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ORIGINAL

Smart Teaching in Rural Indonesia: Harnessing AI-Assisted Deep Learning for Teacher Professional Development

Enseñanza inteligente en las zonas rurales de Indonesia: Aprovechamiento del aprendizaje profundo asistido por IA para el desarrollo profesional de los docentes

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ABSTRACT

This study presents an innovative AI-assisted TPD framework that uses Microsoft Copilot and AI-powered lesson plan generators to fully incorporate Indonesia's four core teacher competencies: pedagogy, professionalism, social engagement, and interpersonal development, while applying deep learning principles of joyful, meaningful, and mindful education. Using a mixed-methods approach, this study combined quantitative experimental analysis with qualitative teacher perceptions to evaluate the effectiveness of AI-assisted interventions. Results from an independent t-test showed a significant increase in post-test scores among the experimental group, with a t-value of 17,1 exceeding the critical value of 1,984 (α = 0,05, df = 98), leading to the rejection of the null hypothesis. This indicates that AI-assisted training had a meaningful and statistically significant impact on teacher development. Moreover, AI promotes community-based learning, improves institutional readiness, and encourages educators to think globally while acting locally. Despite these benefits, challenges remain, such as interpersonal disengagement, cultural and pedagogical mismatches, difficulties in curriculum adaptation, the need for prompt engineering skills, and concerns about teacher autonomy. However, the limited duration of the intervention is a constraint, suggesting that long-term engagement is necessary for sustained improvement. Policy efforts should focus on extending training periods and integrating culturally responsive AI pedagogy.

Keywords: Deep Learning; Joyful; Meaningful; Mindful; The 21st-Century Skills.

RESUMEN

Este estudio presenta un innovador marco de Desarrollo Profesional Docente (TPD) asistido por IA que utiliza Microsoft Copilot y generadores de planes de lecciones impulsados por inteligencia artificial para incorporar plenamente las cuatro competencias básicas del profesorado en Indonesia: pedagogía, profesionalismo, compromiso social y desarrollo interpersonal, aplicando al mismo tiempo principios de aprendizaje profundo para una educación alegre, significativa y consciente. Usando un enfoque de métodos mixtos, este estudio combinó análisis experimental cuantitativo con percepciones cualitativas de docentes para evaluar la efectividad de las intervenciones asistidas por IA. Los resultados de una prueba t independiente mostraron un aumento significativo en las puntuaciones del post-test en el grupo experimental, con un valor t de 17,1 que supera el valor crítico de 1,984 (α = 0,05, gl = 98), lo que llevó al rechazo de la hipótesis nula. Esto indica que la capacitación asistida por IA tuvo un impacto significativo y estadísticamente relevante en el desarrollo docente. Además, la IA promueve el aprendizaje comunitario, mejora la preparación institucional y alienta a los educadores a pensar globalmente mientras actúan localmente. A pesar de estos beneficios, persisten desafíos

como el distanciamiento interpersonal, desajustes culturales y pedagógicos, dificultades en la adaptación curricular, la necesidad de habilidades en ingeniería de *prompts* y preocupaciones sobre la autonomía docente. Sin embargo, la duración limitada de la intervención constituye una restricción, lo que sugiere que se requiere un compromiso a largo plazo para lograr mejoras sostenidas. Los esfuerzos de política deberían centrarse en extender los periodos de capacitación e integrar una pedagogía de IA culturalmente receptiva.

Palabras clave: Aprendizaje Profundo; Alegre; Significativo; Consciente; Habilidades del Siglo XXI.

INTRODUCTION

Ensuring high-quality teacher professional development (TPD) remains global challenge, particularly in rural areas where educators encounter limited access to resources, inadequate training opportunities, and insufficient institutional support.[1,2] In Indonesia, these challenges are especially pronounced in rural Papua, where the scarcity of qualified and certified teachers underscores the urgent need for sustainable and scalable TPD models.[3,4,5,6,7]

Despite Indonesia's Teacher and Lecturer Regulation No. 14 of 2005, which mandates teacher competencies in pedagogy, professionalism, interpersonal skills, and personal attributes, many educators, particularly in remote communities, struggle to meet these standards because of structural barriers, such as minimal government intervention, lack of motivation for professional growth, and outdated teaching approaches.[8,9,10] Moreover, frequent shifts in educational orientation, approaches, and national curriculum targets have contributed to teachers' disengagement from TPD initiatives. Many educators perceive teacher training programs as temporary policy-driven projects, assuming that evolving curriculum standards render long-term professional development (PD) futile. Consequently, some teachers feel like subjects of experimental policy implementation rather than empowered professionals shaping educational progress.[11,12,13]

Addressing these concerns necessitates a stable and adaptive TPD model that aligns AI-assisted innovations with culturally responsive, long-term strategies, ensuring that teachers view development programs as valuable and enduring investments rather than transient policy shifts.

In response to these challenges, this study introduces an innovative AI-assisted DLTPD model that leverages "AI Lesson Plan Generator - Education CoPilot, Eduaide.AI, Yoodli, Replika.AI" and comprehensively integrates Indonesia's core teacher competencies. By embedding deep learning principles rooted in joyful, meaningful, and mindful education, this approach seeks to transcend conventional PD programs by offering immersive, adaptive, and culturally responsive training solutions to educators.

Preliminary findings from a survey of 50 teachers in rural Papua underscore the critical need for structured lesson planning and evaluation design training, with 90 % of participants expressing a need for more specialized educational interventions. Numerous studies have examined the advantages of AI integration in TPD.[14] found that teachers' AI literacy improved through exposure to diverse case studies.[15] explored AI as an educational tool to enhance learning outcomes in developing countries.[16] emphasized the importance of ethical AI integration in instructional practices and teacher training programs.[17] investigated strategies to cultivate teacher identity and AI readiness in K-12 education, particularly in Science, Technology, Engineering, Mathematics, and Computer Science (STEM-C) through targeted support.[18] argued that integrating AI into education can facilitate organizational learning and promote literacy enhancement.

Practically, this scalable model enables universities and stakeholders to conduct effective workshops in rural areas, equipping teachers with AI-integrated strategies and adaptive learning tools to improve student outcomes and strengthen educational equity.

Theoretical underpinning

Adult Learning

Continuous or lifelong learning programs for educators, known as TPD, are essential for enhancing teaching practice. The current study also utilized the influential Adult Learning Theory introduced by Knowles in 1980, which was further developed by him and other researchers. This theory, termed andragogy, is defined as "the art and science of helping adults learn".[19] According to the anatomical model proposed by [20] adult learning is predicated on six principles: understanding the need to learn, learners' self-concept, experience, readiness to learn, orientation to learning, and internal motivation.

TPD encompasses wide range of teaching-related topics, including specific subjects such as lesson planning, instructional strategies, educational theories and practices, regulatory guidelines, evaluation data, and teachers' roles and responsibilities. TPD can be implemented through various modalities, such as online learning modules, workshops (virtual or face-to-face), conferences, self-directed studies, in-house training sessions, and collaborative efforts, such as working with a learning partner.

