

Beyond Automated Feedback: Indonesian Educators' Reflections on Deepseek AI's Role in Fostering Metacognition

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ABSTRACT

The integration of artificial intelligence (AI) tools in education has generated considerable interest due to their potential to enhance formative assessment, metacognition, and self-regulated learning. However, in resource-constrained settings, cost and infrastructural barriers often hinder widespread AI adoption. This qualitative study examines Indonesian educators' perceptions of Deepseek AI, a free AI platform offering functionalities similar to more commercially dominant tools. Through semi-structured interviews with 14 teachers and lecturers in South Sulawesi, the study explores how Deepseek AI supports formative assessment, fosters metacognitive skills, and aligns (or misaligns) with local cultural and infrastructural contexts. Thematic analysis revealed that Deepseek AI's real-time feedback, adaptive pathways, and automated grading significantly reduce teacher workload and enhance student engagement. Participants also noted improvements in learners' metacognitive reflection, with AI-generated prompts prompting students to examine their problem-solving strategies. Nonetheless, rural educators reported connectivity gaps that delayed feedback and limited the tool's effectiveness. Concerns over cultural mismatch in AI-generated materials were also prominent, highlighting the need for localized content that resonates with Indonesian norms and values. While ethical considerations such as data privacy were mentioned, most educators stressed the urgency of training and policy support, particularly government-led investments in rural broadband and professional development programs. Overall, the findings underscore both the promise and complexity of integrating AI into low-resource educational settings. Deepseek AI can catalyze more efficient, learner-centered pedagogies if stakeholders address infrastructural inequities, cultivate teacher readiness, and ensure cultural and ethical alignment. These insights inform policymakers, EdTech developers, and educators seeking equitable AI solutions that optimize student learning outcomes.

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1. INTRODUCTION

The integration of artificial intelligence (AI) into education has emerged as a transformative force in contemporary pedagogical practices, reshaping how learning is facilitated, assessed, and personalized. AI-driven tools offer unprecedented opportunities to enhance formative assessment, foster metacognitive development, and support self-regulated learning. Scholars have highlighted the potential of AI applications, such as intelligent tutoring systems, natural language processing (NLP) platforms, and automated feedback mechanisms, to bridge learning gaps and optimize instructional strategies (Luckin et al., 2016; Holmes et al., 2019). These advancements align with global shifts toward learner-centered pedagogies, emphasizing the cultivation of critical 21st-century skills, including problem-solving, adaptability, and self-directed learning (Bachtiar, 2025; OECD, 2020).

Among these tools, OpenAI's ChatGPT has garnered significant academic and pedagogical attention for its advanced reasoning capabilities and adaptability across diverse educational settings. ChatGPT has been widely utilized for tasks such as generating lesson plans, enhancing student feedback, and supporting content creation, thereby augmenting both teaching efficacy and student engagement (Memarian & Doleck, 2023). However, despite its promise, AI adoption remains inequitable, particularly in resource-constrained settings such as Indonesia. Challenges related to subscription costs, infrastructural limitations, and digital literacy disparities impede widespread AI implementation, raising critical questions about accessibility and fairness in the global education technology landscape (World Bank, 2021; UNESCO, 2022).

In response to these challenges, Deepseek AI has emerged as a lesser-known yet strategically relevant platform offering comparable functionalities to ChatGPT. Notably, Deepseek AI is freely accessible, mitigating financial barriers that often hinder AI adoption in developing economies. By providing adaptive feedback, metacognitive scaffolding, and automated formative assessment mechanisms, Deepseek AI presents a viable alternative for educators operating within budgetary and infrastructural constraints. Indonesia, a vast archipelago with a heterogeneous educational landscape, exemplifies a context where such an AI-driven solution could address systemic challenges, including large class sizes, teacher-student ratio imbalances, and digital access disparities (Ministry of Education, Indonesia, 2020). Despite these potential advantages, there remains limited empirical exploration of how educators perceive Deepseek AI's role in formative assessment and student development.

