Proceeding of International Joint Conference on UNESA
Homepage: https://proceeding.unesa.ac.id/index.php/pijcu
ISSN: 3032-3762

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Integrating Artificial Intelligence and Deep Learning to Enhance Pedagogical Quality among Muhammadiyah Teachers in Surabaya

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Keywords:
Deep Learning, Artificial Intelligence, Teacher Professional Development, Participatory Action Research

ABSTRACT

This study investigates the implementation and impact of an AI-integrated Deep Learning Training Program for teachers at Muhammadiyah Karang Pilang Schools in Surabaya, Indonesia. Using a Participatory Action Research (PAR) design, the program was conducted from July to September 2025 and involved 40 teachers from four educational levels: elementary, junior high, senior high, and vocational. The intervention aimed to enhance teachers' understanding and application of deep learning pedagogy through artificial intelligence (AI)-based lesson design, classroom implementation, and reflective mentoring. Data were collected using pre- and post-tests, classroom observation checklists, perception questionnaires, and semi-structured interviews. Quantitative results revealed significant improvement in teachers' AI literacy and deep learning knowledge ($t(39) = 14.27$, $p < .001$, $d = 1.75$)*, alongside notable growth in classroom practice and professional self-efficacy. Qualitative findings indicated transformative shifts toward student-centered, technology-enhanced instruction supported by collaborative reflection and mentoring. The study concludes that integrating AI into deep learning pedagogy effectively strengthens teacher capacity, promotes reflective practice, and aligns with Indonesia's* Kurikulum Merdeka *vision for meaningful, autonomous, and future-ready education. Further research is recommended to expand this model across diverse educational contexts to sustain innovation and equity in teacher professional development.*

INTRODUCTION

Indonesia's education system is presently experiencing a significant transformation to align with 21st-century expectations, where critical thinking, creativity, cooperation, and digital competence are essential abilities for contemporary learning (OECD, 2023). Equipping young Indonesians to thrive in a globalized knowledge economy necessitates not only curriculum change but also a fundamental transformation in the design and delivery of education. Thus, the Ministry of teaching, led by Abdul Mu'ti, has underscored the implementation of the Deep Learning model, which advocates for significant, reflective, and student-centered teaching (Kompas, 2024). This paradigm emphasizes fostering learners' cognitive and emotional involvement with content, prompting them to design, assimilate, and meaningfully apply knowledge instead of rote memorization (Biggs & Tang, 2022).

The Deep Learning approach seeks to transcend memorization in favor of conceptual comprehension and reflective investigation. It aims to enable students to investigate, analyze, and generate knowledge through experiential and collaborative learning (Fullan, Quinn, & McEachen, 2018). The notion of Mindful Learning, introduced by Ragoonaden (2015), underscores the importance of awareness, intentionality, and emotional presence in educational situations. These approaches, when integrated, foster profound cognitive processing and metacognitive awareness, enabling students to relate academic knowledge to real-world circumstances and personal significance (Biggs et al., 2022; Ragoonaden, 2015).

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In Indonesia, the Deep Learning model inherently corresponds with the tenets of Merdeka Curriculum, which advocates for the freedom to study (Merdeka Belajar) via project-based, inquiry-driven, and contextualized education (Kemendikbudristek, 2023). This curriculum promotes collaborative design of learning experiences by instructors and students, emphasizing curiosity, relevance, and social involvement. Nonetheless, despite this congruence, the execution of deep learning continues to pose difficulties, particularly in institutions that lack sufficient teacher preparedness, pedagogical innovation, and technology integration.

A salient example is evident at Muhammadiyah Karang Pilang Schools, where educators frequently encounter difficulties in implementing interactive and student-centered pedagogies owing to insufficient exposure to technology-enhanced learning and deep learning concepts. According to Lin and Reigeluth (2019), teacher preparedness and professional autonomy are critical factors in effective pedagogical reform. The execution of deep learning necessitates educators capable of crafting genuine learning activities, meaningfully incorporating technology, and promoting reflection and dialogue instead of depending on traditional instructional methods. Many educators continue to be restricted by inflexible curricular requirements, insufficient professional development, and an evaluation system that emphasizes efficiency rather than substantive learning (Tan et al., 2022).

