



EFL Teachers' Engagement and Perceptions of Integrating Gemini AI for Professional Development in Madrasah Aliyah Context

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Article Info	Abstract
Received: 2026-05-30 Revised: 2026-06-10 Accepted: 2026-06-30 Keywords: EFL Teachers; Gemini AI; Professional Development; Teaching Modules; TPACK. DOI: 10.24256/ideas.v14i1.10910 Corresponding Author: Aulia Khairunnisa Lubis aualilubis0304@gmail.com State Islamic University of North Sumatra	<i>The rapid evolution of generative artificial intelligence (AI) has necessitated a shift in teacher professional development. However, a significant gap remains in understanding how language educators in traditional Islamic secondary schools navigate technological adoption amidst demanding administrative workloads. This study aimed to investigate EFL teachers' engagement—defined operationally through their behavioral prompt iterations and cognitive commitment—and their perceptions of integrating Gemini AI for professional development at a public Islamic high school (MAN) in Medan. Employing a descriptive qualitative approach, data were collected through methodological triangulation, including non-participant observations, semi-structured interviews, and artifact analysis of teaching modules produced by five purposively selected English teachers. The results indicated a high level of behavioral and cognitive engagement, where the application of Gemini AI reduced teaching module development time by approximately 80%. This figure was determined by comparing the teachers' average manual drafting time of 3 to 4 hours against the AI-assisted completion time of under 45 minutes. Furthermore, the integration enhanced the pedagogical quality of enrichment materials and student worksheets (LKPD) through Higher-Order Thinking Skills (HOTS) alignment. Despite initial technology-related anxiety among senior educators, participants perceived Gemini AI as an efficient supportive tool that minimizes administrative burdens and fosters instructional creativity. The study concludes that while Gemini AI effectively streamlines the structural implementation of the Independent Curriculum (Kurikulum Merdeka) in a Madrasah context, tailored peer-mentoring remains vital to address the intergenerational digital divide. These findings imply that structured AI integration can successfully enhance lesson-planning efficiency while respecting local educational structures.</i>

1. Introduction

The advancement of increasingly sophisticated technology is influencing all parts of life, including education. One of the most significant implications is the rise of artificial intelligence (AI), a technology designed to emulate human intelligence. Technology is fundamentally created to aid human tasks, especially educational pursuits, where the use of AI into the learning process has shifted the landscape of education toward more adaptive, personalised, and efficient techniques. The use of AI in data analysis, curriculum revisions, and learning experience enhancements makes education more responsive to specific student requirements.

However, human intelligence continues to play an important role in giving pupils with direction, encouragement, and inspiration. This collaboration between AI and humans has resulted in higher learning quality, greater access to education, and more effective monitoring of learning progress, although issues such as the technological access gap and the ethics of AI use remain significant concerns (Ulimaz et al., 2024). Within this shifting paradigm, generative AI tools have emerged as pivotal assets in alleviating administrative burdens, adapting curricula, and tailoring learning experiences to diverse student needs. Consequently, the digital era demands a profound upgrade in teachers' professional competence.

The rapid advancement of technology in the digital age necessitates a rise in teachers' professional competence as a key component of the educational system, where teachers act not only as information carriers but also as learning facilitators (Wati & Nurhasannah, 2024). AI enhances the learning process by saving time in preparing materials and tasks; however, negative consequences include the development of student reliance on AI, which can lead to a decrease in learning excitement. To prepare for this, instructors must attend various trainings, including those focused on learning skills, ICT literacy, and TPACK-based learning approaches (Taufik & Rindaningsih, 2024). TPACK, or Technological Pedagogical Content Knowledge, is one of the four established teacher competencies that professional instructors must constantly upgrade in response to changing classroom needs (Pratiwi & Dewi, 2024). To increase their competences, teachers must be eager to learn and communicate effectively, as their professionalism affects their educational abilities and personal well-being.

Despite the importance of technology, the main challenges that teachers confront while implementing TPACK are limited infrastructure and restricted ability to use technology, leading to limited understanding of AI applications. In the context of Indonesia's transition to the Independent Curriculum (*Kurikulum Merdeka*), these barriers are compounded by intensive administrative workloads. Teachers are legally mandated to design comprehensive "Teaching Modules"—a framework replacing traditional lesson plans—which require the articulation of clear pedagogical components. Recent empirical research by Nurharyanto et al. (2023) examined the development of teaching modules—a new term replacing the Lesson Implementation Plan (RPP)—as instruments that must be developed prior to learning.