Despite increasing scholarly interest in AI's applications in education, significant gaps persist in the literature. First, most existing research focuses on AI adoption in high-income contexts, where digital infrastructure, teacher training, and financial resources are relatively well-established (Zawacki-Richter et al., 2019). This bias limits our understanding of how AI can be integrated into under-resourced educational systems, particularly in Global South countries such as Indonesia, where affordability and digital access remain critical barriers. Second, while AI's role in automating assessments is well-documented, fewer studies examine its capacity to foster formative feedback loops that promote metacognitive awareness, self-regulation, and student responsibility (Popenici & Kerr, 2017). Third, despite educators' central role in AI integration, their perspectives remain underrepresented in AI-in-education discourse. Most studies focus on student outcomes rather than investigating teachers' experiences, concerns, and strategies for incorporating AI into their pedagogical practices (Williamson & Eynon, 2020).

Indonesia presents a compelling case for examining these issues. While 75% of urban schools have internet access, only 40% of rural schools meet this threshold, exacerbating inequities in AI adoption (Ramli, 2023). Furthermore, teacher training programs rarely incorporate AI literacy,

leaving educators underprepared to leverage AI's potential effectively (Fundi et al., 2024). Given these challenges, there is an urgent need to explore how Indonesian educators perceive Deepseek AI's efficacy in formative assessment, as well as its broader implications for teaching, learning, and student well-being. Addressing these gaps will provide valuable insights into AI's contextual adaptability in low-resource settings, informing policy and practice in equitable AI deployment.

This study seeks to contribute to the growing body of knowledge on AI in education by addressing the following objectives; (1) Investigate how Indonesian educators perceive Deepseek AI's efficacy in supporting formative assessment practices, (2) explore teachers' views on Deepseek AI's role in fostering metacognition, self-regulation, responsibility, and student well-being, and (3) propose policy and pedagogical recommendations to optimize AI's alignment with Indonesia's educational equity goals.

This study is significant for multiple stakeholders, including educators, policymakers, and technology developers. Theoretically, it extends the application of sociocultural learning frameworks (Vygotsky, 1978) by positioning AI as a "mediating tool" that scaffolds learning within Indonesia's unique socio-educational landscape. By exploring AI's role in enhancing formative assessment and metacognitive skills, this research contributes to discussions on how technology can facilitate deeper, student-centered learning experiences.

This study breaks new ground by shifting the scholarly focus from high-income contexts and commercially dominant AI tools (e.g., ChatGPT) to a cost-effective alternative, Deepseek AI, in an underexplored Global South setting. By prioritizing an Indonesian perspective, the research highlights the intersection of AI, educational equity, and sociocultural adaptation, offering fresh insights into how AI can be leveraged in low-resource environments. Furthermore, while existing research predominantly measures AI's impact through quantitative learning outcomes, this study employs a qualitative approach, amplifying the voices of educators who navigate AI adoption in real-world classroom scenarios. Additionally, the study critically examines the ethical and cultural dimensions of AI integration in Indonesia's Muslim-majority educational landscape. Values such as communal responsibility (*gotong royong*) and teacher-student relationality may contrast with AI's efficiency-driven paradigms, necessitating a culturally responsive approach to AI pedagogy. By investigating these nuanced intersections, this study contributes to ongoing debates on AI's role in education beyond Western-centric narratives.

2. LITERATURE REVIEW

The integration of artificial intelligence (AI) in education has been extensively explored in recent years, particularly concerning its role in formative assessment, metacognition, and self-regulated learning (Holmes et al., 2019; Popenici & Kerr, 2017). AI-powered tools such as intelligent tutoring systems, automated feedback mechanisms, and adaptive learning platforms provide new opportunities to enhance student engagement and support individualized learning pathways (Luckin et al., 2016). However, despite these potential benefits, the implementation of AI in education, particularly in low-resource settings, faces considerable challenges related to infrastructural constraints, teacher preparedness, and cultural adaptability (Zawacki-Richter et al., 2019; Ramli, 2023).