Notwithstanding these obstacles, the capacity of deep learning to revolutionize Indonesian education is substantial. Studies in various contexts demonstrate that deep learning markedly enhances students' comprehension, engagement, and retention (Biggs et al., 2022; Fullan et al., 2018). It additionally fosters higher-order thinking and socio-emotional development, preparing kids with the adaptability necessary for a swiftly changing global community (Darling-Hammond et al., 2020). With sufficient teacher development and systemic alignment, deep learning can facilitate the realization of the Merdeka Belajar vision—cultivating autonomous, reflective, and internationally capable learners.

Furthermore, the swift advancement of digital technology and artificial intelligence facilitates the incorporation of AI-assisted deep learning, which provides additional opportunities to customize instruction, improve learner engagement, and increase access to quality education, especially in resource-constrained regions (Widyawati, 2023; Holmes et al., 2022). AI-driven educational tools assist educators in creating immersive experiences that foster creativity, cooperation, and self-directed learning—principles aligned with both deep learning and the Kurikulum Merdeka paradigm. This technology integration can mitigate geographical and socioeconomic disadvantages, guaranteeing that all Indonesian students, regardless of urban or rural status, can access transformational and meaningful education.

Implementing the Deep Learning methodology in Muhammadiyah schools can strategically enhance the quality of Islamic-based education while matching with national educational objectives. It can motivate educators to innovate, students to engage in critical thinking, and institutions to operate as ecosystems of continuous learning. This method embodies a comprehensive educational vision in Indonesia: to harmonize academic brilliance, ethical values, and global competence in cultivating a generation prepared to confront the challenges of the 21st century.

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RESEARCH METHOD

This research employed a Participatory Action Research (PAR) methodology, incorporating aspects of community involvement and educational advancement. PAR was chosen for its ability to enable participants to collaborate identify issues, co-design interventions, and assess outcomes within their actual teaching environments (Kemmis, McTaggart, & Nixon, 2014). The project was executed from July to Septembet 2025 in Muhammadiyah Karang Pilang Schools in Surabaya, encompassing four educational tiers: elementary (SD Muhammadiyah 22), junior high (SMP Muhammadiyah 6), senior high (SMA Muhammadiyah 4), and vocational (SMK Muhammadiyah 2).

Subjects

Forty teachers, comprising ten from each school, participated in the study. Participants encompassed a variety of disciplines—English, Science, Mathematics, Social Studies, and Religious Education. The inclusion requirements mandated that teachers (a) have a minimum of two years of teaching experience, (b) exhibit an interest in AI-based learning, and (c) agree to participate in all phases of training and mentorship.

Instruments

Four devices were employed to guarantee data triangulation and validity.

1. AI Literacy and Deep Learning Knowledge Assessment — a 25-item multiple-choice examination evaluating educators' conceptual comprehension of AI applications, deep learning principles, and classroom integration (Cronbach's α = 0.86).
2. Observation Checklist — utilized during classroom mentoring to assess instructors' pedagogical efficacy across five criteria: course design, classroom interaction, technology integration, student involvement, and assessment (inter-rater reliability r = 0.82).
3. Survey on Perceptions and Satisfaction — a Likert-scale (1–5) instrument assessing teachers' self-efficacy, motivation, and perceived utility of the AI deep learning methodology.
4. Interview Guide — semi-structured interviews performed with 12 randomly selected educators to provide qualitative perspectives into the advantages, obstacles, and sustainability of the program.

