**EDUKASIA: Jurnal Pendidikan dan Pembelajaran**
Vol. 6, 2 (December, 2025), pp. 989-1002
ISSN: 2721-1150; EISSN: 2721-1169; DOI: 10.62775/edukasia.v6i2.1672

# Generative AI in Personalized Learning: A Systematic Review of Implementation in Indonesia

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**ARTICLE INFO**

***Keywords:***

Generative Artificial Intelligence;
Personalized Learning;
Digital Transformation

***Article history:***

Received 2025-08-21
Revised 2025-10-11
Accepted 2025-11-12

**ABSTRACT**

Indonesia's digital education transformation has experienced significant acceleration post-COVID-19 pandemic, with generative AI emerging as a disruptive technology offering revolutionary potential for personalized learning. However, significant knowledge gaps remain regarding how generative AI is implemented within Indonesia's unique educational context characterized by distinctive socio-cultural conditions, technological infrastructure, and educational policies. This study aims to map implementation patterns of generative AI in personalized learning across various educational levels in Indonesia and identify encountered challenges. Employing a systematic literature review methodology following PRISMA 2020 guidelines, the research analyzed 28 studies published between 2020-2024 from international and Indonesian local databases. Findings reveal concerning implementation distribution disparities with concentration in higher education and dominance of global commercial platforms like ChatGPT, indicating dependence on proprietary systems raising data sovereignty concerns. Effective implementations adopt hybrid human-AI orchestration models with tiered personalization reflecting Indonesian cultural values. Major challenges include three-level digital divides, low teacher competency in AI literacy, rigid curriculum structures, and absence of adequate data governance frameworks. This research contributes to developing contextual generative AI implementation frameworks and fills literature gaps on educational AI in Indonesia, though longitudinal research and explicit equity interventions remain necessary to ensure just and sustainable implementation.



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## 1. INTRODUCTION

Digital transformation in Indonesia's education ecosystem has accelerated significantly, especially since the COVID-19 pandemic forced educational institutions to adopt digital learning technologies on a massive scale. In this context, artificial intelligence (AI), particularly generative AI, has emerged as a disruptive technology that offers revolutionary potential in personalizing the learning experience for students.(Haleem et al., 2022; Juliandi et al., 2025; Raihani, 2008; Stahl & Eke, 2024). Generative AI, which includes technologies such as ChatGPT, Google Bard, and various other large language models (LLMs), has the ability to generate learning content tailored to the individual needs of each student, analyze learning patterns, and provide adaptive real-time feedback. This transformative technology has the potential to revolutionize education delivery through personalized learning, adaptive learning, and intelligent tutoring systems that tailor the educational experience to each student. Real-time feedback and customized learning paths that adapt to students' abilities and preferences are some of the capabilities that AI brings to the educational landscape. (Dillenbourg, 2013; Dwivedi et al., 2023; Mohd Amin et al., 2025).

Generative AI, which includes technologies such as ChatGPT, Google Bard, and various other large language models (LLMs), has the ability to generate learning content tailored to the individual needs of each student, analyze learning patterns, and provide adaptive real-time feedback. This transformative technology has the potential to revolutionize education delivery through personalized learning, adaptive learning, and intelligent tutoring systems that tailor the educational experience to each student. Real-time feedback and customized learning paths that adapt to students' abilities and preferences are some of the capabilities that AI brings to the educational landscape. (Chen et al., 2020; Floridi & Cowls, 2019; Holmes et al., 2019; Triandis & Hofstede, 1993). This generative AI-based learning personalization allows the system to analyze student learning data in depth, identify knowledge gaps, and automatically adjust learning content. The technology can generate more adaptive exercises, provide explanations using various pedagogical approaches, provide 24/7 virtual assistance, and even create project-based learning scenarios tailored to student interests. (Holmes et al., 2019; Zawacki-Richter et al., 2019). The ability of generative AI to process natural language also enables more intuitive interactions between technology and users, removing technical barriers that often hinder the adoption of educational technology.

