational programs that cater to the demands of a digital economy, focusing on fields such as engineering, IT education, and business (Bustos, 2024). The commission has advocated for the use of learning management systems, such as Google Classroom, which have proven effective in colleges and universities (Oluyinka & Cusipag, 2021). Despite these initiatives, challenges persist, including ensuring equitable access and addressing entrenched

digital divides at various levels (Laufer et al., 2021).

In the Philippine higher education setting, AI adoption and instructor training are still emerging areas. This study focuses on assessing AI literacy among science instructors, their views on AI's role in enhancing critical thinking, the practical challenges they encounter, the frequency of AI usage, and the support provided by institutions for integrating AI into the curriculum. This survey aims to illuminate these aspects, thereby contributing to the ongoing discourse on digital literacy and technology integration in higher education in the Philippines and beyond. The primary aim of this study was to explore science instructors' familiarity, perceptions, and experiences with using AI to enhance students' critical thinking skills, as well as to evaluate institutional support for AI integration in teaching. This research seeks to address five key questions: (1) science instructors' familiarity with AI applications in education, (2) their perceptions of AI's role in fostering critical thinking, (3) challenges faced in integrating AI tools, (4) the frequency of using AI-driven teaching strategies, and (5) the level of institutional support and professional development received for AI integration. By examining these aspects, this study aims to provide valuable insights into the current state of AI adoption in science education and its potential impact on promoting critical thinking skills.

Literature Review

AI Technologies in Education

AI technologies in education, such as chatbots, intelligent tutoring systems, and adaptive learning platforms, have been increasingly integrated into various disciplines to enhance the learning experience. For instance, chatbots such as ChatGPT have gained attention for their ability to provide interactive learning environments and address a wide range of student queries (Rejeb et al., 22024; Livberber and Ayvaz, 2023). Intelligent tutoring systems facilitate personalized learning through adaptive testing and predictive analytics, tailoring educational content to meet individual needs (Wang et al., 2023). Empirical studies have highlighted the benefits of AI-driven personalization in education, including improved student motivation, cognitive skills, and real-time feedback (Wang et al., 22024; Alsagri and Sohail, 2024). However, these technologies also pose challenges, such as concerns over academic integrity, data privacy, and the need for ethical guidelines to manage AI integration effectively (Rejeb et al., 22024; Zhou et al., 2024). Nonetheless, studies suggest that AI has the potential to transform education by providing scalable, personalized experiences and improving access to quality education, thus contributing to educational equity and sustainability (Alsagri and Sohail, 2024; Chalkiadakis et al., 22024)

AI and Critical Thinking Development

The integration of AI technologies in educational settings can significantly enhance higher-order thinking (HOT) skills in students. AI literacy, particularly prompt engineering, plays a pivotal role in fostering critical thinking skills by enabling students to elicit specific responses from AI systems, thus enriching their educational experience (Walter, 2024). In a study exploring the impact of digital game-based AI chatbots, it was found that these tools could improve students' academic performance and engagement in problem-solving and computational thinking. The experimental group, which used a digital game-based AI chatbot, performed better in these areas than those who used a traditional AI chatbot, although there was no significant difference in creativity (Xu et al., 2024). Another approach, integrating augmented reality and the AI of things (AIoT), has been shown to positively influence computational thinking by immersing students in practical problem-solving scenarios, thus enhancing their application planning and design skills (Lin et al., 2021). Meta-analyses of AI's influence on HOT skills confirm a medium positive effect, suggesting that AI technologies within instructional settings enhance students' HOT skills by about 9.3%. This effect is moderated by factors such as the country, publication year, and the specific type of AI tool used (Dibek et al., 2024). However, there are potential downsides, particularly related to cognitive offloading. Frequent reliance on AI tools can negatively correlate with critical thinking abilities, as people may become overly dependent on these technologies for cognitive tasks

(Gerlich, 2025). This underscores the importance of using AI technologies to complement rather than replace traditional cognitive skill development. Comparative studies between AI-supported and traditional methods reveal that while AI tools can effectively foster critical thinking and other higher-order skills, their impact is contingent on their integration into the education system (Celik et al., 2024). For instance, AI-powered tools, such as chatbots and intelligent tutoring systems, promote skills such as collaboration, communication, and problem-solving within educational environments.