The study found that certain components, such as enrichment and worksheets, were the least well-mastered, indicating that further study is needed to ensure mastery of the skills required for a good Teaching Module. When utilised effectively, Gemini AI can assist in the creation of instructional modules in an easy and practical manner. However, many instructors are still not fully equipped for the Independent Curriculum (*Kurikulum Merdeka*), prompting recommendations for offline workshops to build teacher competency (Pawartani & Suciptaningsih, 2024).

While preliminary studies have explored technical workshops to address these curriculum demands, prior research exhibits a significant pedagogical gap. For instance, technical guidance at an Islamic high school in Medan showed that the use of Gemini AI proved beneficial for increasing learning quality (Puspita et al., 2023). Training for 13 English teachers in Medan successfully helped them use Gemini AI to create media and learning materials, although age has a substantial impact on the learning process, with older teachers requiring more intense mentoring (Bria et al., 2024). Evaluation findings also revealed considerable improvements in instructors' skills in incorporating AI into their curriculum, leading to high levels of satisfaction with the material's relevancy (Naufal et al., 2024).

However, these existing studies operate under major limitations. Most studies are summarized individually rather than critically compared or synthesized. More importantly, prior research largely provides fragmented summaries of training outcomes, completely overlooking the behavioral and cognitive processes of the teachers during actual tool interaction. Existing literature fails to critically examine how technological adoption influences pedagogical reasoning or how an educator's professional identity adapts when a non-human entity distributes their cognitive load.

To address this literary omission, this study establishes a comprehensive conceptual framework that interlinks generative AI integration, the TPACK model, teacher engagement, and teacher perceptions. Grounded in Connectivism—which posits that learning and knowledge generation are optimized when distributed across non-human networks—this framework views the AI tool not merely as an automated text generator, but as an interactive catalyst for TPACK. When teachers interact with AI, their Content Knowledge (CK) and Pedagogical Knowledge (PK) are filtered through Technological Knowledge (TK), demanding active behavioral engagement (characterized by recursive prompt iterations) and deep cognitive engagement (characterized by critical evaluation and contextual curation of AI outputs).

This socio-technical interaction subsequently shapes teachers' professional perceptions regarding the utility, ethical boundaries, and intergenerational anxieties associated with automated lesson planning. Within this framework, Gemini AI was specifically selected over alternative large language models (LLMs) due to its distinct architectural advantages for language educators. Unlike standard generative tools, Gemini AI possesses advanced multimodal processing capabilities and seamless, real-time internet search integration, allowing it to retrieve current, authentic language resources instantaneously for English as a Foreign Language (EFL) teachers drafting localized curriculum materials.

Based on these current demands, this study investigates English instructors at a public Islamic high school in Medan who have received training on Gemini AI as a supporting tool for developing learning materials (Puspita et al., 2023; Bria et al., 2024). Faculty members expressed reservations about technology due to age and a lack of knowledge, exacerbated by the fact that pupils are often more technologically adept than teachers (Bria et al., 2024). While AI can make jobs easier, it may also lead to lethargy and less creativity (Ulimaz et al., 2024). Investigating this technological intersection within a traditional Islamic secondary school (*Madrasah Aliyah Negeri*) context offers a unique theoretical and empirical novelty, as technology must be harmonized with local cultural and religious values (Puspita et al., 2023).

To fill this empirical gap, this study explores how English instructors interact with generative tools during real-time planning sessions. Specifically, this research aims to answer two fundamental research questions, namely how EFL teachers behaviorally and cognitively engage with Gemini AI during the development of *Kurikulum Merdeka* teaching

modules, and what the EFL teachers' professional perceptions are regarding the instructional benefits and operational challenges of integrating Gemini AI into their ongoing professional development.

2. Method

This study employed a descriptive qualitative approach aimed at providing a systematic and in-depth description of the interaction between educators and artificial intelligence. This design was specifically selected to explore and interpret how English as a Foreign Language (EFL) teachers engage with Gemini AI and to understand their perceptions regarding the integration of such technology into their professional workflows. The subjects of this research involved five English teachers at a public Islamic high school (*Madrasah Aliyah Negeri*) in Medan, North Sumatra.