TPD is crucial for rural educators, for several reasons. It enhances instructional quality by providing contemporary knowledge and strategies that might otherwise be inaccessible owing to geographical constraints. TPD can be tailored to address specific requirements and challenges encountered in rural settings, including cultural and socioeconomic contexts. It also facilitates opportunities for collaboration and support among educators, potentially mitigating professional isolation.[21,22,23]

Furthermore, TPD equips teachers with the skills to utilize technology and overcome infrastructure and resource limitations. By enhancing teacher motivation and professionalism, TPD enables educators to adapt to evolving educational policies, and ultimately provides rural educators with tools and expertise to address challenges and improve student learning outcomes[24,25] assert that integrating AI education into teacher training programs is essential for equipping educators to teach AI effectively. They also stressed the significant impact of pre-service teachers on the development of robust professional AI training initiatives.[26] Explored the use of prompting techniques to assist pre-service teachers in crafting AI-enhanced lesson plans for special education. Their study underscored the need to avoid copying and pasting when utilizing ChatGPT for lesson planning. Instead, candidate teachers are urged to create and incorporate AI into their curricula by generating tailored content that meets students' unique needs, prior knowledge, and learning styles. This model facilitates a personalized and efficient learning experience for students with special needs. Moreover, the process of designing AI-assisted lesson plans provides an excellent opportunity to aspire educators to enhance their critical thinking and analytical skills during lesson preparation.

Indonesian TPD competencies

Pedagogy

Pedagogy is derived from the ancient Greek words "paidos," meaning child, and "agogos," meaning escort or guide. Pedagogy denotes children's guidance. In a broader context, it encompasses the theoretical and practical aspects of learning influenced by the social, political, and psychological development of learners. As an academic discipline, pedagogy investigates how science, knowledge, skills, and interactions manifest during the learning process. Through an examination of these elements, pedagogy can enhance the efficacy of teaching and learning in diverse educational settings.[27,28]

Teachers should continuously enhance their instructional competencies to maintain professional standards in pedagogical practice.[29] This developmental process can be delineated into the following components:(1) Planning of learning: this encompasses the establishment of objectives, selection of appropriate media, and design of evaluation tools. Teachers should be encouraged to develop instructional skills by incorporating learning theories, addressing learner requirements, and considering sociocultural backgrounds and individual interests when formulating instructional methodologies. (2) Monitoring the learning process: comprehending the mechanisms by which knowledge and skills are transmitted and assimilated within the learning process is crucial for effective teaching. (3) Evaluation: this involves diagnostic, formative, and summative evaluation. Assessing interpersonal dynamics during educational experiences contributes to the optimization of teaching efficacy. (4) Providing feedback: reflective actions are implemented to enhance learning quality, ensuring continuous improvement in both teaching and learning processes.[30,31]

Professionalism

Professionalism is a critical competency of educators. This concept encompasses the extensive knowledge and understanding instructors possess within their specific subject areas or domains of expertise. In this context, professional educators need to demonstrate both strong foundational and advanced knowledge and apply this knowledge to real-world scenarios.[32] Educators are expected to nurture their professionalism sustainably to achieve this goal. This ongoing development ensures that they maintain their effectiveness and remain current in their teaching practices. In the Indonesian context, professional teachers receive designation upon obtaining professional teacher certification. The government grants this certification to individuals who have completed a competency examination.[33]

Social or Interpersonal

Interpersonal skills are crucial in TPD as they significantly impact a teacher's ability to interact and collaborate with students, colleagues, the school community, and parents. These skills, defined as the capacity to communicate and interact with others, are essential to creating a positive learning environment. According to [34] social skills encompass specific behaviors, whether competent or not, in areas such as conversation, making friends, and playing games with peers.[35] Identified six dimensions of teachers' interpersonal skills: flexibility, communication, leadership, collaboration, networking, and responsibility. Additionally [36] emphasized social competencies as encompassing empathy and organizational awareness [37] posited that teachers' interpersonal skills constitute their capacity to establish rapport and cultivate relationships with students.

Based on perspectives mentioned previously, the current study concludes that interpersonal or social skills

are vital for teachers to achieve professional excellence. These skills can be characterized by the following attributes: (1). establishing strong relationships with students: effective interpersonal skills enable teachers to establish strong positive relationships with their students. (2) Enhancing communication: the ability to communicate clearly and effectively facilitates teachers' conveyance of course materials.[38] (3) Fostering collaborative environment: proficient interpersonal skills allow teachers to collaborate effectively with colleagues and parents. (4). effectively managing the classroom: teachers with strong interpersonal skills demonstrate increased efficacy in classroom management, discipline maintenance, and harmony without resorting to authoritarian measures.

In conclusion, teachers' interpersonal skills are essential throughout the learning process, and are acquired through experience and communication with team members or partners. Therefore, the continuous development of these skills is necessary for professional growth. By developing interpersonal skills, educators not only enhance their instructional effectiveness but also facilitate engaging and meaningful learning experiences for students.[39,40]

Personality

Teachers' personality skills refer to the ability to exhibit high-quality personality in the presence of students. This competence significantly affects learning, attitudes, and students' overall development, fostering a positive and engaging learning environment.[41] identified the Big Five personality measurement tool as influential in determining teacher professionalism and stressors, specifically focusing on emotional stability, agreeableness, intellect, and conscientiousness.[42]

Defined teachers' personal skills as the development of rapport and strong relationships with students. [43] propose that educators' personal resources such as a sense of purpose, enthusiasm, positive outlook, humor, emotional stability, professional curiosity, and diligence constitute resilience as a professional skill, presenting a novel approach to enhancing teachers' well-being.

In summary, the present study indicates that teachers' personal skills encompass the following behaviors: demonstrating respect towards students, exhibiting enthusiasm, fostering a comfortable and stimulating learning environment, maintaining positive and humorous demeanor, building rapport with students, and showing empathy both academically and personally.[44,45]

Rural area definition

To mitigate the varying interpretations of rural areas, we define rural areas as those characterized by geographic isolation and limited technological infrastructure. These regions are typically situated far from urban centers and often exhibit remote and less accessible features. Such remoteness contributes to challenges in terms of connectivity, resources, and opportunities for residents. In the educational context, rural areas face significant challenges regarding access to technology. Internet connectivity is scarce, unreliable, and available only in specific locations such as district offices or village leader offices. This limited access hinders educational progress and communication, resulting in a notable disparity compared to urban regions. Schools in rural areas experience substantial technological resource limitations.

Typically, these schools possess only a few computers, one for the principal and another for the school administrator, thereby severely restricting access to modern learning tools and platforms. This situation underscores the resource scarcity prevalent in rural schools, posing barrier to fostering digital literacy and enhancing educational quality.[46,47] This definition aligns with the observations of [6,7,8] as well as [9], emphasizing two primary aspects: geographic remoteness and technological infrastructure limitations. Addressing these challenges is crucial for bridging the gap between rural and urban communities in terms of opportunities and resources.

Deep Learning (DL)

According to [48], deep learning is the process of acquiring applicable, transferable, and sustainable knowledge to solve real-life problems. This approach emphasizes critical thinking, collaboration, creativity, and real-world problem solving, rather than rote memorization. The authors highlighted that the deep learning framework transcends traditional education by engaging students with meaningful learning experiences that prepare them for the modern world. [49] introduced a deep learning framework based on the development of six global competencies: (1) character, (2) citizenship, (3) collaboration, (4) communication, (5) creativity, and (6) critical thinking, which collectively prepare learners to navigate real-world challenges.