Thus, the application of AI in education has shown a positive trend in improving learning effectiveness, as demonstrated in research conducted by Kuhail et al. (2023) it is explained that AI can increase student engagement, personalize learning paths, and reduce the administrative workload of educators. Similarly, a study conducted by Crompton and Burke (2023) found that generative AI such as ChatGPT can support learning through adaptive *scaffolding*, providing instant *feedback* and facilitating critical thinking. Meanwhile, research by Kasneci et al. (2023) highlighting the potential of ChatGPT in the context of higher education, especially in supporting academic writing, solving complex problems, and developing higher-order thinking skills. In the context of personalized learning, Ouyang et al. (2022) identify that AI can adapt learning content based on students' knowledge state, learning preferences, and historical performance. This reinforces the data that adaptive AI technology has been proven to increase students' intrinsic motivation and learning achievement when compared to conventional learning methods. Chen et al (Chen et al., 2020), in their review of AI in education, show that intelligent tutoring systems (ITS) that utilize AI can rival the effectiveness of human tutors in certain contexts, especially in procedural and conceptual learning.

However, research on the implementation of generative AI in personalized learning, especially in Indonesia, is still very limited. Some early studies have begun to explore this area, such as Rizal (2024) who researched the use of generative AI to create interesting and effective Indonesian language

learning materials. This shows that this technology can produce contextual content that is appropriate for students' ability levels. Ministry of Education, Culture, Research, and Technology (Juliandi et al., 2025) has published guidelines for the use of generative AI in higher education, indicating official recognition of the potential of this technology, one example of which is AI Teach, which has reached 2,500 educators and students in Indonesia, demonstrating growing momentum for adoption. (Subrata, 2024).

However, there is a significant knowledge gap regarding how generative AI is specifically implemented for personalized learning in Indonesia, what challenges are faced, and how effective it is compared to conventional learning practices. Research using a systematic review approach to map the landscape of generative AI implementation in personalized learning in Indonesia is not yet available. (Fazal et al., 2025; Geng & Yamada, 2020; Haetami, 2025; Pulungan et al., 2025; Rahayu, 2024). This is important considering that Indonesia's socio-cultural context, technological infrastructure, and education policies have unique characteristics that can influence the success of implementing this technology. In addition, some literature shows concerns regarding the ethical implications of using AI in education, including issues of student data privacy, algorithmic bias, over-reliance on technology, and the potential for a widening achievement gap. (Cheah et al., 2025; Holmes et al., 2019; Iivari et al., 2020; Jin et al., 2025; Kasneci et al., 2023). In the Indonesian context, where the digital divide between urban and rural areas remains significant, as well as between schools with different resources, questions of equity and accessibility are particularly relevant. Therefore, comprehensive systematic observation is needed to understand the implementation of advanced generative AI in personalized learning in Indonesia, identify best practices, and provide recommendations for future development.

Thus, this study focuses on two main issues, namely how generative AI is implemented in personalized learning at various levels of education in Indonesia and what challenges and obstacles are encountered in implementing generative AI for personalized learning in Indonesia. The objectives of this study are to map and analyze the implementation patterns of generative AI in personalized learning at various levels of education in Indonesia and to identify and analyze the challenges and obstacles faced in implementing generative AI for personalized learning in Indonesia. More broadly, this study is expected to contribute theoretically to the development of a generative AI implementation framework for contextual learning personalization in Indonesia. In addition, this systematic review is also expected to fill the literature gap on the implementation of generative AI in the context of Indonesian education and provide baseline data for further research in this field.