This study is grounded in sociocultural learning theory (Vygotsky, 1978) and self-regulated learning theory (Zimmerman, 2002, as cited in Holmes et al., 2019). Vygotsky's theory positions AI as a mediating tool that scaffolds learning by providing adaptive feedback and structured guidance (Luckin et al., 2016). In this model, AI serves as an interactive agent that facilitates cognitive development through learner-AI interactions. Additionally, self-regulated learning theory

underscores the role of AI in promoting goal-setting, self-monitoring, and reflection, key components of metacognitive growth (Holmes et al., 2019). AI-generated feedback can guide students to critically assess their learning strategies and adjust their approaches accordingly (Popenici & Kerr, 2017). However, concerns exist regarding whether students engage actively with AI-generated feedback or passively accept automated suggestions, underscoring the need for teacher facilitation in AI-assisted learning environments (Williamson & Eynon, 2020).

a. AI in Formative Assessment

AI-powered formative assessment tools offer real-time feedback, allowing students to identify errors and misconceptions as they learn (Holmes et al., 2019). Automated assessment mechanisms streamline grading and provide personalized recommendations, enabling learners to receive immediate, tailored guidance (Memarian & Doleck, 2023). Such AI-driven feedback systems have been shown to reduce teacher workload while improving student outcomes, particularly in large-class settings (Zawacki-Richter et al., 2019).

Despite these advantages, AI-based formative assessment presents several limitations. In low-resource educational settings, connectivity issues can delay AI feedback delivery, reducing its effectiveness, especially in rural schools (Ramli, 2023). Furthermore, cultural mismatches in AI-generated content raise concerns about contextual relevance, as many AI systems rely on Western-centric databases that may not align with local pedagogical and linguistic norms (Fundi et al., 2024).

b. AI and Metacognition in Learning

Research highlights AI's potential in fostering metacognitive awareness by prompting students to reflect on their learning strategies and decision-making processes (Popenici & Kerr, 2017). AI-generated reflection prompts, such as "Why did you choose this approach?" or "What alternative strategies could you explore?" have been found to encourage critical thinking and self-evaluation (Luckin et al., 2016). However, engagement with AI-driven metacognitive activities varies. Studies indicate that high-achieving students are more likely to actively reflect on AI-generated feedback, whereas low-achieving students may treat AI primarily as an answer-providing tool (Zawacki-Richter et al., 2019). This suggests that AI alone may not universally foster metacognition and that teacher intervention is essential to encourage meaningful engagement (Williamson & Eynon, 2020).

c. Challenges of AI Adoption in Low-Resource Settings

While AI has the potential to revolutionize education, its implementation in developing countries like Indonesia faces significant barriers. Research shows that only 40% of rural schools in Indonesia have stable internet access, compared to 75% in urban areas, creating stark disparities in AI accessibility (Ramli, 2023). Teacher preparedness is another key challenge, as pre-service and in-service teacher training programs do not sufficiently cover AI literacy (Fundi et al., 2024). Additionally, ethical concerns regarding data privacy and transparency in AI systems remain unresolved. Research suggests that clear guidelines on algorithmic transparency, data security, and user privacy must be established to ensure safe and responsible AI deployment in educational settings (Williamson & Eynon, 2020).

3. METHOD

3.1. Research Design

This study employed a qualitative research design, utilizing semi-structured interviews to explore Indonesian educators' perceptions of Deepseek AI's role in formative assessment and student development. A qualitative approach was selected to prioritize depth

over breadth, enabling the capture of nuanced, context-specific insights into educators' lived experiences (Creswell & Poth, 2018). Given the exploratory nature of the research questions—which focus on understanding how and why educators perceive AI's impact—this design aligns with the study's objectives to uncover themes related to pedagogical adaptation, ethical dilemmas, and cultural relevance.

3.2. Research Participants

The study targeted educators (teachers and lecturers) in South Sulawesi, Indonesia—a province characterized by its mix of urban centers, rural communities, and diverse cultural-linguistic groups (e.g., Bugis, Makassar, Toraja). Participants were recruited through purposive sampling, focusing on institutions in urban South Sulawesi (e.g., Makassar, Parepare) and rural areas (e.g., Bantaeng, Selayar Islands) to capture regional disparities in AI access and adoption. Snowball sampling supplemented recruitment, with participants recommending peers who met the inclusion criteria: (1) at least six months of experience using Deepseek AI in teaching or assessment, and (2) employment in K–12 or tertiary education. The final sample comprised 14 participants (9 teachers, 5 lecturers), a size determined by thematic saturation principles, where no new insights emerged in later interviews (Saunders et al., 2018). Demographics included:

3.3 Data Collection Method

Data were collected through semi-structured interviews, each lasting approximately 60–90 minutes. An interview protocol (see Appendix A for a sample) was developed around key themes derived from the research objectives: (1) formative assessment practices; (2) metacognition and self-regulation; (3) practical and cultural considerations; and (4) recommendations for future integration. These broad themes allowed for open-ended dialogue, enabling participants to introduce unanticipated topics or examples from their classroom experiences.