In the context of TPD, particularly in rural Indonesia, AI-assisted deep learning has significant potential to enhance educators' competencies and instructional strategies. AI-powered training programs provide personalized learning experiences, adapting to teachers' strengths and weaknesses, while offering real-time feedback and automated lesson planning tools. Furthermore, digital platforms facilitate collaboration among educators, allowing them to exchange insights and refine their teaching methodologies despite geographical

barriers. AI also plays a crucial role in addressing accessibility issues, bridging the digital divide through localized learning resources and offline AI-assisted teaching models tailored to rural contexts. By integrating AI-driven smart teaching strategies, educators can foster creativity and critical thinking by employing interactive content and data-driven decision making to optimize lesson delivery.

The combination of Fullan's deep learning principles with AI-assisted education not only empowers teachers but also ensures equitable learning opportunities for students in remote areas, making quality education more sustainable and impactful. This synergy between human-centered pedagogy and technological innovation ultimately reinforces the overarching goal of deep learning: cultivating adaptable, engaged, and globally competent learners.[50,51]

To the best of our knowledge, this approach is particularly valuable for TPD, as it encourages innovative teaching methods tailored to the diverse needs of students. This represents a transformative shift in education that aims to foster meaningful learning experiences that extend beyond traditional methods, as shown in figure 1.

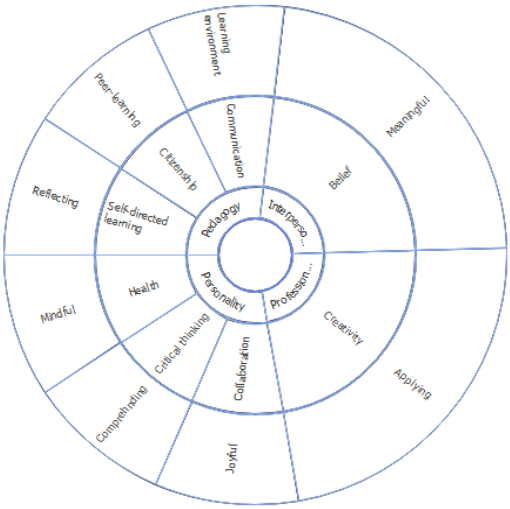

Figure 1. Conceptual Framework of the research

METHOD

Research design

This study utilized a true experimental design, incorporating randomized controlled trials (RCTs), to evaluate the effects of AI-assisted DLTPD intervention on educators' competencies and student learning outcomes.[52] The mixed-methods approach integrates quantitative data through statistical analysis of teacher and student performance alongside qualitative data capturing teacher experiences, perceptions, and classroom observations. The study comprised two groups: the experimental group, in which teachers engaged in AI-based DLTPD, and the control group, in which teachers continued with traditional teaching methods. A pre- and post-test framework was employed to measure teacher competencies before and after the intervention, while student learning analysis assessed whether improvements in teacher competencies led to enhanced student outcomes. The study design ensured a causal relationship between AI-assisted training and teacher effectiveness, rendering it scalable for replication in rural educational settings across various regions.

Participants' profiles

This study concentrated on educators in rural areas, particularly within underdeveloped communities where digital education interventions are imperative. The target demographics comprised teachers with limited prior exposure to technology-driven training, thereby ensuring that the study evaluated the efficacy of AI-assisted DLTPD in contexts where such professional development is infrequent. A purposive sampling strategy was employed to select teachers who met the following specific criteria: (1) employment in rural schools with restricted access to professional development training, (2) absence of prior participation in technology-based training, and (3) age under 50 years to ensure adaptability, and a minimum of five years of teaching experience to ensure proficiency in traditional instructional methods. The sample size included 100 teachers, with 50 assigned to the experimental group and 50 to the control group, although adjustments may have been made based on the local educational infrastructure. Participants were recruited based on recommendations from the headmaster and subsequently completed a Google Form registration to confirm their enrollment in the intervention class. For this reason, teachers as participants were required to develop their professionalism,

particularly at the beginning of the academic year. The participants' characteristics are presented in table 1.

Table 1. Descriptive Statistics of Participant Profiles.

Description	Count	(%)	Mean	Standard Deviation
Gender				
Male	20	20	-	-
Female	80	80	-	-
Teaching Experience (years)			5,3	1,8
Less than 5 years	35	35	-	-
5 years and above	65	65	-	-
TPD Training Experience				
Attended Training	20	20	-	-
Never Attended	80	80	-	-
Technology Use in Teaching				
WhatsApp	100	100	-	-
Laptop	70	70	-	-
Infocus	10	10	-	-
Digital Technology Use			11,25	10,5
Email	5	5	-	-
Google Drive	5	5	-	-
Zoom	30	30	-	-
Google Meet	5	5	-	-

Data collection and research instruments

Data collection employed various research instruments to ensure a comprehensive analysis of the impact of the intervention. Quantitative tools included observation sheets to monitor teacher behavior, technological engagement, and instructional strategies; pre-test and post-test assessments to evaluate competencies in pedagogy, professionalism, social skills, personality, and technology literacy; and student learning outcome assessments to measure performance before and after the teacher intervention. Qualitative tools comprised questionnaires to gather teacher feedback on training effectiveness, interviews to explore teachers' perceptions and challenges in adapting to AI-assisted training, focus group discussions (FGD) to facilitate shared discussions among teachers, document reviews, and analyses of teacher lesson plans. This multi-instrument approach ensured robust and adaptable data collection, thus enhancing the replicability of the study across various rural contexts.

To facilitate the interviews, researchers developed a set of guiding questions aimed at exploring the impact of AI-assisted deep learning on teacher professional development. The first question examined how AI-assisted deep learning influences various aspects of professional growth among educators. The second question sought participants' perceptions of AI-assisted deep learning about key teacher competencies, including pedagogy, professionalism, interpersonal skills, personality development, and deep learning. These questions were designed to generate insightful discussions and provide a comprehensive understanding of the role of AI in enhancing teacher development.

In addition, an observation checklist was developed to systematically assess the impact of AI-assisted DLTPD on teachers' professional development by observing participants' performance during the intervention. This checklist allows researchers to methodically evaluate changes in pedagogy, professionalism, interpersonal skills, personality development, and engagement with deep-learning principles, such as joyful, mindful, and meaningful learning. Through this structured evaluation, researchers can assess the effectiveness of AI interventions and refine strategies for broader implementation in rural educational settings.

Furthermore, during the Focus Group Discussion (FGD), researchers facilitated open dialogue to evaluate the impact of AI-assisted DLTPD. The participants engaged in discussions encompassing pedagogy, professionalism, interpersonal skills, personality development, and deep learning principles, including joyful, meaningful, and mindful learning. Researchers guided the conversations, ensuring diverse perspectives and reflective insights while maintaining a structured yet flexible approach. Active participation, critical reflection, and collaborative knowledge exchange were encouraged. The responses were systematically documented to ensure validity, aligning the findings with the objectives of the study.