AI in Science and Physics Education:

AI-powered simulations play a crucial role in enhancing the understanding of abstract physics concepts such as kinematics and electromagnetism. These simulations offer interactive and visual experiences, making complex topics more accessible to students and enhancing their understanding of the subject. AI technologies incorporate principles from fundamental physics to create more robust learning tools, as seen in initiatives such as the IAIFI, which aim to fuse AI with deep physics concepts (Thaler et al., 2024). Additionally, AI integration in training and educational contexts, such as sports, highlights the potential for simulation and modeling to improve teaching outcomes by offering personalized and innovative learning approaches (Wei et al. 2021). Intelligent tutoring systems have been assessed for their effectiveness in STEM education. A meta-analysis found that interventions such as project-based learning significantly enhance STEM learning outcomes, with informal project-based models yielding moderate improvements compared to traditional settings (Santhosh et al., 2023). Similarly, STEM enactment in Asian education systems has demonstrated moderate effectiveness in improving students' learning achievements, indicating the universal benefits of STEM approaches (Wahono et al., 2020). The integration of specific strategies and technologies in STEM education programs can have varying effects on cognitive skills and academic performance, suggesting that optimizing these programs can lead to substantial educational benefits (Chen et al., 2025).

Philippine Higher Education Context of AI Intelligence

The integration of digital and AI literacy in Philippine higher education has been a topic of increasing focus as educators and policymakers have recognized the transformative potential of these technologies in the academic sector. In the context of the Commission on Higher Education (CHED) in the Philippines, there has been an ongoing discussion about enhancing AI literacy among university students. This involves equipping students with the necessary digital skills to effectively engage with AI technologies in various settings, including academic, professional, and personal, thus preparing them for future academic pursuits and career opportunities (Jr and Corpuz, 2022 ; Ng et al., 22023) Local case studies, such as the evaluation of research productivity in a state university in Central Luzon, highlight the infrastructural and cultural challenges and enablers of the Philippine higher-education system. This study indicates that while the university has a commendable research citation record, there is a notable disparity in terms of publication in CHED-accredited journals, suggesting a need for stronger institutional support and research collaboration (Corpuz, Jr. and Corpuz, 2022).

Specifically, the global trend of developing AI curricula mirrors the Philippines' efforts to foster AI literacy. However, various barriers, such as inadequate access to resources and the need for professional development among educators, hinder the effective integration of AI and digital technologies into curricula (Morales et al., 2021). Furthermore, discussions on AI literacy in higher education also emphasize the importance of not just theoretical knowledge but also practical skills such as prompt engineering and critical thinking, which are crucial in maximizing the benefits of AI technologies while mitigating potential risks. This is evident from analogous studies conducted in other countries, which point to the need for a holistic approach to AI literacy education involving interdisciplinary collaboration and engagement (Bian et al., 22024; Walter, 2024). The development of AI literacy in Philippine universities requires comprehensive policy support, infrastructural improvements, and cultural shifts towards integrating innovative technologies into

education. This necessitates a collaborative effort among educators, policymakers, and the academic community to address the challenges and leverage the opportunities associated with digital and AI technology in higher education.

Methods

Research Design

The research design of this study employed a quantitative survey approach to assess AI literacy, prompt engineering competency, and the integration of AI tools to foster critical thinking among science teacher educators. Specifically, a descriptive correlational design was used to analyze the relationships between AI adoption, instructional strategies, and perceived institutional support.