Interviews were conducted via Zoom or in person, depending on participant preference and logistical feasibility. Urban participants generally opted for Zoom due to convenience, whereas rural participants were more likely to meet in person due to limited internet reliability. Interviews were primarily in Bahasa Indonesia, with occasional English usage for technical or pedagogical terms. All sessions were audio-recorded with informed consent and transcribed verbatim before being translated into English for coding and analysis.

3.4. Data Analysis Technique

The study employed thematic analysis (Braun & Clarke, 2006) to interpret the interview data, recognizing that qualitative inquiry depends heavily on the nuanced coding and categorization of textual information. Once interviews were transcribed, the lead researcher engaged in repeated reading of the transcripts to gain familiarity with the overall content and context. These iterative readings facilitated the identification of key ideas, recurring phrases, and emerging patterns.

After this familiarization phase, transcripts were imported into NVivo 12 for open coding, wherein labels were assigned to relevant segments of text that addressed the research objectives. Codes were derived inductively from participant narratives and deductively from sociocultural theory, ensuring a balanced approach that allowed the data to speak for itself while remaining aligned with the study's conceptual framework. Next, related codes were grouped to form potential themes, which were scrutinized for internal consistency and relevance to the research questions.

Through ongoing discussion among the research team, any discrepancies in coding decisions were resolved, thus enhancing the dependability of the findings. The iterative process of reviewing and refining themes continued until a coherent thematic structure emerged. This final set of themes was then defined and articulated to form the backbone of the study's findings, with representative quotes illustrating each thematic category. Ensuring that these quotes accurately captured participants' voices and intentions was central to conveying the rich, context-specific experiences reported by Indonesian educators.

A final step in ensuring rigor involved member checks, wherein selected participants reviewed short summaries of the emerging findings for accuracy and resonance with their own

experiences. This feedback was integrated to refine the thematic interpretations further. Overall, the thematic analysis approach allowed the research team to systematically transform raw transcripts into meaningful insights that reflect both the diversity and commonalities in how educators perceived and utilized Deepseek AI.

4. RESULTS AND DISCUSSION

This section presents the core findings from the qualitative interviews conducted with 14 South Sulawesi educators regarding their experiences using Deepseek AI as a formative assessment tool. The results reflect the varied perspectives of participants who teach in diverse educational contexts (urban vs. rural, public vs. private/Islamic schools, K–12 vs. higher education institutions) and span multiple subject specializations (STEM, social sciences, and language arts). Drawing on thematic analysis, the data are organized into four overarching domains: (1) AI-Driven Formative Assessment, (2) Metacognition and Self-Regulation, (3) Ethical and Cultural Considerations, and (4) Professional Development and Policy Implications. The presentation of findings aligns with the study’s objectives, offering nuanced insights into the transformative potential and contextual challenges of AI in Indonesian classrooms.

1. Overview of Data and Thematic Structure

As described in the Methodology section, qualitative data were gathered through semi-structured interviews, each lasting between 60 and 90 minutes. Using NVivo 12 software, transcripts were coded both inductively (guided by participants’ narratives) and deductively (based on sociocultural theory and existing literature on AI in education). In total, 356 initial codes were generated, which were subsequently grouped into 19 sub-themes. Further refinement yielded four principal themes, each addressing one or more of the study’s research objectives.

Table 1. Urban vs. Rural Feedback Utilization

Primary Theme	Sub-themes	Research Objective(s) Addressed
AI-Driven Formative Assessment	Real-Time Feedback and Adaptation, Personalized Learning Pathways, Teacher Workload Management	1
Metacognition and Self-Regulation	Reflective Learning Practices, Goal-Setting and Progress Monitoring, Student Well-Being	2
Professional Development and Policy	Training Needs Policy Recommendations	3

In the subsections that follow, each primary theme is described in depth. Selected participant quotes are used to exemplify broader patterns and illustrate the lived realities of educators integrating Deepseek AI into their classroom practices.