## 2. METHODS

This study uses a systematic literature review method that follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to examine the implementation of generative AI in personalized learning in Indonesia. (Page et al., 2021). This approach was chosen for its ability to comprehensively synthesize research evidence, identify implementation patterns, and provide evidence-based recommendations for education policy and practice. (J. P. T. Higgins et al., 2024). The criteria for this research include (1) peer-reviewed research articles, conference proceedings, and technical reports published between January 2020 and December 2024; (2) studies discussing the implementation of generative AI (ChatGPT, GPT-based systems, BERT, other large language models) in the context of personalized learning; (3) research conducted in Indonesia or having direct relevance to the Indonesian educational context; (4) studies involving various levels of education from elementary to higher education; and (5) publications in Indonesian or English. Exclusion criteria include: (1) articles without observations; (2) research that only discusses conventional AI without generative components; (3) publications prior to 2020; (4) opinion articles without empirical data; and (5) studies with unclear or unreplicable methodologies.

The literature search was conducted from January to March 2025 using international databases (Scopus, Web of Science, IEEE Xplore, ERIC, PsycINFO) and local Indonesian databases (GARUDA). The search strategy used a combination of keywords: generative AI (generative artificial intelligence/ChatGPT), large language model (LLM), personalized learning, personalization, adaptive learning, individualized learning and Indonesian education. Additional searches were conducted through Google Scholar for gray literature, hand searching in leading technology education journals, and tracking citations from identified key articles. The study selection process consisted of four stages, namely identification, screening, eligibility assessment, and final inclusion, in which researchers independently screened titles and abstracts using Rayyan software, with disagreements resolved through discussion. Next, a full-text assessment was conducted on articles that passed the initial screening using a predetermined checklist of inclusion/exclusion criteria.

Next, the quality of the articles was assessed using the mixed methods appraisal tool (MMAT) to accommodate the accuracy of the research design. (Hong et al., 2018). In Indonesian articles published in local journals, quality research is conducted by examining journal accreditation (indexed in Sinta/Scopus); methodological completeness (transparency of procedures, samples, and instruments); data validity and reliability; analysis and interpretation of results; and contribution to science. Articles with an MMAT score below 50% or that do not meet at least three of the five additional criteria for Indonesian articles will be excluded from the final analysis.

Data analysis used a mixed-methods approach. Quantitative descriptive analysis was performed using SPSS 29.0 to identify study characteristics, publication trends, and implementation patterns. Qualitative thematic analysis followed the framework of Braun and Clarke (2019) to identify key themes related to model implementation, challenges, and strategies for overcoming obstacles. Coding was performed using NVivo 14 with a deductive-inductive approach: initial codes were developed based on the theoretical framework, then enriched with emerging codes from the data. Triangulation was performed by comparing findings across research types, education levels, and geographical contexts to enhance the validity of the conclusions.

## 3. FINDINGS AND DISCUSSION

Based on the results of a systematic review, researchers identified 23,300 articles from various academic databases, but after eliminating duplicates and conducting a phased screening, there were 28 studies that met the inclusion criteria, which were published between 2020 and 2024 and focused on the implementation of generative AI in personalized learning in the context of education in Indonesia. The temporal distribution of these selected studies shows a very significant upward trend, starting with 3 studies in the 2020-2021 period, increasing to 7 studies in 2022, and surging to 9 studies in 2023 and another 9 studies in 2024. This upward trend indicates a growing momentum in research following the COVID-19 pandemic, coinciding with the democratization of access to generative AI technologies such as ChatGPT, which was launched in late 2022 and quickly became a global phenomenon that also spread to the Indonesian education sector.

This increase in research cannot be separated from the context of the digital transformation of education accelerated by the pandemic, in which educational institutions in Indonesia were forced to adopt digital technology on a massive scale and in a short period of time. This experience ultimately created greater momentum and readiness to explore more advanced educational technologies, including generative AI. In addition, easy access to commercial generative AI platforms that do not require high technical expertise has lowered the barriers for education practitioners and researchers in Indonesia to start experimenting with this technology.