Research Participants

The research participants, who were science instructors from higher education in Isabela, explained and described their experiences, knowledge, and practices related to AI literacy, prompt engineering competency, and AI tool integration in teaching. These participants provided firsthand accounts and insights into how they understood, utilized, and incorporated AI technologies into their science instruction. Their explanations and descriptions offer valuable data on the current state of AI adoption among science educators within this specific university setting and the impact of these technologies on critical thinking instruction in higher education.

Research Instrument

The primary data-collection instrument was a 40-item, five-point Likert-type questionnaire (1 = Strongly Disagree to 5 = Strongly Agree) directly adopted from Anselmo et al. (2025) a 40-item Likert-type questionnaire adopted from Anselmo et al.. (2025). Cultivating 21st-Century Skills: A Comparative Study of Critical Thinking Development Across Higher Education Disciplines. This validated tool measures four constructs—AI Literacy, Critical Thinking Development, Technology Integration in Pedagogy, and Institutional Support—grounded in the Delphi Report, Paul and Elder's Critical Thinking Framework (2001), the TPACK and SAMR models, and the Community of Inquiry Framework. Its prior validation (overall Cronbach's $\alpha = .94$; subscales $\alpha = .88$–$.92$) ensured strong content and internal consistency for capturing nuanced insights into instructors' AI-related competencies and experiences.

Research Locale

The research location for this study was higher education in Isabela,Philippines. The study targeted science instructors across various campuses of the institution. This location was chosen to allow a focused examination of AI literacy, prompt engineering competency, and AI tool integration among science instructors in a specific university setting. This approach enabled the researchers to gather data from diverse groups of science educators while maintaining a controlled institutional environment. This study provides valuable insights into AI adoption and its impact on critical thinking instruction in higher education institutions.

Data Gathering Procedure

The data-gathering procedure used in this study involved several steps, as follows. First, researchers must identify and select a representative sample of participants from the target population. Informed consent was obtained from all participants. Researchers then administered carefully designed surveys or questionnaires to collect relevant data on the variables of interest. These instruments should be validated and pilot-tested in advance to ensure reliability. Trained observers conducted structured observations of all components using standardized protocols. If interviews are part of the methodology, researchers conduct semi-structured interviews with key informants to collect data. All data collection sessions were scheduled at convenient times and locations for participants to attend. The researchers maintained detailed field notes and recordings throughout the study. Finally, all gathered data were securely stored and organized in preparation for analysis, and the participants' confidentiality was strictly protected. This systematic approach will help ensure the collection of high-quality relevant data to address the research question.

Data Analysis Procedure

Demographic and professional profile variables (age, gender, civil status, educational attainment, years of experience, grade level taught, and e-learning training) were summarized using frequency and percentage. Core construction-learning adoption, professional development, personal growth, and 21st-century competencieswill be described with arithmetic means and standard deviations, and the internal consistency of each multi-item scale will be checked via Cronbach's alpha ($\alpha \geq .70$ acceptable). Pearson's correlation analysis will be used to assess the strength and direction of bivariate relationships among these constructs, and, where appropriate, multiple regression will be used to identify which adoption and development variables significantly predict 21st-century competencies. To examine profile-based differences (e.g., by age group, years of experience, and educational attainment), a one-way ANOVA will be conducted, with Tukey's HSD post-hoc tests applied following any significant omnibus F-tests. All inferential statistics will use a two-tailed significance threshold of $\alpha = .05$.

Result and Discussion

from the investigation of science instructors' familiarity with and perceptions of AI integration in education, particularly in relation to the enhancement of students' critical thinking skills. This section also explores instructors' practical experiences in implementing AI tools,the frequency with which AI-driven strategies are employed, and the extent of institutional support and professional development available to facilitate such classroom integration. By analyzing these dimensions, the findings offer a comprehensive understanding of the current landscape of AI adoption in science instruction and highlight the opportunities and challenges associated with leveraging AI to support critical thinking in educational settings.