This technique ensures the collection of valuable qualitative data, contributing to the refinement and broader implementation of the AI-assisted DLTPD model. The data collection process adhered to a structured field-implementation procedure to ensure reliability and consistency. It commenced with baseline observations to document teachers' existing instructional methods before AI integration. A pre-test was administered to assess teacher competencies before the intervention, along with a collection of baseline student learning outcomes. During the experimental phase, teachers in the experimental group underwent AI-assisted training focusing on curriculum design, lesson planning, AI-based student evaluation, and innovative teaching strategies, while the control group continued using traditional methods. Upon completion of the four training sessions, post-test was conducted to assess improvements in teacher competency, complemented by follow-up observations to evaluate changes in pedagogy. To gain deeper qualitative insights, interviews and FGDs were conducted with teachers.

Research procedures

In alignment with the study's research questions, the researchers implemented four-week training program for participants. The training aimed to assess their competencies before and after receiving intervention. Table 2 outlines the research procedure. In week 1, pre-test was conducted for both the control and experimental classes, while in week 4, post-test was administered.

Table 2. Control and experimental scenario

Week	TPD Competence	AI Tool(s)	Activities		DL profiles	Expected Outcome
Pre-test	Pre-test control and experimental class		Control Group Scenario	Experimental Group Scenario		
I	a. Pedagogy (Curriculum Design & Lesson Planning)	MagicSchool AI, AI Lesson Plan Generator - Education CoPilot	Teachers manually design lesson plans and weekly curriculum using experience and textbooks.	Teachers use AI tools to assist in lesson plan and curriculum development.	1. Religiousness 2. Citizenship 3. Health 4. Collaboration 5. creativity 6. critical thinking 7. communication 8. independence or autonomy	AI-enhanced lesson plans, integrating Digital Literacy (DL) skills. Increased efficiency and creativity in curriculum design.
II	b.Professionalism (Planning, Implementation, Evaluation, Feedback)	Eduaide.AI	Teachers use traditional methods for planning, evaluation, and reflection.	Teachers utilize AI tools for structured assessment and feedback.		AI-generated planning documents, feedback scripts, and assessment rubrics, enhancing efficiency and systemization.
III	c. Social / Interpersonal Skills	Yoodli, Replika.AI	Public speaking and conflict resolution practiced without AI assistance.	AI-assisted practice using Yoodli for public speaking and Replika. AI for conflict simulations.		Enhanced communication and conflict resolution strategies through AI-driven tools.
IV	d. Personality (Self-Competence & Self-Management)	Mindsera AI, Notion AI	Journaling and task management done manually.	AI-assisted journaling with Mindsera AI and structured task planning using Notion AI.		Improved discipline, focus, and productivity through AI-driven task organization.
Post-test	Post-test control and experimental class					

Data analysis

Data analysis employs both quantitative and qualitative techniques to ensure a rigorous examination of findings. Quantitative analysis included descriptive statistics to calculate the mean, standard deviation, and score range of test results; normality tests, using Kolmogorov-Smirnov tests to assess data distribution; and hypothesis testing, where Paired Sample t-test measures the statistical significance of score improvements between pre-test and post-test results. Hence, the following hypothesis was proposed:

Null Hypothesis (H_0): there were no significant differences in teacher competencies and student learning outcomes between AI-assisted DLTPD and traditional PD model in rural Indonesia.

Alternative Hypothesis (H_1): AI-assisted DLTPD significantly improves teacher competencies and student learning outcomes compared with traditional PD model in rural Indonesia. Aligning with qualitative data, this study followed a systematic thematic approach to examine the impact of AI-assisted TPD in rural areas. Various

qualitative data sources, including classroom observations, teacher interviews, questionnaires, FGD, and document reviews, provide rich contextual insights into teachers' experiences, perceptions, and behavioral shifts following the intervention. To ensure structured and replicable analytical process, this study adapts[53,54] the five-phase data analysis framework, which enhances the rigor and depth of qualitative examination.

The initial phase, data organization, involved thorough review of interview transcripts, observation notes, questionnaire responses, and FGD recordings to achieve comprehensive understanding of the raw data. This phase ensures that all collected materials are systematically stored and accessible for coding. The subsequent phase, sorting data into relevant topical categories, involves categorizing information based on predefined research themes such as pedagogical impact, professional growth, social interactions, and technological adaptation.

This step facilitated structured approach to data segmentation, ensuring clarity in subsequent analyses. The third phase, open/initial coding, was conducted using Atlas.ti 9, in which data were segmented into meaningful units, ensuring that individual statements accurately reflected participants' perspectives. Codes were assigned to capture key themes emerging from the qualitative responses, such as teachers' engagement with AI tools, challenges in AI adoption, and confidence in technology integration.

Following open coding, the fourth phase, identifying patterns, themes, and findings, applies axial coding and groups related concepts into broader thematic categories to generate an in-depth understanding of teachers' experiences. By refining these themes through selective coding, coherent framework of findings has emerged, enabling structured interpretation. In the final phase, applying theory and explaining findings synthesizes qualitative insights by linking emergent themes to established educational theories. This includes examining how AI-assisted TPD aligns with adult learning principles and teacher-competency frameworks.

The interpretation was further enriched through comparative analyses between the experimental and control groups, ensuring the contextual relevance of the findings. To validate the reliability of the qualitative results, triangulation was employed by cross-referencing observational data with interviews and FGDs, while member checking ensured that participants' perspectives were accurately represented. Additionally, peer review and expert validation maintained objectivity throughout the analytical process. By integrating's[53] structured approach with advanced qualitative software tools, this methodology ensures replicability, making it adaptable for examining AI-driven teacher training programs in various rural educational contexts worldwide. Comprehensive thematic analysis and rigorous validation measures provided valuable insights into how AI-supported professional development influences instructional strategies and competency enhancement.

To uphold research ethics, all participants' identities were kept confidential. This measure was implemented under ethical guidelines to ensure anonymity and privacy throughout the study. To formalize the ethical approval process, Institutional Review Board (IRB) authorization was obtained from the Research and Community Service Committee at the University of Musamus Merauke, Papua, Indonesia.

RESULTS

Research question 1: how does harnessing of AI-assisted deep learning impact on teachers' professional development?

Aligned with the first research question, this study examined participants' outcomes before and after the TPD intervention. The primary objective of this analysis was to assess the effectiveness of the intervention in enhancing the test scores. To achieve this, two groups were compared: the experimental group, which underwent treatment, and the control group, which did not receive any intervention. The pre- and post-test data were subjected to an independent t-test to determine the statistical significance of the observed differences. Table 3 presents the key statistical metrics for both groups, with each group comprising of 50 participants.