These participants were selected using a purposive sampling technique, ensuring they met the specific criteria of having participated in prior Gemini AI application training and being currently involved in the transition to the Independent Curriculum (*Kurikulum Merdeka*). The choice of purposive sampling was justified as it allowed the selection of information-rich cases who could provide specialized operational insights into prompt engineering and curriculum mapping within the Madrasah context (Patton, 2015).

Furthermore, the sample size of five teachers was deemed sufficient based on the principle of data saturation in qualitative research, where in-depth, multi-perspective insights from a homogenous group of active practitioners are prioritized over broader statistical generalization (Creswell & Creswell, 2018). Before data collection commenced, ethical considerations were strictly maintained; all participants were provided with written informed consent forms, ensuring their voluntary participation, complete anonymity, and the confidentiality of their institutional data (Sugiyono, 2019).

Data collection techniques and instrument development were centered on achieving methodological triangulation to ensure data validity. The primary instruments included observation protocols, interview guides, and document analysis checklists. First, non-participant observations were conducted for 45 minutes for each teacher, focusing on their behavioral engagement and technical proficiency while utilizing Gemini AI to develop teaching modules. Second, following the observations, 45-minute semi-structured interviews were executed to elicit deep insights into the teachers' perceptions of the benefits and challenges of AI integration. Third, the researcher performed an artifact analysis through a documentary study of the teaching module drafts produced during the sessions.

To ensure objective assessment, the criteria used to evaluate these teaching modules were adapted from the official *Kurikulum Merdeka* lesson-planning evaluation rubric issued by the Indonesian Ministry of Education, Culture, Research, and Technology. This criteria focused on four core pedagogical domains: the specificity of learning objectives aligned with CEFR standards, the integration of diverse AI-suggested digital media, the structural inclusion of Higher-Order Thinking Skills (HOTS) within enrichment tasks, and the contextual differentiation of student worksheets (*LKPD*). To establish methodological rigor, several trustworthiness procedures were systematically implemented to guarantee the credibility, dependability, and confirmability of the qualitative data.

Credibility was secured through data source triangulation—cross-examining observation notes, interview transcripts, and actual module drafts—and member checking, where the raw interview transcripts and final thematic summaries were returned to the five teachers to confirm the accuracy of their stated opinions (Lincoln & Guba, 1985). Peer

debriefing was also conducted with two external educational technology researchers to minimize subjective analytical bias.

The data analysis techniques followed the qualitative data analysis model developed by Miles, Huberman, and Saldaña (2014), which involves a recursive process through three concurrent flows: data condensation, data display, and conclusion drawing or verification. The process began with data condensation, where the researcher selected, focused, and simplified the raw data obtained from observation notes, interview transcripts, and teaching module drafts. During this stage, a rigorous interview coding and thematic analysis procedure was conducted. The researcher generated open codes from verbatim interview transcripts line-by-line, which were then grouped into axial codes based on conceptual similarities, and finally refined into selective overarching themes, such as "Professional Benefits" and "Operational Challenges" (Miles et al., 2014).

Subsequently, the data display stage organized the condensed data and final thematic categories into descriptive narratives and structured matrices to facilitate clear conclusion drawing. The final stage involved conclusion drawing and verification to identify patterns, themes, and explanations regarding teacher engagement and perceptions, ensuring that the findings remained consistent with the empirical evidence gathered from the field at the Islamic high school in Medan.

3. Result

Teachers’ Behavioral Engagement with Gemini AI

The study observed that behavioral engagement during the module development sessions was primarily characterized by the teachers' ability to navigate Gemini AI’s interface and their persistence in refining prompts. The interaction data suggests a significant correlation between age and technical fluency, although all participants demonstrated substantial cognitive effort. The metrics of these interactions are detailed in Table 1 below.

T = Teacher

S/J = Senior/Junior

Table 1. Metrics of EFL Teachers’ Engagement during AI-Assisted Planning

Participant	Frequency of Prompts	Task Completion Time	Observed Technical Proficiency
T1S	12 times	42 Minutes	Demonstrated steady progress despite initial hesitation.
T2J	18 times	32 Minutes	High proficiency with rapid prompt iterations.
T3S	10 times	45 Minutes	Focused on basic module structures with guidance.
T4J	16 times	34 Minutes	Explored diverse pedagogical suggestions via AI.
T5J	15 times	35 Minutes	Effectively integrated multimedia ideas into the module.