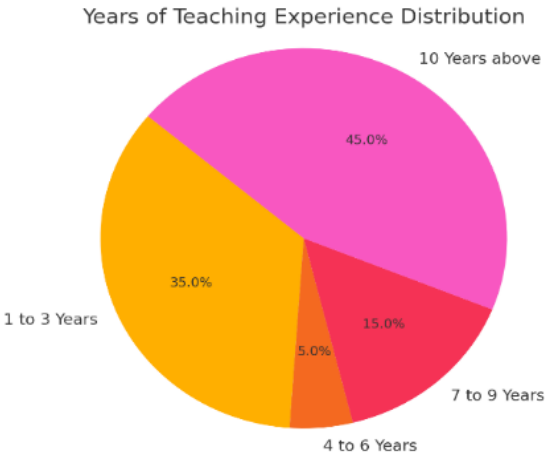

Figure 1

The demographic profiles of the respondents in terms of years of teaching experience revealed a diverse range of professional backgrounds. A significant portion of the respondents (45.00 %) had more than ten years of teaching experience, indicating a strong presence of seasoned educators in the sample. This was followed by 35.00% of respondents who had been teaching for one to three years, suggesting a notable representation of early career teachers. Meanwhile, 15.00% of the respondents had seven to nine years of experience, and a smaller group (5.00 %) had four to six years of teaching experience. These findings suggest that while the majority of respondents are experienced, there is also a meaningful proportion of newer educators, providing a balanced perspective across different stages of teaching careers.

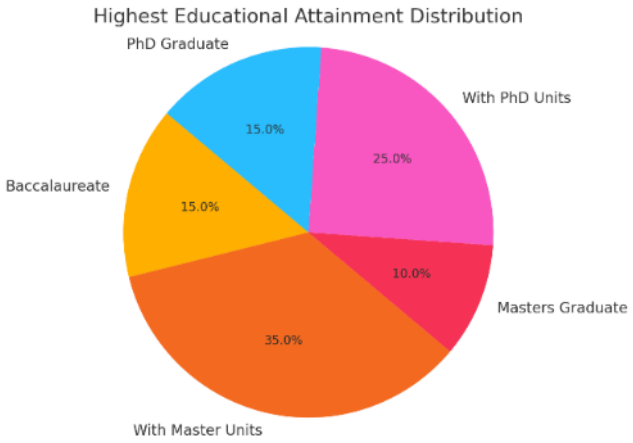

Figure 2.

The respondents had diverse educational backgrounds. Those with Master Units formed the largest group at 35% (seven respondents), followed by PhD Units at 25% (five respondents). Baccalaureate degree holders and PhD Graduates each comprised 15% (three respondents), while Master's graduates made up 10% (two respondents). Half of the respondents pursued education beyond their master's degree, demonstrating high academic achievement.

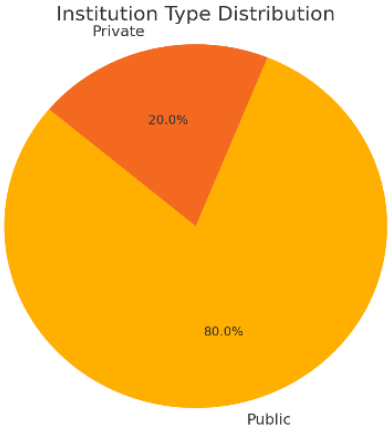

Figure 3

The demographic profile of the respondents in terms of Institution Type reveals that most participants were from public institutions. Specifically, 16 respondents (80% of the sample) were affiliated with public institutions. In contrast, only four respondents, accounting for 20% of the total, were associated with private institutions. This distribution indicates a significant predominance of public institution representation in the study, with a 4:1 ratio of public to private institution respondents. The total sample size for this demographic category was 20 respondents, providing a comprehensive overview of the study population's institutional landscape.