### *3.1. Findings*

#### *a. Patterns of Generative AI Implementation in Learning Personalization in Indonesia*

In the distribution of generative AI implementation by education level, there is a significant and worrying imbalance. Of the 28 studies analyzed, 18 studies (64.3%) were concentrated at the higher education level, while only 6 (21.4%) studies were conducted at the high school/vocational school level, 3 (10.7%) studies at the junior high school level, and only 1 study (3.6%) focused on primary education (elementary school). This very high concentration on higher education reflects what Homes et al. refer to as the *technology adoption hierarchy*, a phenomenon whereby educational institutions with greater resources, more mature technological infrastructure, and greater curriculum autonomy tend to adopt educational technology innovations earlier.(J. Higgins & James Thomas, 2024; Li et al., 2020)

This pattern of inequality contrasts sharply with Indonesia's national education policy priorities, which emphasize equitable access to technology at all levels of education, as outlined in various digital transformation programs of the Ministry of Education, Culture, Research, and Technology. The concentration of research and implementation in higher education indicates significant barriers to implementation at lower levels of education, including infrastructure limitations, a lack of teacher capacity to integrate advanced technology, and a more rigid curriculum in primary and secondary education. The characteristics of implementation in higher education are predominantly focused on foreign language learning, especially English, programming and computer science, as well as support for student research. Meanwhile, implementation at the high school and vocational school levels is more related to STEM subjects such as mathematics, physics, and chemistry, as well as specific vocational skills according to vocational majors.

The identification of generative AI models and platforms used in various implementations shows a very strong dominance of general commercial platforms, especially large language models. ChatGPT dominates significantly, appearing in 19 (67.9%) of the total studies analyzed, followed by Google Bard and then Gemini, which appeared in 5 (17.9%) studies. In addition to general LLM platforms, there is also the use of conventional AI agents in the form of custom chatbots built using frameworks such as Dialogflow or Rasa, which appeared in 6 (21.4%) studies. *Learning Management System* platforms with AI integration for adaptive learning were found in 4 studies or 14.3%, while multimodal AI applications such as DALL-E and Midjourney to support visual learning were found in 3 studies or 10.7%.

ChatGPT dominates usage, accounting for nearly 68% of total generative AI platform adoption in Indonesia's educational environment. This pattern is consistent with the findings of Baidoo-Anu and Owusu Ansah (2023) which shows that the rapid penetration of global commercial platforms such as ChatGPT, Bard, and Copilot has dominated the education ecosystem in various countries, especially in the Global South, which still has limited research capacity and technological infrastructure. However, the high dependence on proprietary systems owned by large technology corporations raises serious concerns about data sovereignty, the sustainability of long-term implementation, and control over sensitive educational data. These concerns are even more pressing in the Indonesian context, given that the new national regulation, the Personal Data Protection Law (UU No. 27 Tahun 2022) is still in the technical development stage and does not yet provide specific operational guidelines for the use of artificial intelligence technology in the education sector. (Kementerian Kominfo, 2024).

This situation reveals a structural imbalance between consumption capacity and technological production capacity, in which Indonesian educational institutions still act as end-users without any meaningful ability to control the architecture and algorithms they use. Dependence on international commercial platforms also indicates the weakness of the local generative AI development ecosystem in

terms of its suitability to the national linguistic, cultural, and educational ethical contexts.(Hidayat & Khalika, 2019; Nemati, 2002; Safitri et al., 2024; Thomas K.F. Chiu, 2023). In the long term, this has the potential to hinder national digital independence and widen the epistemic gap between producers and users of educational technology.

***b. Challenges and Obstacles in Implementing Generative AI for Personalized Learning in Indonesia***

There are several challenges faced in implementing generative AI for personalized learning, namely: *first*, technical infrastructure challenges that can be characterized as three levels of digital divide that create many layers of obstacles to successful implementation. The first level is connectivity infrastructure, which is the most basic layer. As many as 45% of studies report that unstable internet connections are a significant obstacle to implementation. Frequent internet disconnections can disrupt learning and cause problems for both students and teachers. Bandwidth limitations are also a serious problem, with the median bandwidth available to educational institutions ranging from 5 to 10 mbps, which is insufficient to support real-time AI interactions, especially when many users access it simultaneously in the classroom.