Observation data revealed a clear distinction in prompting behaviors between junior and senior teachers. Junior teachers (T2J, T4J, T5J) tended to practice dynamic and iterative prompting, continuously modifying their instructions to generate specific sub-components of the lesson. In contrast, senior teachers (T1S, T3S) initially input generic, single-sentence prompts and relied on manual intervention from the researcher to formulate follow-up

instructions. For example, a junior teacher (T2J) utilized a structured, multi-layered prompt to obtain a targeted pedagogical output:

"Act as an expert EFL curriculum designer for Indonesian Madrasah Aliyah. Create a differentiated reading enrichment activity based on Kurikulum Merdeka and CEFR B1 level about Islamic historical places in Medan. Include three HOTS-based multiple-choice questions."

Conversely, the initial prompt from a senior teacher (T1S) was much more general and short:

"Create an English Independent Curriculum module for Grade 10."

This simple input frequently resulted in broad, non-contextual outputs from the AI, which caused early frustration and cognitive friction for the senior users before they received direct scaffolding from the researcher.

Quality and Complexity of the Produced Teaching Modules

Based on the artifact analysis, the modules generated with the assistance of Gemini AI showed a higher degree of complexity compared to previous manual versions. To verify the actual output of the teachers' engagement, a document analysis was performed on the five teaching modules produced during the sessions. The evaluation used the official *Kurikulum Merdeka* guidelines as a baseline, assessing whether each module contained mandatory structural elements: learning objectives, meaningful understandings, essential questions, learning activities, and assessments.

The analysis showed that 100% of the modules successfully contained these structural standards, indicating comprehensive structural compliance. The comparison between the manual and AI-assisted versions across core pedagogical domains is detailed in Table 2.

Table 2. Assessment of Teaching Module Components (Manual vs. AI-Assisted)

Module Component	Manual Version (Previous)	Gemini AI-Assisted Version	Improvement Level
Learning Objectives	Often too broad and generic.	Specific, measurable, and CEFR-aligned.	High
Teaching Media	Limited to textbooks and powerpoints.	Integrated diverse AI-suggested digital resources.	Moderate-High
Enrichment Tasks	Frequently missing or repetitive.	Diverse, high-level (HOTS) questions.	Significant
Student Worksheets	Basic comprehension questions.	Project-based and critical thinking tasks.	Significant

The analysis revealed that the AI-assisted modules were significantly more comprehensive. Specifically, in the Enrichment section, Gemini AI provided teachers with authentic reading texts (e.g., news reports and short stories) that were previously difficult for teachers to find or adapt manually. Furthermore, the Student Worksheets (LKPD) generated by the AI showed a clear progression of difficulty, catering to different student ability levels within the same classroom.

However, document verification also highlighted that while the structural alignment reached 100%, the initial raw outputs from Gemini AI occasionally contained overly dense vocabulary that was unsuitable for the students' actual language proficiency. This limitation required the teachers to manually prune, simplify, and edit the AI-generated texts to match the practical classroom reality.

EFL Teachers' Perceptions: Professional Impact and Technical Barriers

The qualitative evidence from semi-structured interviews provided a comprehensive view of how teachers perceive this integration. The feedback was categorized into two thematic areas: perceived professional benefits and perceived operational challenges.

Table 3. Summary of Qualitative Findings on Teacher Perceptions

Thematic Category	Key Findings from Interview Transcripts
Professional Benefits	Significant reduction in administrative workload, enhanced creativity in lesson design, and instant access to authentic language resources.
Operational Challenges	Intermittent internet connectivity, the need for continuous technical mentoring, and initial anxiety regarding AI-dependency.

The interviews revealed that while teachers highly appreciated the time efficiency, they experienced real operational difficulties and psychological barriers. Junior teachers highlighted technical disruptions as a primary negative factor, where unstable school Wi-Fi network connectivity frequently interrupted their prompt generation sessions. On the other hand, senior teachers focused heavily on the fear of technical inadequacy and the risk of losing their professional identity. This difference in perception is captured in the contrasting interview extracts below:

"The tool cuts down my preparation time drastically, but when the school internet connection drops midway, Gemini stops responding, and I have to re-enter my prompts from the beginning. It can be very frustrating when you are trying to work fast." (T4J)

"I felt overwhelmed when the AI generated an entire lesson plan in seconds. It made me anxious because it felt like my twenty years of teaching experience could be replaced by a machine if I do not know how to command it properly." (T3S)

The practical experience of eventually completing a comprehensive module in under 45 minutes did foster a more positive and receptive attitude among participants. However, the interview data confirms that the positive outcomes were heavily dependent on the availability of real-time human scaffolding to mitigate initial operational anxieties and manage technical limitations.