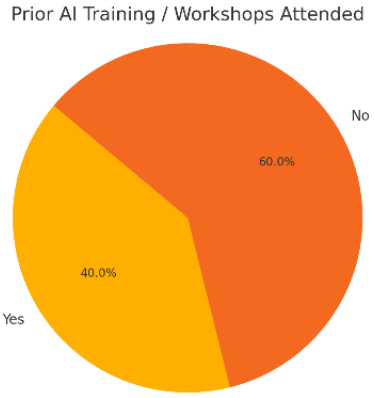

Figure 4 The demographic profile of respondents regarding prior AI training or workshops revealed that a minority of participants had previous exposure to AI-related education. Specifically, 40% of respondents (eight individuals) reported having attended AI training or workshops in the past. In contrast, the majority (60% of respondents, 12 individuals) indicated that they had not participated in any AI-related educational activities prior to the study. This distribution suggests that more than half of the participants lacked formal AI training experience, potentially influencing their perspectives and knowledge of AI topics.

Indicator	Weighted Mean	Interpretation	Standard Deviation
I am familiar with AI-powered educational tools (e.g., ChatGPT, AI simulations, AI-based tutoring systems).	3.85	Agree	1.09
I understand how AI can be used to enhance student learning in science courses.	3.90	Agree	1.02
I am confident in my ability to evaluate AI-generated content for accuracy in science education.	3.25	Average	0.79
I am aware of ethical concerns related to AI use in education (e.g., bias, misinformation).	3.85	Agree	1.09
I have received training in professional development on AI applications in teaching	2.90	Average	1.25
Average	3.55	Agree	

The data presented in Table 1 provide insights into AI literacy among science instructors, revealing both the strengths and areas for improvement in their understanding and application of AI in education. Science instructors demonstrate a strong grasp of AI's potential to enhance student learning in science courses, with the highest mean score of 3.90 (Salhab 2024). This suggests that educators recognize the value of AI in improving the educational outcomes. However, the lowest mean score (2.90 for receiving training or professional development in AI applications in teaching) indicates a significant gap in formal AI education for instructors (Salhab, 2024; Zhao et al., 2022). This discrepancy between understanding AI's potential and receiving adequate training aligns with the findings of other studies. For instance, research has shown that while educators may perceive the importance of AI literacy, there is often a lack of structured curricula and professional development opportunities to support its integration (Velander et al., 2023; Wang & Lester, 2023). The overall "Agree" status on AI literacy among science instructors is encouraging, but it also highlights the need for more comprehensive AI education programs for teachers (Lérias et al., 2024; Zhao et al.,

2022). In conclusion, while science instructors demonstrated a positive attitude towards AI in education, there is a clear need for more structured training and professional development opportunities. This gap between perception and practical knowledge underscores the importance of developing robust AI literacy programs for educators, which can lead to more effective AI integration in science education (Ng et al., 2023; Wijaya et al., 2024).

Indicator	Weighted Mean	Interpretation	Standard Deviation
AI tools help students develop higher-order thinking skills in science subjects.	3.35	Average	0.88
AI can support inquiry-based learning and scientific reasoning.	3.30	Average	0.73
AI-generated explanations enhance students' conceptual understanding of science topics.	3.50	Agree	0.89
AI tools allow for more personalized learning experiences in science education.	3.35	Average	0.88
The use of AI in science education encourages students to engage in analytical discussions	3.35	Average	0.88
Average	3.37	Average	

The data presented in Table 2 regarding the Perceived Role of AI in Critical Thinking Development reveal both promising aspects and potential limitations in the integration of AI in enhancing critical thinking skills in science education. The highest agreement among respondents was that AI-generated explanations could enhance students' conceptual understanding of science topics (M = 3.50, SD = 0.89). This aligns with research suggesting that AI tools can provide personalized and adaptive learning experiences, potentially improving students' understanding of complex scientific concepts (Wang et al. 2022). However, the overall average perception of AI's role in critical thinking development indicates that educators and researchers may still have reservations regarding its effectiveness across all aspects of critical thinking. Interestingly, the lowest agreement was on AI's ability to support inquiry-based learning and scientific reasoning (M = 3.30, SD = 0.73). This finding contradicts some of the potential benefits of AI in education highlighted in previous studies. For instance, Alsagri and Sohail (2024) suggested that AI technologies could revolutionize education by providing scalable, personalized learning experiences. However, this discrepancy might be explained by the concerns raised by Kaczkó and Ostendorf (2022), who pointed out that the pragmatic use of AI tools may compromise the intended dimension of fostering critical thinking.