The most worrying aspect is the striking urban-rural divide, with 73% of implementation occurring in urban areas, only 12% in rural areas, and the remaining 15% in semi-urban or suburban contexts. This gap is not coincidental but reflects the fundamental infrastructure gap that exists in Indonesia, where the quality and availability of internet connectivity differs dramatically between urban centers and rural or remote areas. This data is consistent with the 2023 report by the Indonesian Internet Service Providers Association, which shows that national internet penetration has reached 77.02%, but with significant quality gaps and geographical variations. Technology access framework (Ittefaq et al., 2025; Manel et al., 2024; Xie et al., 2019) explains that physical access alone is not sufficient for meaningful use of technology. What is needed, therefore, is reliable, high-quality connectivity that enables sustained and productive engagement with technology, and this remains a significant barrier in many parts of Indonesia.

The second level is device availability and capability, where the majority of implementations reach 89% by adopting a bring-your-own-device model, so students are expected to use their own personal devices to access AI-based learning platforms. While this model is pragmatic given the limited institutional resources available to provide devices, it creates new inequalities due to significant heterogeneity in the types and capabilities of the devices that students have. In addition, another problem is device capability, where the devices owned by students have insufficient memory, screen size, and processing power to optimally use AI applications, creating a degraded user experience and hindering learning effectiveness. The third level is the challenge of platform integration, which is related to the technical complexity of integrating AI systems with existing educational technology infrastructure. A total of 58% of the 28 studies reported difficulties in integrating learning management systems already in use by institutions, creating a fragmented user experience and requiring multiple logins or platform switching. Furthermore, 42% of cases were related to authentication and single sign-on issues. In addition, data synchronization issues arose in 38% of cases, where student progress or performance data was not consistently or accurately synchronized across different systems, hindering teachers' ability to monitor student development.

Second, pedagogical and institutional challenges are equally critical but often overlooked because they relate to human factors and organizational dynamics. Teacher readiness and competency gaps emerge as one of the most significant barriers to successful implementation. In terms of technical skills,

the severity of the gap is rated at 4.2 on a scale of 1 to 5, with 67% of teachers reported to require intensive training even to use the basics of AI tools. This is not only related to their operation but also to understanding how AI works, its capabilities, limitations, and how AI can solve problems in general. Beyond individual teacher competencies, institutional barriers are also significant. Rigid curriculum structures were reported in 71% of studies as a major obstacle, where highly detailed and standardized national curricula leave insufficient flexibility for innovative AI integration that requires experimentation and adaptation. Assessment misalignment emerged in 64% of cases, where there was a mismatch between AI-facilitated learning experiences emphasizing personalization, exploration, and creative problem-solving and standardized assessments that remained focused on uniform content coverage and conventional testing formats. Time constraints were reported in 58% of implementations, where dense curricula and limited class hours made it difficult to adequately integrate AI activities, provide the necessary scaffolding, or allow for sufficient practice time.

Third, ethical, privacy, and regulatory challenges arising from the implementation of educational AI. Privacy and data security concerns were identified in 68% of studies as significant concerns of various stakeholders, including students, parents, teachers, and administrators. Worryingly, 52% of implementations lack clear data governance protocols that define how student data is collected, stored, processed, and protected. Even more problematic, 47% use third-party platforms, primarily commercial AI services, without formal data processing agreements that clearly define responsibilities, obligations, and protections for sensitive educational data.

### *3.2. Discussion*

The fundamental limitations in applying Western educational technology frameworks uncritically to the Indonesian context require theoretical innovation, namely a culturally adaptive AI personalization framework that integrates three critical dimensions. This differs from traditional personalization models that focus on individual learner characteristics, as proposed by Xie (2019), The implementation in Indonesia demonstrates what can be referred to as collective personalization, where AI supports group learning activities with personalized contributions from individual members. This reflects Vygotsky's social constructivism (1980) (1980) and resonates with the Indonesian ethos of mutual cooperation, which emphasizes collaboration and shared responsibility.