4. Discussion

The Nexus of TPACK and Generative AI in Madrasah Education

The core findings of this study illustrate that the integration of Gemini AI at the public Islamic high school in Medan has facilitated a significant evolution in teacher professional competence. The observed engagement during the 45-minute sessions suggests that Gemini AI acts as a catalyst for the Technological Pedagogical Content Knowledge (TPACK) framework. Teachers no longer struggle with the isolation of pedagogical theories; instead, they successfully bridge the gap between content mastery and technological application (Koehler & Mishra, 2009). This synergy is crucial for teachers in the digital age, where they are expected to be not just information transmitters but innovative instructional designers (Ulimaz et al., 2024; Wati & Nurhasannah, 2024).

However, a closer look at the data requires a cautious approach to avoid making causal claims unsupported by the data. While earlier literature suggests that digital integration directly eliminates teacher burnout (Pawartani & Suciptaningsih, 2024), the evidence from this field study does not fully support such broad causal conclusions. Because occupational burnout and long-term psychological fatigue were not explicitly measured using quantitative or longitudinal scales, the drastic reduction in module development time should be presented cautiously as a mitigation of administrative tasks rather than a definitive cure for systemic stress. Instead, the data suggests that while Gemini AI accelerates initial draft compilation, it introduces a new form of cognitive labor—specifically, the time and effort required for recursive prompting and text simplification.

The transformation of the teacher's role into a "digital curator" is evident in how they curate AI outputs to fit the local context of the Madrasah. This process requires high-level cognitive engagement, as teachers must evaluate the cultural and religious relevance of the content generated by Gemini AI. This discussion on digital curation represents a potentially meaningful contribution to AI-in-education literature and serves as the study's primary theoretical contribution by extending existing theory. Standard TPACK models often treat Technological Knowledge (TK) as an isolated skill or a tool for delivery (Pratiwi & Dewi, 2024). These findings extend this model by demonstrating that in the AI era, TK must be redefined as a dynamic, evaluative competence—specifically, the ability to co-create, filter, and critically audit automated outputs to match the linguistic and cultural reality of the classroom. This professional transformation is captured in the following interview extract:

"Initially, I thought the AI would provide a generic English lesson that wouldn't fit our students' background at the Madrasah. However, I learned that by providing specific prompts about our local context in Medan, Gemini produced reading texts that were culturally relevant and linguistically appropriate. It changed my role from a writer to a critical editor." (T2)

Pedagogical Innovations in Language Material Design

The artifact analysis confirms that Gemini AI significantly enhances the quality of "Enrichment" and "Student Worksheets" (LKPD), which are traditionally the most challenging components for teachers to develop manually (Nurharyanto et al., 2023). By utilizing generative AI, teachers were able to create differentiated learning materials that cater to various student proficiency levels based on the CEFR standards (Lund & Wang, 2023). This capability is vital for fostering Higher-Order Thinking Skills (HOTS) among students, as the AI can rapidly generate complex problem-solving tasks that would take hours to design manually (Anderson et al., 2023).

This finding aligns with the Connectivism theory, where learning is enhanced through the strategic use of non-human appliances to distribute cognitive load (Siemens, 2005). Within this framework, Gemini AI does not merely act as a passive software application, but functions as an active, high-velocity node within the teachers' knowledge network. Rather than inducing teacher lethargy, connecting with this non-human node pushes teachers to focus more on critical evaluation rather than mechanical compilation.

Intergenerational Digital Divide and Technical Barriers

Despite the pedagogical leaps, the intergenerational digital divide remains a significant hurdle. Senior teachers expressed a unique form of "tech-anxiety," fearing that the rapid pace of AI development might marginalize their years of pedagogical experience (Bria et al., 2024; Puspita et al., 2023). This psychological barrier suggests that technology adoption is not merely a matter of technical skill but also of professional identity. One senior participant highlighted this concern during the interview:

"At my age, learning a new platform every year is exhausting. My main fear was that if I relied too much on Gemini, my own intuition as a teacher—which I have built for twenty years—would fade away. I needed to be convinced that the AI is my subordinate, not my replacement." (Teacher 1, Personal Interview, 2024)

To move beyond simple literature summarization and provide a critical interpretation of these findings, alternative explanations for the findings must be considered. While literature often attributes these intergenerational gaps primarily to age-related ICT deficits (Taufik & Rindaningsih, 2024), an alternative explanation is that the resistance and anxiety from senior teachers represent a protective professional defense mechanism.