Table 3. Experimental and control class statistic descriptive

Statistic descriptive	Experimental (Pre-Test)	Experimental (Post-Test)	Control (Pre-Test)	Control (Post-Test)
Mean	52,94	66,5	52,74	53,6
Standard Deviation	2,298	4,867	2,202	2,185
Sample Variance	5,282	23,684	4,849	4,776
Range	9	18	9	10
Minimum	48	59	48	49
Maximum	57	77	57	59
Sum	2647	3325	2637	2680
Count (n)	50	50	50	50

Table 3 illustrates that the experimental group exhibited a significantly greater increase in test scores than the control group. To assess the impact of the intervention, an independent t-test was performed to evaluate the following hypotheses: (H_0) the null hypothesis, positing no significant difference between the experimental and control groups post-intervention, and (H_1) the alternative hypothesis, suggesting significant difference between the two groups after the intervention. The statistical analysis produced a t-value of 17,1, surpassing the critical t-value of approximately 1,984 (α = 0,05, df = 98), thereby leading to rejection of the null hypothesis. This outcome confirms that the intervention had ameaningful and statistically significant effect on the experimental group, resulting in substantial improvements in post-test scores. By contrast, the control group demonstrated only minimal increase, further substantiating the effectiveness of the intervention. These findings have important practical implications, including the potential for broader implementation of the intervention on a larger scale; opportunities for optimization through further research to refine the methodology; and data-driven decision-making for institutions aiming to enhance education, training, or development programs. Overall, the results provided compelling evidence that the intervention significantly improved test scores, underscoring its potential as valuable approach for enhancing learning and performance.

Research question 2: How do educators perceive the harnessing of AI-assisted deep learning in the context of their professional growth?

In response to the second research question, the current study presents a descriptive statistical report on teachers' perceptions of the AI-assited DLTPD. This analysis examined overall positive and negative impact and areas for potential improvement based on quantitative feedback from participants. Table 4 provides an overview of the collected responses, highlighting key statistical metrics that offer valuable insights into teachers' experiences with the intervention class.

Table 4. Teachers' perception category

No	Interval	Category
1	25-44	Low
2	45-64	Average
3	65-84	High
4	85-100	Very high

Table 5. Teachers' perception of TPD

Statistic	Value	Interpretation
Maximum Score	78	Highest rating given by a participant, indicating strong approval of the training.
Minimum Score	51	Lowest rating given, showing variability in participant experience.
Mean Score	65,54	The average score suggests that the training was perceived positively overall.
Standard Deviation	4,878	Moderate variation in responses, indicating differences in individual perceptions.
Satisfaction Percentage	81,93 %	High percentage of approval, confirming the effectiveness of the training.
Category	High	The training is classified as highly effective based on participant ratings.

The findings indicate that the majority of teachers evaluated the AI-assisted TPD training favorably, with an average score of 65,54 and high satisfaction rate of 81,93 %. The standard deviation of 4,878 suggests that while individual responses varied, most scores were closely aligned with the mean. The statistical analysis categorizes training within the high satisfaction range, implying that teachers generally perceive the program as advantageous. The collected data demonstrated consistently positive reception, with scores ranging from minimum of 51 to maximum of 78. The mean score of 65,54 reflects strong consensus among teachers that the training met their expectations and provided valuable insights for professional development. The moderate variability in responses, as indicated by the standard deviation, likely arises from differences in individual experiences and learning preferences.

Thematic analysis was employed to capture Indonesian teachers' perspectives on key TPD competencies such as pedagogy, professionalism, personality, interpersonal skills, and deep learning, ensuring their

relevance in both local and global educational contexts. This framework incorporates adult learning principles, acknowledges challenges specific to rural education, and emphasizes deep learning as a crucial factor in improving professional growth and instructional effectiveness. Through this analysis, both positive and negative perceptions of teachers were identified and explored further in this section.

Positive impact

AI-Driven DL for enhancing adaptive cutting-edge Pedagogical Practices

The present study highlights the application of AI-assisted DLTPD, facilitating the creation of effective student-centered instruction. Utilizing Fullan's deep learning framework, AI-supported pedagogy encourages active, collaborative, and self-directed learning. Specifically, AI-powered adaptive learning models can provide Indonesian teachers in rural areas with instructional methods tailored to individual students' needs. These technologies offer educators real-time, data-driven pedagogical insights, thereby promoting critical thinking and knowledge retention while enhancing teaching and learning strategies. To achieve this, teachers integrate AI tools such as MagicSchool AI, Autoclassmate, AI Lesson Plan Generator, and Education Copilot to support curriculum design and lesson planning. Through this process, participants internalized essential DL behaviors, including collaboration, creativity, critical thinking, and self-directed learning.

I am enthusiastic about this training because it enables me to complete my administrative tasks efficiently, thereby saving time. The materials and tasks provided were diverse (teacher 17, week 4).

AI-Assisted Professional Development for Rural Educators

This study indicates that educators perceive artificial intelligence (AI) as beneficial instrument for enhancing their professional competence within the TPD framework, encompassing planning, implementation, evaluation, and feedback. Eduaide: AI has been employed as a structured assessment and feedback mechanism to assist teachers in refining their instructional strategies. Furthermore, AI-driven training enhances communication and conflict-resolution skills, thereby facilitating more effective teacher interactions. AI-generated lesson plans, feedback scripts, and assessment of rubric streamline processes increase efficiency. Traditional teacher training in rural Indonesia has encountered logistical challenges that restrict access to mentoring and certification. AI-powered deep-learning tools can address this issue by personalizing professional growth plans and ensuring continuous training, skill assessment, and automated feedback. This scalable approach enables rural educators to engage in lifelong learning despite geographical barriers. Moreover, TPD aligns with 21st-century educational needs by promoting communication, collaboration, creativity, and critical thinking skills that are essential for contemporary education.

Promoting Emotional Resilience and Personality Development: The Unique Strength of Rural Teachers Empowered by AI

Teachers in rural settings possess a unique strength that distinguishes them: the capacity to maintain emotional resilience despite numerous challenges such as limited resources and reduced financial stability. In contrast to their urban counterparts, who frequently have ready access to technological advancements, rural educators cultivate strong adaptability and unwavering dedication, thereby forming distinctive professional identities. AI functions as a conduit that enables rural educators to adopt contemporary pedagogical practices and remain attuned to technological advancements while preserving their local wisdom and resilience. By providing AI-assisted lesson planning, adaptive learning strategies, and access to global insights, AI empowers rural educators to enhance their teaching strategies without compromising their foundational values. This transformation ensures that rural educators are not marginalized but continue to advance professionally, integrating innovative teaching techniques that align with the needs of their students and the evolving educational landscape.

We value this training because it has significantly transformed my traditional pedagogical approach. We are now able to adapt and modify various tasks to better accommodate my students' needs and learning style. We strongly advocate the continuation of this training on a periodic basis, rather than as a singular event to ensure long-term sustainability and ongoing professional development. (Teacher 9, 28, 32 in week 4)

AI-Facilitated interpersonal and Community-Based Learning for TPD in Rural Areas

Interpersonal competence is a fundamental component of Indonesia's TPD framework. Nevertheless, educators in rural regions frequently encounter obstacles to accessing peer interactions and cross-cultural learning opportunities. AI-powered tools can mitigate this challenge by facilitating collaborative learning communities through virtual platforms, multilingual teaching forums, and intelligent peer matching networks. These innovations enable rural teachers to connect on a global scale, exchange best practices, and engage in pedagogical exchanges, thereby enhancing their professional development. By promoting a community-driven approach to TPD, AI empowers educators to transcend geographical constraints and foster continuous learning

and collaboration, which bolsters teaching practices in rural communities.

As one educator noted, "AI helps me create lessons that connect global ideas with my students' local realities. This makes preparing interactive projects and simulations easier and improves engagement and learning in my rural classroom. AI doesn't replace me it empowers my teaching" (teacher 39 week 4).