Relationship	r	Kind of Correlation	p	Decision
AI Literacy → AI Integration	0.524	Moderate Positive Correlation	0.018	Significant
AI Literacy → Critical Thinking	0.680	High Positive Correlation	0.001	Significant
AI Integration → Emotional Connection	0.644	High Positive Correlation	0.002	Significant

Table 3 The provided data indicates significant positive correlations between AI literacy, AI integration, critical thinking, and emotional connection among educators. AI literacy was moderately positively correlated with AI integration (r = 0.524, p = 0.018), suggesting that as AI literacy increases, there is a tendency for greater AI integration in educational settings

(Salhab, 2024; Wijaya et al., 2024). This aligns with findings that higher AI literacy and trust correlate with increased AI dependency among teachers (Wijaya et al. 2024). Additionally, AI literacy demonstrated a strong positive correlation with critical thinking (r = 0.680, p = 0.001), implying that individuals with higher AI literacy tended to exhibit stronger critical thinking skills (Jia & Tu, 2024; Shen & Teng, 2024). Interestingly, AI integration showed a high positive correlation with emotional connection (r = 0.644, p = 0.002). This suggests that as AI becomes more integrated into educational environments, students and educators may develop stronger emotional connections with these technologies (Hashish & Alnajjar, 2024; Su and Yang, 2023). However, it's important to note that excessive reliance on AI can potentially hinder the development of essential 21st-century skills, including critical thinking and problem-solving (Wijaya et al., 2024).

	B	T	Sig.
(Constant)	.961	1.403	.178
AI Integration	.704	3.574	.002

Table 4 The regression results indicate a significant positive relationship between AI Integration and Critical Thinking (Saritepeci & Durak, 2024; Wijaya et al., 2024). The coefficient for AI Integration (B = 0.704) suggests that for every unit increase in AI Integration, there is a 0.704 unit increase in Critical Thinking, holding other factors constant. This relationship is statistically significant (p = 0.002), implying that AI Integration is a reliable predictor of Critical Thinking skills (Jia & Tu, 2024; Saritepeci & Durak, 2024). However, these findings contrast with those of some studies that caution against the unexamined adoption of AI in education. For instance, Al-Zahrani (2024) highlighted concerns about AI potentially hindering critical thinking development. Similarly, Wijaya et al. (2024) suggested that excessive reliance on AI might impede the development of essential 21st-century skills, including critical thinking.

	Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*Interpretation*
AI Literacy Among Science Instructors	Between Groups	1.379	3	.460	.572	.641	Not Significant
	Within Groups	12.851	16	.803			
	Total	14.230	19				
Perceived Role of AI in Critical Thinking Development	Between Groups	.200	3	.067	.121	.946	Not Significant
	Within Groups	8.782	16	.549			
	Total	8.982	19				
Challenges in AI Integration for Critical Thinking	Between Groups	.886	3	.295	.713	.558	Not Significant
	Within Groups	6.626	16	.414			
	Total	7.512	19				
AI Prompt Engineering and Teaching Strategies	Between Groups	.206	3	.069	.152	.927	Not Significant
	Within Groups	7.234	16	.452			
	Total	7.440	19				
Institutional Support & Professional Development	Between Groups	3.035	3	1.012	1.686	.210	Not Significant
	Within Groups	9.597	16	.600			
	Total	12.632	19				

Table 5 presents the results of an Analysis of Variance (ANOVA) examining the relationship between teaching experience and various AI adoption levels. The analysis revealed no significant differences across all measured aspects. For AI Literacy Among Science Instructors ($p = 0.641$), Perceived Role of AI in Critical Thinking Development ($p = 0.946$), Challenges in AI Integration for Critical Thinking ($p = 0.558$), AI Prompt Engineering and Teaching Strategies ($p = 0.927$), and Institutional Support & Professional Development ($p = 0.210$), all p-values exceeded the 0.05 threshold. Consequently, the null hypothesis was accepted for each category, indicating that the Years of Teaching Experience did not significantly influence the level of AI adoption among science instructors. This suggests that factors other than teaching experience may play a more substantial role in determining AI adoption and integration in educational settings than teaching experience.