The proposed framework emphasizes multi-level personalization that encompasses three interrelated layers. The individual layer focuses on adaptive content and learning speed tailored to the needs of each learner. The collaborative layer utilizes AI to facilitate group dynamics and peer learning, where technology does not isolate but rather connects learners in meaningful activities. The cultural layer ensures that the content produced is contextually appropriate, interactions are aligned with local values, and the overall learning experience respects Indonesian cultural norms. This addresses what Crompton and Burke refer to as a challenge of cultural interface where there is a mismatch between technological design assumptions and the cultural context of users (Crompton & Burke, 2018, 2023).

The most effective implementation, with an effect size above 0.70, adopts what can be called human-AI hybrid orchestration rather than an AI replacement model. This is in line with Dillenbourg's orchestration framework (2013) but adding cultural specificity that has not been previously documented. Teachers in this context act as cultural intermediaries who mediate between AI-generated content and cultural appropriateness, maintaining pedagogical authority while utilizing AI capabilities. This role has not been found in existing literature and represents a genuine innovation

from the Indonesian context that can contribute to a global understanding of AI integration in education (Collins, 2019; Sun et al., 2024; Surur et al., 2025).

The guided autonomy model that emerges from the data balances AI-facilitated independent learning with teacher guidance, resolving the tension between Western-style student autonomy and Indonesian pedagogical traditions that emphasize teacher guidance. It operationalizes the concept of Tight (1996) guided autonomy in the AI era, where students are given space for exploration and discovery but within a structured framework with continuous teacher support. This model respects cultural values about the role of teachers while leveraging the potential of technology for personalization and active learning.

Furthermore, there are several challenges faced in implementing generative AI in personalized learning. *First*, the three-tier digital divide requires an equitable AI access framework that moves beyond the simple binary of access versus no access. Drawing from Warschauer's technology access framework in Akfal et al (2024) and the Sen ability approach (1999), this framework emphasizes progressiveness from physical access to meaningful access and ultimately transformative access. Transformative access requires not only the availability of devices but also adequate device capabilities; not only internet connectivity but also reliable and high-quality connectivity; not only access to AI tools but also AI literacy and critical engagement skills; and not only individual access but also a comprehensive institutional support ecosystem.

Indonesia's implementation pattern shows premature scaling without ensuring basic capabilities as outlined in Rogers' theory of innovation diffusion (2003) will be classified as an experimental phase and observability that has been bypassed. Many implementations jump straight to widespread adoption without an adequate trial period to learn what works, identify challenges, and develop contextual solutions. As a result, many implementations encounter avoidable problems that undermine trust and enthusiasm for the technology.

Furthermore, the Matthew effect in the context of educational AI paradoxically widens the achievement gap rather than narrowing it. The identified mechanism involves three mutually reinforcing stages. (Kim, 2025; Saleem et al., 2025; Tsai et al., 2020) First, amplification of initial advantages, where students with higher prior knowledge, digital literacy, and home resources benefit disproportionately from AI personalization. Second, cumulative advantages, where AI-facilitated student's progress faster, access more advanced content, creating an accelerating divergence from less fortunate groups. *Third*, invisible disadvantages where students who struggle with AI interfaces or lack support systems fall further behind without visible markers for intervention because personalization masks their difficulties.

Six studies with follow-ups of six months or more showed an 18 to 34% widening of the achievement gap above baseline in implementations without explicit equity interventions. This stands in stark contrast to the promise of AI personalization to democratize access. This is not a coincidence but reflects fundamental infrastructure gaps in Indonesia, where the quality and availability of internet connectivity varies dramatically between urban centers and rural or remote areas. This data is consistent with the 2023 report by the Indonesian Internet Service Providers Association, which shows that national internet penetration has reached 77.02%, but with significant quality gaps and geographical variations. Haetami's technology access framework (2025) explains that physical access alone is not sufficient for meaningful use of technology; what is needed is reliable, high-quality connectivity that enables sustained and productive engagement with technology, and this remains a significant barrier in many parts of Indonesia.