Contextual: The readiness of educational institutions to support the implementation of AI for teachers

Educational institutions' readiness to facilitate the implementation of artificial intelligence (AI) for educators is contingent on several critical factors. Schools must ensure the provision of adequate infrastructure, including access to AI-powered tools, reliable internet connectivity, and digital literacy programs. Professional development is essential to equip teachers with the necessary training in the ethical use of AI, its integration into pedagogy, and its impact on student-learning outcomes. Institutional policies should address issues related to data privacy, equitable access, and AI-based evaluation methods. Commitment to leadership, availability of funding, and collaboration between educators and technology developers are also pivotal. A well-prepared institution fosters innovation, enabling teachers to leverage AI effectively while maintaining the quality of education and adapting to evolving technological landscapes. In the context of professional development of teachers in rural areas, robust government support is crucial for success. Without serious commitment from the government, AI-assisted distance learning (DL) in teacher professional development (TPD) will be ineffective. Our extensive experience indicates that rural teachers have often been neglected, with insufficient attention and resources allocated to their professional growth.

To fully realize the potential of AI-driven education, policymakers must prioritize sustainable investment, ensuring that rural educators receive the necessary training, infrastructure, and technological support to enhance their teaching practices and improve education in remote communities (teacher 20 week 4).

AI Encourages Teachers to Think Globally but Act Locally

In rural Papua, student learning should be firmly anchored to local materials and real-world conditions that reflect the region's unique characteristics. However, limited access to diverse educational resources has historically impeded teachers' ability to create assignments, projects, role-playing activities, and simulation scenarios. Many educators have been hesitant to develop new instructional materials because of the scarcity of reference books and learning sources and the burden of administrative tasks. AI addresses this gap by offering teachers relevant insights and generating educational content tailored to their classroom needs. While AI enables educators to incorporate global perspectives, it does so in a manner that reinforces local values and cultural relevance. It allows teachers to design engaging and contextually appropriate learning experiences, facilitating students' connection with broader global knowledge while remaining deeply rooted in familiar cultural and environmental settings.

By integrating AI, teachers can explore innovative teaching strategies, making lessons more dynamic without compromising the core traditions and learning styles of their communities. AI-driven tools empower educators to enhance professionalism, personalize instruction, and create diverse teaching materials while ensuring that technological advancements serve as catalysts for localized, high-quality education rather than replacing the fundamental essence of rural teaching traditions.

As an Indonesian rural teacher, I am committed to preserving contextual materials that align with my students' background and needs. However, I have integrated AI-generated lesson plans as a support tool to enhance the teaching process. To me, AI is simply a resource that helps streamline lesson preparation, but the content itself remains deeply rooted in the reality of rural education. My students' needs dictate the learning materials, ensuring that lessons remain relevant and culturally appropriate while leveraging AI to provide diverse, engaging, and well-structured educational experiences (teacher 30 week 4).

Negative Impact

The findings of this study reveal several negative perceptions of AI-assisted DL **TPD**. While AI integration has helped teachers enhance collaboration and professional skills, certain drawbacks have emerged during the intervention sessions.

Interpersonal, Emotional, and behavioural

While educators recognized that AI-assisted DLTPD facilitated learning and collaboration within rural teaching communities, overreliance on AI could inadvertently diminish interpersonal interactions. Traditional TPD models prioritize direct engagement between educators and mentors, promoting reflective discussions and collaborative problem-solving. However, AI-driven learning systems may constrain human-centered exchanges, potentially impairing teachers' abilities to cultivate strong interpersonal competencies. Furthermore, some educators perceived that AI integration resulted in a decline in behavioral and emotional engagement. A few participants believed that they could independently generate lesson plans at home, leading to occasional

disengagement during TPD intervention sessions. Although AI offers efficient instructional planning, it may also reduce active participation and peer collaboration, which are essential components of professional development.

Cultural and Pedagogical Misalignment

AI-generated recommendations frequently fail to align with local pedagogical traditions, values, or specific needs of students, particularly in rural areas. Educators in these contexts often depend on culturally embedded instructional methods informed by community-based educational practices. When AI-driven lesson plans lack sensitivity to contextual and societal factors, they risk creating disconnect between the learning experience and foundational principles upheld by rural educators.

Disruptions in Adapting to Frequent Curriculum Changes

Indonesia's educational framework is subject to frequent curriculum revisions because of shifts in national leadership. Although AI-assisted deep learning is designed to facilitate adaptation, it may inadvertently increase complexity rather than enhance clarity among educators in rural areas. Many teachers in these remote regions lack consistent access to AI training, which complicates the alignment of AI-generated lesson plans with new national standards. In the absence of structured guidance, AI-driven recommendations may not adequately accommodate evolving curricula, ultimately increasing teachers' workload instead of reducing it.

From our perspectives, frequent shifts in curriculum approaches and orientations present significant challenges for educators attempting to integrate artificial intelligence into their pedagogical practices. Constant changes in Indonesia's curriculum generate uncertainty, causing educators to hesitate to fully embrace AI-driven instruction. This reluctance arises from concerns that AI tools may not seamlessly adapt to evolving educational policies, resulting in inconsistent implementation and increased workload for teachers (teacher 34, 8 and 49, week 4).

Teacher Autonomy and Human-Centered Learning

The extensive integration of AI into TPD poses a challenge to educators' autonomy. Overreliance on AI-generated lesson plans, assessments, and feedback may diminish teachers' creativity and critical thinking in instructional design. Additionally, students may begin to favor AI-generated responses over direct teacher guidance, potentially undermining traditional teacher-student relationships and shifting trust away from human-centered learning experiences.

While AI offers significant advantages for professional development, its implementation must be judiciously balanced with human-driven engagement to ensure that teachers remain actively involved in creating meaningful student-centered learning environments. A structured and culturally responsive approach to AI integration can help address these concerns, ensuring that educators continue to effectively develop pedagogical, interpersonal, and professional competencies.

Educators have articulated several concerns regarding the adverse effects of artificial intelligence (AI) on educational landscapes. Teacher 27 observed that, although AI can enhance creativity, it may simultaneously undermine critical thinking skills. Teacher 50 concurred with this perspective, contending that AI tends to prioritize administrative efficiency over interpersonal engagement. This shift could potentially lead educators to become more reliant on AI, thereby adopting a more individualistic approach than promoting human interaction. Additionally, Teacher 32 highlighted that AI's lack of emotional engagement poses a risk of moral crisis, as diminished human connections within the learning process may adversely affect ethical decision-making and social values (teacher 27, 30, 50 week 4).

AI needs prompting engineering skill

Prompt engineering is essential to ensure that AI produces information that is aligned with user expectations. Nevertheless, many educators in rural areas lack proficiency in this skill and have only participated in brief intervention sessions designed to integrate AI into TPD. Owing to their limited experience with AI, their ability to formulate effective prompts is significantly constrained, posing a considerable challenge. Consequently, AI may become a more impediment than a beneficial tool. In the absence of these skills, AI-generated lesson plans, assignments, and tasks may contain misleading or repetitive information, as AI relies solely on globally stored data without considering local contexts or the specific needs of students. This can adversely affect the quality of education and diminish teaching effectiveness in regions that already face various constraints.