Summary

This study explored science instructors' familiarity with, perceptions of, and experiences using AI to enhance students' critical thinking skills, alongside institutional support for AI integration in teaching. A quantitative survey was conducted among 20 science instructors in Higher Education in Isabela, Philippines. The findings indicate that while instructors acknowledged AI's potential to improve educational outcomes, there was a notable gap in formal AI training and literacy. Positive correlations were found between AI literacy, AI integration, and critical thinking development. Challenges persist in the effective implementation of AI tools, including concerns about overreliance on AI-generated responses and the necessity for clear assessment guidelines. Regression analysis revealed that AI integration was a significant predictor of critical thinking development. Interestingly, years of teaching experience did not significantly affect AI literacy, perceptions, or integration. This study underscores the importance of developing comprehensive AI literacy programs for educators and integrating AI into curriculum structures to balance AI-enhanced learning with human-centered pedagogy. Science instructors recognize AI's potential of AI to enhance student learning in science courses. A significant gap exists in formal AI training and literacy among educators. Positive correlations were found between AI literacy, AI integration, and critical thinking development. Challenges remain in the effective implementation of AI, including an overreliance on AI-generated responses. AI integration was identified as a significant predictor of critical thinking development through regression analyses. Teaching experience did not significantly influence AI literacy, perceptions, or integration. Comprehensive AI literacy programs and curriculum integration are crucial for balanced AI-enhanced learning.

Conclusion

This study offers valuable insights into the adoption of AI in science education and its potential impact on critical thinking skills. Key findings reveal that science instructors recognize AI's potential to enhance student learning, but there is a significant gap in formal AI training and literacy among educators. Positive correlations were found between AI literacy, AI integration, and critical thinking development, suggesting that as AI literacy increases, AI integration and enhancement of critical thinking skills also increase. AI integration was identified as a significant predictor of critical thinking development through regression analyses. Challenges remain in the effective implementation of AI, including concerns about overreliance on AI-generated responses and the need for clear assessment guidelines. Interestingly, years of teaching experience did not significantly influence the participants' AI literacy, perceptions, or integration. The study highlights the need for comprehensive AI literacy programs and professional development opportunities for science educators, as well as the importance of integrating AI into curriculum structures in a balanced manner. Guidelines and frameworks are needed to effectively assess AI-enhanced learning and critical thinking development. Further research on effective strategies for AI integration across different teaching experience levels would be valuable. This study emphasizes both the promise and challenges of leveraging AI to promote critical thinking in science education, underscoring the

need for thoughtful implementation and ongoing research.

Implications and Recommendation

The implications and recommendations of this study can be categorized into short- and long-term actions, with a focus on practical and policy-oriented measures. Short-term recommendations include implementing immediate safety protocols in high-risk areas, conducting targeted awareness campaigns, and establishing rapid response teams for emergencies. Long-term recommendations include developing comprehensive urban planning strategies that prioritize pedestrian safety, investing in infrastructure improvements such as dedicated pedestrian walkways and improved lighting, and fostering collaboration between government agencies, community organizations, and private sector stakeholders to create sustainable solutions. These recommendations have a strong multistakeholder appeal, addressing the needs of various groups, including pedestrians, city planners, policymakers, and local businesses. However, to enhance the effectiveness of these recommendations, it would be beneficial to prioritize them based on feasibility and urgency, thereby providing a more structured approach for implementation. Additionally, specific timelines and responsible parties for each recommendation should be outlined to ensure accountability and progress tracking.

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