The second level is the availability and capabilities of the device. The majority of implementations, reaching 89%, adopted a bring-your-own-device model, where students were expected to use their own personal devices to access AI-based learning platforms. While this model is pragmatic given the limited institutional resources to provide devices, it creates new inequities due to the significant heterogeneity in the types and capabilities of devices students own. Device distribution shows the dominance of Android devices at 67%, followed by iOS at 18%, and PCs or laptops at only 15%. Even more problematic is that 32% of implementations reported device capability issues, where students' devices had insufficient processing power, memory, or screen size for optimal use of AI applications, creating a degraded user experience and hindering learning effectiveness.

The third level is the platform integration challenge which relates to the technical complexity of integrating AI systems with existing educational technology infrastructure. As many as 58% of the studies reported difficulties in learning management system integration, where AI tools do not integrate smoothly with the learning management systems already used by the institution, creating a fragmented user experience and requiring multiple logins or platform switching. Authentication and single sign-on issues were reported in 42% of cases, creating friction in access and consuming valuable instructional time. Data synchronization issues emerged in 38% of implementations, where student progress or performance data was not consistently or accurately synchronized across different systems, hampering teachers' ability to monitor and intervene.

This three-tier digital divide creates cumulative disadvantages: students already disadvantaged at the connectivity layer face additional barriers at the device layer, and institutions struggling with basic infrastructure also typically lack the technical expertise to handle complex integration challenges. The cumulative effect is that successful AI implementation is highly correlated with pre-existing resource advantages, potentially widening rather than narrowing educational inequalities.

*Second*, pedagogical and institutional challenges are equally critical but often underestimated, as they relate to human factors and organizational dynamics. Teacher readiness and competency gaps emerged as one of the most significant barriers to successful implementation. Systematic analysis reveals the multi-dimensional nature of this readiness gap. In the technical skills dimension, the gap severity was rated 4.2 on a scale of 1 to 5, with 67% of teachers reporting requiring extensive training for even basic use of AI tools. It's not just about operating the technology but understanding how AI works, what its capabilities and limitations are, and how to solve common technical problems. In the AI literacy dimension, the gap severity rating reached 4.5, which is the highest across all dimensions, with 78% of teachers reported being unfamiliar with fundamental concepts about AI capabilities and limitations. This unfamiliarity creates unrealistic expectations on the one hand by expecting AI to do things beyond its capabilities and underutilization on the other hand by not exploiting its full potential due to not realizing what is possible. Lack of AI literacy also leaves teachers vulnerable to misinformation about AI and unable to critically evaluate AI output or detect bias and inaccuracies.

Pedagogical innovation competency showed a gap severity of 3.8, with 58% of teachers reporting difficulties in integrating AI in lesson design and instructional planning. This reflects a deeper challenge: using AI is not simply about replacing traditional tools with AI-powered equivalents, but requires rethinking pedagogical approaches, redesigning learning activities, and orchestrating complex interactions between students, AI, and teachers. Many teachers are trained in traditional pedagogy and lack models or examples for AI-integrated instruction. Assessment redesign competency showed a gap severity of 4.1, with 63% of teachers struggling to design appropriate assessments in the AI era. Traditional assessments that focus on knowledge recall or procedural tasks are easily manipulated with

the help of AI, requiring a shift towards higher-order thinking, creativity, and authentic performance tasks which pose significant pedagogical challenges.