Yeah, sometimes, we feel confused about using AI because its materials seem repetitive across all course lessons. (Teacher 11, 38, 49, week 4).

DISCUSSION

The integration of AI-assisted DL into TPD in rural areas presents substantial benefits, particularly in

enhancing educators' capacities to facilitate joyful, meaningful, and mindful learning experiences. AI empowers teachers to reinforce three fundamental learning pillars: comprehension, application, and reflection, which are crucial for cultivating 21st-century learners. In contrast to their urban counterparts, who often have access to advanced learning resources, rural educators encounter challenges in mentorship, certification, and adapting to frequent curriculum changes associated with ministerial transitions. AI addresses these challenges by offering personalized instructional tools, adaptive learning strategies, and automated feedback systems, thereby aiding educators to effectively adjust to evolving curriculum frameworks.

Furthermore, AI supports the development of eight essential DL competencies religiousness, citizenship, communication, creativity, critical thinking, collaboration, health, and self-directed learning which align with Indonesia's vision of preparing a globally competitive golden generation by 2045. Through structured AI integration, rural educators can overcome geographical and systemic barriers, ensuring their engagement in lifelong professional development while adapting to ongoing curriculum shifts. Rather than supplanting traditional teaching methods, AI functions as an enabler, allowing rural teachers to refine their pedagogical practices despite changing policies, ensuring consistency, and innovating classroom instruction.Throughout class intervention, teachers trained in four times to intergrate all those DL concept, behaviour and competencies into each course materials.

Consistent with the findings of this study, we affirmed the assertions of [48,49,50,51], who emphasized the integration of DL into AI tools to engage students in comprehensive learning processes and prepare them for future challenges. AI-assisted DL not only fosters critical thinking among students but also promotes responsible citizenship. In alignment with Fullan's framework, students are encouraged to enhance their self-directed learning while also cultivating citizenship, morality, and religious values. In this context, we propose that AI-assisted DL constitutes holistic TPD model, which is particularly impactful for educators in rural areas. The more students and teachers engage with the DL concept, the more likely they are to ethically use AI.

Furthermore, we concur with [55] assertion that academic freedom in education transcends knowledge transfer and serves a more comprehensive purpose. Our findings align with the philosophy of learning, emphasizing its crucial role in fostering a system dedicated to holistic human development. This philosophy provides a guiding framework that ensures that educational objectives and processes remain relevant to the social, cultural, and contemporary challenges. As John Dewey cited in [56,57], education is not merely preparation for future life; it is life itself. This perspective suggests that education should go beyond the simple transmission of knowledge, functioning as a mechanism for shaping an ideal society that embodies universal values such as freedom, justice, and humanity, integrating these principles into students' lived experiences. This philosophy reflects a desire to cultivate an inclusive and progressive society.

Consequently, education is not merely a conduit for acquiring knowledge but also transformative tool that enables individuals to evolve in tandem with changing times. Additionally, our findings indicate that AI-assisted DL enhances students' academic performance and prepares them for citizenship skills. Furthermore, the findings of this study confirmed that AI-assisted training significantly enhances teacher competency, particularly in professional development. Statistical analysis revealed a substantial improvement in the test scores for the experimental group, validating AI's effectiveness of AI in instructional design. The intervention strengthened pedagogical practices, enabling educators to align content with student needs more effectively. The notable increase in mean scores (+13,56 points) indicates AI's pivotal role in refining teaching strategies, while the broader variance highlights individual adaptability to AI-driven learning methods.

Beyond pedagogy, AI-supported training significantly contributes to the development of teachers' personalities, enhancing their confidence and adaptability in integrating AI tools into instructional practices. The transition from negative to positive skewness in score distribution indicates an increase in educators' self-efficacy, reinforcing their capacity to navigate technological advancements. Furthermore, AI-driven platforms improve interpersonal competencies and promote collaborative learning, peer interactions, and shared problem-solving strategies that are essential for professional growth. This study also highlighted AI's role of AI in continuous professional development, demonstrating its scalability in skill refinement and adaptation to evolving curricula. By providing structured yet flexible learning pathways, AI empowers educators, particularly in rural settings, to engage in lifelong learning despite limitations in mentorship access. Moreover, AI facilitates lesson planning, task creation, project development, evaluation, and feedback, thereby ensuring that students experience joyful, mindful, and meaningful learning. These findings underscore AI's potential of AI as a transformative force in education, equipping teachers with necessary tools to enhance instructional effectiveness while fostering dynamic, evolving professional identity.

Our findings are consistent with those of [58] who posited that artificial intelligence facilitates curriculum restructuring and enhances professional development. Similarly, [59] identified AI as an innovative tool that significantly influences teacher development and instructional design. Despite these positive contributions, we acknowledge the concerns raised by [60] regarding potential risks such as the overuse and misuse of AI in education. Reflecting on their insights, we recognize the importance of ensuring that rural teachers approach

AI-generated content with cautious optimism. Early adoption should be accompanied by thorough validation through credible research and empirical studies to prevent misleading information from adversely affecting students' learning experience.

The findings of this study highlight both the benefits and challenges associated with the integration of AI-assisted deep learning within the framework of TPD. While AI positively influences pedagogy, professionalism, personality development, and interpersonal competencies, certain challenges extend beyond commonly discussed risks. These challenges include the potential impact on teacher autonomy and human-centered learning, where overreliance on AI may diminish educators' creative and critical thinking in instructional design.

Additionally, frequent curriculum changes pose difficulties as AI-generated lesson plans may not consistently align with evolving national standards, thereby complicating rather than streamlining solutions. Furthermore, cultural and pedagogical misalignment raises concerns regarding AI's capacity to adapt to local teaching traditions and values, potentially disconnecting technology-driven learning from rural educators' deeply rooted educational approaches.

Finally, interpersonal, emotional, and behavioral disengagement present a risk, as AI integration may inadvertently reduce teacher collaboration, peer interactions, and emotional engagement during professional development. Addressing these challenges necessitates balanced approach that ensures that AI complements rather than replaces meaningful human-driven learning experiences in TPD.

Following the findings of this study, the current study affirms [29]'s assertion that teachers must continuously refine their instructional competencies to maintain professional standards in pedagogical practice. To support this, the teachers in our study engaged in intervention training focused on AI-assisted digital learning DL to enhance professional development among rural educators. This approach aligns with the principles of adult and lifelong learning, as described by [61], and agrees with [48,49,50,51]. Their framework emphasizes digital learning competence as a form of self-directed learning that is essential for professional growth. Our study also found that AI assisted teachers in Indonesian TPD competencies such as pedagogy, professionalism, personality, and interpersonal skills. In this context, teachers' post-test performance provides empirical evidence.

Integrating AI-assisted DL into TPD enhances educators' ability to create engaging and effective lesson plans. AI-powered lesson plan generators streamline the planning process by offering a variety of instructional resources such as task examples, role-playing scenarios, and content tailored to students' needs and interests. This allows teachers to design meaningful lessons without spending excessive time in preparation. Following the intervention, teachers had access to a diverse array of learning materials, enabling them to cultivate student engagement and mindfulness.