Data Collection

Data were gathered at three stages: pre-intervention, during implementation, and post-intervention. The program sought to improve educators' skills in Artificial Intelligence (AI)-integrated deep learning pedagogy, in accordance with Indonesia's Kurikulum Merdeka goal for significant and independent learning. The implementation process had six stages:

1. Executed via structured observations and semi-structured interviews to ascertain deficiencies in teachers' AI literacy, pedagogical creativity, and deep learning methodologies.
2. Conducted expert-led courses on AI-driven lesson design, digital resource creation, and advanced learning methodologies.

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3. Educators jointly created lesson plans, instructional materials, and evaluations incorporating AI tools like ChatGPT, Canva, and Quizizz.
4. Participants utilized the generated materials in classrooms with supervision and iterative feedback cycles.
5. Pre- and post-tests were employed to evaluate knowledge enhancement in AI integration and deep learning design.
6. Reflection and Follow-Up: Group discussions pinpointed critical challenges and suggested sustainable approaches for institutional implementation.

Data Analysis

Quantitative data from assessments and surveys were evaluated using paired-sample t-tests to identify significant variations in instructors' knowledge and perceptions pre- and post-training. Effect sizes (Cohen's d) were computed to evaluate the extent of change. Descriptive statistics encapsulated frequency, mean scores, and standard deviations of individuals' replies.

Qualitative data from observations and interviews were subjected to thematic analysis (Braun & Clarke, 2006), encompassing coding, categorization, and pattern recognition to elucidate teachers' reflective experiences and pedagogical reform. The amalgamation of quantitative and qualitative data employed a convergent mixed-method approach, facilitating a thorough comprehension of both quantifiable results and contextual subtleties. The research complied with ethical standards for community-based educational studies, guaranteeing informed consent, anonymity, and voluntary participation of participants.

RESULTS AND DISCUSSION

Quantitative Results

The quantitative data were analyzed to measure teachers' improvement in knowledge, classroom implementation, and perceptions after the AI-integrated deep learning program.

Table 1 Pre- and Post-Test Scores on AI Literacy and Deep Learning Knowledge

Domain	Pre-Test Mean (SD)	Post-Test Mean (SD)	Mean Gain	*t*(39)	*p*	Cohen's *d*	Interpretation
AI Awareness	60.4 (9.8)	85.2 (6.9)	+24.8	13.22	< .001	1.71	Large improvement
Pedagogical Application	56.8 (11.3)	84.7 (8.1)	+27.9	14.56	< .001	1.82	Large improvement
Deep Learning Concepts	59.3 (10.7)	83.5 (7.5)	+24.2	12.47	< .001	1.66	Large improvement
Assessment and Reflection	58.1 (9.5)	83.8 (8.3)	+25.7	13.86	< .001	1.74	Large improvement
Overall Score	**58.7 (10.5)**	**84.3 (7.8)**	**+25.6**	**14.27**	**< .001**	**1.75**	**Highly significant**

The findings of Table 1 indicated a significant enhancement in teachers' conceptual comprehension subsequent to the execution of the training program. The mean pre-test score was 58.7 (SD = 10.5), which rose to 84.3 (SD = 7.8) in the post-test, indicating a mean

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improvement of 25.6 points. Statistical investigation employing paired-sample t-tests validated that this enhancement was very significant ($t(39) = 14.27$, $p < .001$), exhibiting a substantial effect size (Cohen's $d = 1.75$).

Of the four assessed categories, the most significant advancement was observed in pedagogical application (+27.9 points) and assessment and reflection (+25.7 points), demonstrating that the training effectively improved instructors' capacity to incorporate AI tools into instructional design and evaluation. This outcome indicates that organized capacity-building initiatives can successfully convert instructors' theoretical knowledge into practical classroom skills.