This teacher competency gap is in line with the technological pedagogical content knowledge framework developed by Mishra and Koehler (2006), which emphasizes that effective technology integration requires a complex intersection between technological knowledge, pedagogical knowledge, and content knowledge. However, the additional complexities in Indonesia have not been fully captured within indigenous frameworks such as what might be called cultural-technological knowledge. For example, understanding how AI personalization can be implemented in a way that respects Indonesia's collectivist values and hierarchical teacher-student relationships requires cultural-technological sophistication that goes beyond the standard competency of technological pedagogical content knowledge.

Beyond individual teacher competencies, institutional barriers are also significant. Rigid curriculum structures were reported in 71% of studies as a major obstacle, where highly detailed and standardized national curricula leave insufficient flexibility for innovative AI integration that requires experimentation and adaptation. Assessment misalignment emerged in 64% of cases, where a misalignment existed between AI-facilitated learning experiences that emphasized personalization, exploration, and creative problem-solving and standardized assessments that remained focused on uniform content coverage and conventional testing formats. Time constraints were reported in 58% of implementations, where dense curricula and limited class hours made it difficult to adequately integrate AI activities, provide necessary scaffolding, or allow sufficient practice time.

*Third,* the ethical, privacy, and regulatory challenges that arise from the implementation of educational AI. Data privacy and security concerns were identified in 68% of the studies as a significant concern from a variety of stakeholders including students, parents, teachers, and administrators. What is worrying is that 52% of implementations lack clear data governance protocols that define how student data is collected, stored, processed, and protected. Even more problematic, 47% use third-party platforms, especially commercial AI services, without formal data processing agreements that clearly define responsibilities, obligations, and protections for sensitive educational data.

## 4. CONCLUSION

This systematic literature review examines the implementation of generative AI in personalized learning in Indonesia by analyzing 28 studies published between 2020 and 2024. The findings indicate a significant increase in research momentum following the COVID-19 pandemic, particularly following the launch of ChatGPT in late 2022, which accelerated the adoption of generative AI in the Indonesian education ecosystem.

Regarding the implementation pattern of generative AI, there are some worrying distribution inequalities where 64.3% of its implementation is concentrated in higher education, while primary education only accounts for 3.6%. ChatGPT's dominance reached 67.9% of the total platforms used, indicating a high dependence on proprietary systems of global technology corporations, which raises concerns regarding data sovereignty and national digital independence. Effective implementation adopts a hybrid human-AI orchestration model with tiered personalization (individual, collaborative, and cultural) that reflects Indonesia's mutual cooperation values, not just a mere technological shift. Regarding implementation challenges, researchers identified a three-level digital divide that reinforces each other, namely 1) connectivity infrastructure with 73% of implementation concentrated in urban areas and a significant bandwidth gap; 2) heterogeneity of device capabilities with 89% adoption of BYOD models creating inequality of access; and 3) platform integration complexity with 58% LMS

integration difficulties. In addition, there are also pedagogical challenges that include the gap in teacher competency with low AI literacy where 78% of teachers are not familiar with the fundamental concepts of AI, the rigidity of the national curriculum, and the misalignment of the assessment system. Next are ethical challenges that include 52% of implementations without clear data governance protocols and 47% of use of third-party platforms without formal data processing agreements, which is problematic amidst evolving data protection regulations.

This research is limited to the Indonesian context, so generalizing the findings to other countries with different socio-cultural characteristics and technological infrastructure should be done with caution. In addition, the publication period in this study is relatively short, namely 2020 to 2024 and the concentration of studies in 2023 to 2024 from 64% of the total studies indicates that the research analyzes a phenomenon that is still very new and developing, so that the findings may not yet capture the long-term implications of the implementation of generative AI. Thus, further research could conduct longitudinal research with a minimum duration of 2-3 years to understand the long-term impact of generative AI implementation on learning outcomes, student skill development, and changes in teachers' pedagogical practices. This kind of research needs to use a mixed-methods design with a combination of quantitative (academic achievement, engagement, retention) and qualitative (learning experiences, attitude changes) data to capture the complexity of the phenomenon.

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