The initiative emphasized the importance of developing students with strong character and national awareness, providing education that integrates religious and cultural values while fostering relevant skills for global competitiveness. Practical applications of this approach include language teachers using Indonesian folktales to enhance writing skills while incorporating moral and cultural lessons; science teachers integrating local environmental projects that combine traditional wisdom with modern scientific innovation; and technology teachers guiding students in producing digital educational content that showcases Indonesian culture in foreign languages.

Our findings corroborate the assertion of [61] that AI enhances TPD by fostering technological pedagogical content knowledge (TPACK) competence in lesson planning. Similarly, [62] emphasized the transformative impact of AI tools in empowering English language teachers to design more effective lesson plans. These empirical studies have identified AI integration as a contributing factor to improved learning outcomes,[6,7] real-time communication, managing social interactions, and providing emotional support.[63]

Our study identified a range of perceptions among teachers regarding AI-assisted DL in the TPD context, encompassing both positive and negative aspects. Although AI-assisted DL is acknowledged for its potential to enhance instructional strategies, it is imperative to recognize its limitations. A significant concern, as highlighted by [60], is the risk of overuse and misuse, as excessive reliance on AI tools may hinder teachers' ability to develop their pedagogical skills.[64,65]

Identified the emotional challenges associated with AI integration, noting instances of increased anxiety and frustration among educators adapting to AI-driven methodologies. Another challenge, as noted by [66] that emotional challenges is the perceived difficulty of fostering meaningful discussion engagement in AI-supported learning environments, with some educators expressing skepticism about the depth of interaction facilitated by AI tools. [67] argued that trust issues related to AI adversely affect self-efficacy, fairness, ethics, and creativity in higher education contexts. These concerns underscore the necessity for thoughtful implementation strategies that balance the advantages of AI with measures to mitigate its potential drawbacks, ensuring that AI-assisted DL serves as a tool for enhancement rather than an impediment to meaningful pedagogy and professional growth.

This study distinguishes itself from prior research by introducing an innovative AI-assisted DLTPD model specifically designed to align Indonesian teacher competencies with advanced technology. By ensuring scalability

and replicability, this model offers a practical solution for rural regions facing similar educational challenges. This model facilitated teacher development by integrating AI-driven instructional strategies, interactive learning tools, and sustainable mechanisms for continuous professional growth. We assert that this model represents a pioneering approach to teacher training in rural contexts such as Indonesia, providing a scalable and adaptable solution to enhance educational outcomes in underserved areas.

Theoretically, this study contributes to global discussions on the integration of AI into education by exploring how technology can enhance teacher autonomy, promote interpersonal collaboration, and strengthen community-based pedagogical practices. The successful implementation of AI-assisted DLTPD necessitates coordinated efforts among policymakers, curriculum developers, educators, local governments, and national ministries, particularly Indonesia's Ministry of Education, Culture, Research, and Technology.

Furthermore, this new model serves as a theoretical foundation supporting Indonesia's national education agenda, specifically in preparing for a globally competitive golden generation by 2045. Through AI-driven instructional strategies, interactive learning tools, and sustainable mechanisms for professional growth, this model enables educators to cultivate competencies in religiousness, citizenship, communication, creativity, critical thinking, collaboration, health, and self-directed learning, all of which are essential in shaping competent and adaptive young professionals. By aligning AI-enhanced teacher training with Indonesia's long-term vision, this study underscores the importance of integrating advanced technology into TPD as a transformative solution to equitable and future-ready education. Policymakers must establish long-term strategies, ensure regulatory clarity, and allocate funding for AI-assisted teacher training. Curriculum developers should design culturally relevant AI-enhanced lesson plans, whereas local governments must bridge national education policies with grassroots initiatives to ensure effective teacher training and institutional support. By fostering collaboration between national and local education systems, AI-assisted TPD can empower educators and improve instructional quality, thereby contributing to global advancements in teacher development.

CONCLUSION

AI-assisted deep learning has been shown to significantly enhance teachers' professional development, as evidenced by improved test scores and positive feedback from educators. Teachers participating in AI-supported programs demonstrate greater advancements in pedagogical skills and knowledge than those in traditional settings, thereby affirming AI's role of AI in augmenting instructional effectiveness. Educators appreciate AI for its capacity to support adaptive teaching strategies, bolster professional growth, and foster emotional resilience, particularly in rural areas. AI-driven community-based learning promotes collaboration among teachers by providing scalable, locally tailored solutions.

Nonetheless, challenges persist, including emotional disengagement, cultural misalignment, curriculum changes, and the need for prompt engineering skills, which many educators lack and lead to ineffective lesson planning. To fully leverage AI's potential, institutions must implement continuous, culturally relevant training programs that empower teachers rather than supplant traditional instructional methods. By aligning AI with local educational needs, educators can bridge knowledge gaps, enhance lesson quality, and maintain autonomy in teaching practices, thereby ensuring that AI supports rather than disrupts professional growth.

Pedagogical implication

Beyond instructional tools, AI assists teachers in cultivating resilience, emotional intelligence, and ethical awareness, thereby transforming students into responsible citizens and leaders. AI also facilitates community-based learning by promoting peer collaboration and cultural adaptation while keeping educators informed about global trends. To fully harness the benefits of AI, training programs must transition from short-term interventions to long-term localized support to ensure that educators can effectively integrate AI without compromising autonomy or cultural relevance. This approach not only prepares students for the future but also preserves traditional values and human-centered education. Furthermore, the integration of AI into TPD in rural areas extends beyond mere knowledge transfer. It enhances students' self-responsibility as learners as well as their sense of citizenship and religiosity, a process referred to as deep learning.

Limitatation and recommendation

The integration of AI-assisted deep learning into teachers' professional development offers both opportunities and challenges, particularly those related to pedagogical adaptation, cultural relevance, and teacher autonomy. A significant limitation is the brief duration of AI training interventions, which often leaves educators, especially those in rural areas, without the requisite skills to effectively utilize AI. Many teachers encounter difficulties with prompt engineering, resulting in AI-generated materials that may be repetitive, misleading, or poorly aligned with local educational contexts. Furthermore, curriculum changes and pedagogical misalignment complicate AI adoption, underscoring the need for structured and contextualized training.

To address these issues, professional development programs should transition toward long-term immersive

learning experiences that integrate AI with Indonesia's teacher competencies (pedagogy, personality, interpersonal skills, and professionalism) to ensure that teachers can develop joyful, meaningful, and mindful teaching methods.

Institutions should prioritize community-driven learning, fostering AI literacy through peer collaboration, mentorship programmes, and culturally responsive AI adaptations. Additionally, education policymakers should establish guidelines that preserve teacher autonomy, ensuring that AI serves as a tool for enhancement rather than replacement. AI-assisted professional development should align with student-centered goals, nurturing critical thinking, communication, collaboration, health, self-directed learning, citizenship, and religious values. By implementing locally grounded AI training frameworks, educators can bridge technological advancements with human-centered pedagogy, creating a balanced approach that embraces innovation while maintaining foundational philosophies. This ensures that AI remains a supportive instructional tool rather than an obstacle to advancing professional development and holistic student learning outcomes.

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CONFLICT OF INTEREST

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