Table 2 Observation Scores for Teaching Implementation

Teaching Indicator	Initial Mean (SD)	Final Mean (SD)	Mean Difference	% Improvement	Interpretation
Lesson Planning and Objective Clarity	3.0 (0.7)	4.4 (0.5)	+1.4	46.7%	Improved markedly
Student Engagement and Interaction	2.8 (0.6)	4.3 (0.4)	+1.5	53.6%	Improved significantly
AI Tool Integration and Digital Resources	2.7 (0.8)	4.2 (0.5)	+1.5	55.6%	Improved significantly
Critical and Creative Thinking Facilitation	3.0 (0.6)	4.3 (0.4)	+1.3	43.3%	Improved markedly
Assessment and Feedback Practices	2.9 (0.5)	4.4 (0.4)	+1.5	51.7%	Improved significantly
Overall Mean Score	**2.9 (0.6)**	**4.3 (0.4)**	**+1.4**	**48.3%**	**Substantial improvement**

Table 2 provides evidence of teachers' improved classroom performance after participating in mentoring and hands-on implementation stages. The overall mean score for teaching performance increased from 2.9 (SD = 0.6) during the initial observation to 4.3 (SD = 0.4) in the final session, an improvement of 48.3%.

All five indicators demonstrated positive growth, particularly in student engagement and interaction (+53.6%) and AI tool integration (+55.6%), suggesting that teachers became more capable of designing and facilitating learning experiences supported by technology. During classroom mentoring, most participants were able to employ digital tools such as *ChatGPT* for generating prompts, *Canva* for creating visual learning aids, and *Quizizz* for formative assessment. This shift reflects teachers' increasing confidence in facilitating interactive and student-centered learning environments.

Table 3 Teacher Perceptions of AI-Integrated Deep Learning

Dimension	Pre-Test Mean (SD)	Post-Test Mean (SD)	Mean Gain	$t(39)$	p	Interpretation
Self-Efficacy and Readiness	3.02 (0.54)	4.55 (0.41)	+1.53	12.88	< .001	Significant increase
Pedagogical Usefulness	3.09 (0.48)	4.51 (0.39)	+1.42	11.67	< .001	Significant increase
Satisfaction and Future Intention	3.21 (0.52)	4.50 (0.42)	+1.29	10.92	< .001	Significant increase

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Dimension	Pre-Test Mean (SD)	Post-Test Mean (SD)	Mean Gain	$t(39)$	p	Interpretation
Overall Mean	**3.11 (0.51)**	**4.52 (0.41)**	**+1.41**	**11.83**	**< .001**	**Highly positive perception**

Table 3 substantiate the positive impact of the program. Teachers' overall perception mean score increased from 3.11 (SD = 0.51) in the pre-test to 4.52 (SD = 0.41) in the post-test, showing a significant improvement ($t(39) = 11.83$, $p < .001$). The strongest gains were observed in self-efficacy and readiness (+1.53) and pedagogical usefulness (+1.42), highlighting participants' growing confidence in utilizing AI as a meaningful component of instruction.

In open-ended reflections, teachers reported that AI tools simplified lesson planning, reduced administrative workload, and enhanced creativity in material development. Many participants also expressed optimism that AI-supported deep learning could make teaching more engaging and adaptive to students' needs. This positive perception corresponds with Holmes et al. (2022), who found that teachers' acceptance of AI technologies increases when they perceive the tools as supportive rather than substitutive to their pedagogical role.

Overall, the integration of AI within deep learning pedagogy produced a dual impact—improving teachers' knowledge and practical competence while simultaneously fostering professional confidence and innovation. The results affirm that when teachers are empowered through contextual, collaborative, and reflective training, they can internalize complex pedagogical concepts and translate them into meaningful classroom practices.

Qualitative Results

Next, thematic analysis of interview transcripts and reflection reports produced three dominant themes: (1) Pedagogical Transformation, (2) Technology Empowerment, and (3) Professional Growth and Collaboration.