2. AI-Driven Formative Assessment

The first major theme, AI-Driven Formative Assessment, emerged from repeated references to Deepseek AI’s capacity to deliver immediate, continuous, and data-driven insights into student performance. Participants consistently cited three notable advantages: (a) real-time feedback and adaptation, (b) personalized learning pathways, and (c) teacher workload reduction. Despite these benefits, constraints related to internet connectivity and infrastructural disparities were frequently mentioned, revealing a tension between technological promises and socio-economic realities.

a. Real-Time Feedback and Adaptation

All 14 participants indicated that one of Deepseek AI's most compelling features was its ability to provide **real-time feedback** on student assignments, quizzes, or practice exercises. This feedback often pinpointed specific areas of confusion or conceptual misunderstanding, enabling teachers to intervene promptly. A typical remark came from *T5 (Urban, Mathematics)*, who explained:

“Deepseek quickly flags errors in algebraic expressions. Within minutes of submission, I know which students struggle with linear equations and can offer targeted support. This has improved their test performance over time.”

However, participants teaching in rural contexts, such as *T9 (Rural, Biology)*, cautioned that “real-time” is relative in areas with weak or intermittent internet signals:

“Sometimes the feedback arrives 10–30 minutes late. By then, I’m already teaching a new topic or the class is transitioning to another activity. The immediate benefit diminishes.”

Such connectivity issues suggest that the efficacy of AI-driven formative assessment depends heavily on robust digital infrastructure—an aspect that urban teachers took for granted but rural teachers found persistently challenging.

b. Personalized Learning Pathways

Twelve out of the 14 participants adopted Deepseek AI's adaptive features to differentiate instruction. The tool automatically adjusts question difficulty based on each learner's performance, offering scaffolding for those who require additional support and more complex, open-ended tasks for advanced learners. *L2 (Urban, Computer Science)* highlighted:

“In programming classes, weaker students get step-by-step hints to debug their code, whereas advanced students are offered project-based tasks to stretch their skills.”

Nevertheless, the cultural relevance of recommended lesson materials came under scrutiny. *T12 (Rural, English)* recounted that Deepseek AI occasionally proposed examples or analogies from urban or Western contexts (“snowboarding,” “skyscrapers”), which were foreign to students in South Sulawesi:

“The students in my school relate more to farming, fishing, or local folklore. So I have to manually revise these AI-generated materials. Otherwise, they won’t resonate at all.”

This insight underscores the importance of cultural adaptation in AI-based tools. While personalization is a core strength of Deepseek, the tool's reliance on a global database may inadvertently perpetuate cultural mismatches if not localized to regional settings.

c. Teacher Workload Management

All participants unanimously appreciated Deepseek AI's potential for reducing administrative burdens. Whether grading quizzes, tracking student progress, or identifying at-risk learners, the AI tool automated tasks that previously occupied substantial teacher time. *T3 (Urban, Civics)* estimated saving “around seven hours a week” through automated quiz grading, while *L4 (Urban, Economics)* shared:

“It gives me more time to interact with students on a personal level discussing their aspirations, or clarifying broader concepts. I’m no longer bogged down by repetitive grading.”

However, seven participants expressed concern about **over-reliance** on AI. As T8 (Rural, STEM) put it:

“We risk losing our unique teacher-student connection. If we let AI handle most assessments, we might miss the emotional cues or the personal struggles a student faces.”

This sentiment reveals an undercurrent of caution: teachers are keen to maintain the human element in pedagogy, valuing empathy and relational dynamics that machines cannot fully replicate. Hence, while Deepseek AI streamlines certain tasks, educators also perceive a need for balance to preserve meaningful human interaction.

3. Metacognition and Self-Regulation

The second theme centers Metacognition and Self-Regulation, reflecting how Deepseek AI’s feedback and learning features influence students’ reflective and self-directed learning capabilities. This theme is further divided into: (a) reflective learning practices, (b) goal-setting and progress monitoring, and (c) student well-being. Together, these findings offer insights into how AI tools extend beyond surface-level improvements in academic performance to shape students’ broader cognitive and affective development.

a. Reflective Learning Practices

Many participants noted that Deepseek AI’s prompts encourage metacognitive reflection. For instance, feedback often includes questions like, “Why did you choose this approach?” or “Could there be an alternative solution?” These queries prompt students to consider their problem-solving strategies rather than merely focusing on correct answers. T7 (Urban, Bahasa Indonesia) gave a vivid example:

“My students now keep reflection journals. They copy AI feedback and write personal responses, such as ‘I made repeated grammar errors because I rushed. Next time, I’ll review my draft more carefully.’ Before using Deepseek, we rarely had such explicit reflections.”