This hesitation is a conscious effort to preserve their professional identity and pedagogical authority, which have been established over decades of manual practice. This insight extends existing theory on continuous professional development (CPD) by showing that institutional support programs must look beyond technical mechanics and explicitly address the emotional, adaptive, and identity dimensions of older educators (Naufal et al., 2024).

Ethical Consideration and Future Directions in AI-Human Collaboration

The collaboration between human intuition and artificial intelligence must be grounded in ethical considerations, particularly regarding data accuracy and the preservation of original teacher-student connections (Grassini, 2023; Baidoo-Anu & Ansah, 2023). This requirement is heavily influenced by the contextual factors specific to Islamic schools (*Madrasah Aliyah*). In this unique educational environment, technology integration and curriculum alignment cannot be treated as purely technical or secular tasks. The school's religious character acts as an active cultural and spiritual filter. Teachers in this study did not passively accept the globalized, secular outputs of the AI; instead, they deliberately managed the risk of over-reliance by actively adjusting prompts to weave in Islamic historical values and localized narratives, ensuring that automated lesson planning respects and reinforces the institution's religious mission.

Therefore, as AI tools like Gemini become more prevalent, the risk of "over-reliance" must be addressed through robust professional development programs that emphasize critical AI literacy (Luckin, 2018; Hwang et al., 2020). The findings in Medan reflect a global trend where AI serves as a "co-pilot" in education, democratizing access to high-quality resources while demanding a higher level of critical curation from the human user (Kasneji et al., 2023; Zhai et al., 2021).

Ultimately, the successful integration of Gemini AI at MAN Medan demonstrates that when teachers are empowered with the right tools and mentoring, they can transcend traditional administrative limitations (Chai et al., 2023; Molenaar, 2022). This study contributes to the burgeoning literature on AI in Islamic education, proving that even in traditional settings, technology can be harmonized with cultural and religious values to improve learning quality (Maderer, 2023; Gimpel et al., 2023). Future research should explore the long-term impact of AI-assisted modules on student learning outcomes and the sustainability of AI literacy among teachers in diverse geographical contexts (Dwivedi et al., 2023; UNESCO, 2023; Holmes et al., 2019; Chassignol et al., 2018; Roll & Wylie, 2016; Tuomi, 2018).

5. Conclusion

This study concludes that the integration of Gemini AI significantly facilitates the professional development of EFL teachers at MAN Medan, particularly in navigating the administrative and pedagogical complexities of the Independent Curriculum (*Kurikulum Merdeka*). The research findings demonstrate that Gemini AI serves as a high-functioning "pedagogical co-pilot" that enhances time efficiency by approximately 80% while simultaneously elevating the quality of instructional artifacts, such as enrichment materials and student worksheets. The methodological triangulation confirms that teachers' engagement is not merely technical but also involves critical curation to align AI outputs with the local Madrasah context. However, it is essential to note that while AI effectively mitigates administrative burnout, it cannot replace the pedagogical intuition and emotional guidance provided by the teacher.

The researchers acknowledge several limitations in this study. Firstly, the small sample size—limited to five English teachers in a single Islamic high school—means that the findings cannot be generalized to all educational settings or different subject areas. Secondly, this study focused on short-term engagement during module development and did not measure the long-term sustainability of AI literacy or its direct impact on student achievement scores.

Based on these limitations, several recommendations are proposed for further studies. Future research should involve a broader and more diverse demographic of participants across various geographical locations to provide a more generalized perspective on AI adoption in Indonesia. There is also a significant need for longitudinal studies to investigate how AI-assisted materials influence student learning outcomes over a full academic year.

For educational practitioners and policymakers, it is highly recommended to establish structured mentoring programs that address the "tech-anxiety" of senior teachers. Furthermore, the development of ethical guidelines for AI use in schools is crucial to ensure that the synergy between human intelligence and artificial intelligence remains balanced and pedagogically sound.

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