(1) Pedagogical Transformation

Teachers reported a paradigm shift from teacher-centered instruction toward student-driven inquiry. Many participants described how AI tools enabled them to design contextual, problem-based tasks that encouraged critical and creative thinking. This finding resonates with Fullan, Quinn, and McEachen (2018), who argue that deep learning emerges when learners engage in authentic, reflective, and socially connected activities.

(2) Technology Empowerment

Teachers expressed that using AI platforms such as ChatGPT, Grammarly, and Canva helped them create richer learning materials and automated parts of lesson preparation and assessment. This aligns with Holmes et al. (2022), who emphasize that AI integration can reduce teachers' administrative load and enhance pedagogical creativity when used ethically and strategically.

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(3) Professional Growth and Collaboration
Participants highlighted the importance of mentoring and peer collaboration in sustaining innovation. Through shared reflection sessions, teachers developed stronger professional networks and collective efficacy, echoing findings by Darling-Hammond et al. (2020) that teacher collaboration fosters continuous learning and adaptive expertise.

Discussion
The statistical results demonstrate that teachers' understanding of AI-integrated deep learning significantly improved across all areas. Effect sizes greater than 1.70 indicate large educational impact (Cohen, 1988). Classroom observations confirmed practical application of training outcomes, while perception data reflected high teacher motivation and readiness for sustained implementation. These findings corroborate previous studies (Fullan et al., 2018; Tan et al., 2022; Holmes et al., 2022), suggesting that collaborative, technology-empowered professional learning fosters both pedagogical innovation and sustainable instructional transformation.
Collectively, these findings demonstrate that the AI-integrated Deep Learning Training Program at Muhammadiyah Karang Pilang Schools effectively enhanced teachers' pedagogical capacity and digital literacy. The statistically significant improvements across all domains, coupled with qualitative reflections, indicate a transformation from traditional, teacher-centered approaches toward deep, student-centered learning ecosystems**.**
This outcome reinforces the theoretical foundations of Vygotsky's sociocultural theory, which posits that learning is socially mediated and enhanced through tools, collaboration, and guided interaction. The results also resonate with the Deep Learning Framework (Fullan et al., 2018), emphasizing communication, creativity, collaboration, and character as key drivers of meaningful learning.
By combining technology integration with reflective practice, this initiative illustrates how educational innovation can be effectively localized within Islamic-based institutions such as Muhammadiyah schools. The program demonstrates a sustainable model for professional growth that supports Indonesia's *Kurikulum Merdeka* agenda and global calls for *transformative, equitable, and future-ready education*.

CONCLUSION
This study concludes that the AI-integrated Deep Learning Training Program significantly enhanced teachers' pedagogical knowledge, classroom implementation, and professional confidence at Muhammadiyah Karang Pilang Schools. The integration of artificial intelligence tools within deep learning pedagogy effectively transformed teaching practices from traditional, teacher-centered methods into student-centered and technology-supported environments. Quantitative results indicated a substantial improvement in teachers' AI literacy and understanding of deep learning principles, while qualitative findings revealed increased motivation, reflective capacity, and collaboration among participants. These outcomes affirm that participatory and collaborative professional development models can successfully promote innovation and sustainability in education, particularly within the framework of Indonesia's *Kurikulum Merdeka*. To ensure long-term impact, schools and policymakers should institutionalize continuous mentoring, strengthen collaboration between universities and educational

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institutions, and integrate AI-based deep learning approaches into curriculum design and teacher training programs. Future research is recommended to examine the broader and long-term effects of such initiatives across various educational levels and contexts, thereby advancing equitable and future-ready education in Indonesia.

ACKNOWLEDGEMENT

The authors would like to express their sincere appreciation to Prof. Dr. Nur Hasan, M.Pd., Rector of Universitas Negeri Surabaya, for his continuous support and encouragement throughout the implementation of the Community Service Program. Special thanks are addressed to the Muhammadiyah teachers in Surabaya whose active participation, enthusiasm, and commitment greatly enriched the program's learning outcomes and research process. Their cooperation and dedication made this project possible and meaningful.

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