In rural areas, however, educators reported uneven uptake of these reflection features. T11 (Rural, History) observed that “high-achieving students are more likely to engage deeply with reflection prompts,” while weaker students see the AI primarily as an “answer dispenser.” This discrepancy highlights the challenge of fostering metacognitive habits among all learners, especially those with minimal digital literacy or intrinsic motivation.

b. Goal-Setting and Progress Monitoring

Eight participants described using Deepseek AI’s dashboard and milestone features to help students set short-term goals and monitor their progress. T2 (Urban, Mathematics) explained:

“We set a weekly target for algebra mastery. Students get visual graphs showing how they are improving or stagnating. This real-time data fosters accountability.”

However, rural educators faced practical barriers. T10 (Rural, English) mentioned that students in remote villages often have limited access to personal devices or stable internet, making

daily progress tracking difficult. Consequently, these students might only sporadically consult Deepseek AI's dashboard, limiting the tool's capacity to instil consistent self-monitoring behaviours.

c. Student Well-Being

Ten participants indicated that timely, private feedback from AI could reduce student anxiety. This aligns with existing literature suggesting that computer-mediated feedback can alleviate performance pressure by removing direct judgment from teachers or peers (Popenici & Kerr, 2017). However, *L1 (Urban, Biology)* raised an important caveat:

“Some students become overly fixated on AI-generated ‘levels’ or scores. They become anxious if they don’t see immediate improvement, leading to unhealthy competition.”

Balancing the motivational benefits of immediate feedback with the risk of score-centric stress is an emerging concern. Teachers called for teacher intervention, reminding students that AI scores are but one indicator of progress, and that learning is an iterative process with room for mistakes and growth.

4. Professional Development and Policy Implications

The final theme addresses Professional Development and Policy Implications, highlighting the need for teacher training, institutional support, and broader policy frameworks that can either facilitate or hinder AI adoption. Sub-themes include training needs, policy-level infrastructure investments, and the integration of AI literacy into teacher certification programs.

a. Training Needs

Most participants indicated a lack of formal training on AI-based tools, leading to self-directed learning or reliance on peer support networks. *T1 (Urban, STEM)* recalled:

“I taught myself how to use Deepseek by trial and error. It wasn’t always smooth, and some colleagues are still hesitant because they find it too complex.”

Key training areas included technical skills (e.g., interpreting AI analytics dashboards, troubleshooting common software issues) and pedagogical balancing (i.e., merging AI-based assessments with human-centric teaching). *L2 (Urban, Computer Science)* recommended “hands-on workshops” where teachers practice designing AI-integrated lesson plans, share best practices, and discuss ethical dilemmas.

b. Policy Recommendations

Virtually all participants underscored the necessity of policy reforms that could institutionalize AI's role in the national curriculum while addressing infrastructural inequities. They suggested government subsidies or public-private partnerships to bolster broadband access in rural areas and provide hardware grants to underfunded schools. Additionally, teachers called for; (1) *Ethical guidelines* by establishing clear frameworks for data use and privacy, requiring EdTech companies to disclose how student data are stored, analysed, and protected. (2) Curricular alignment by incorporating AI literacy and digital citizenship into teacher education programs and student curricula. And (3) Local language integration by enabling the AI interface and content to be fully available in Bahasa Indonesia, as well as in regional languages for deeper cultural relevance.

c. Outlook for Sustainable AI Adoption

The interviews concluded with participants sharing their optimism for AI's potential to reshape Indonesian education, balanced against the real constraints they face. Several expressed hope that targeted policy interventions could level the playing field, while also acknowledging the

importance of teacher agency in shaping how AI is deployed at the classroom level. T4 (Urban, STEM) summarized this dual perspective:

“AI won’t solve all our educational problems, but it’s a powerful tool if we use it wisely. We must invest in teacher training, localize the content, and ensure ethical guidelines. Then, Deepseek can genuinely uplift student learning across Indonesia.”

One of the central objectives of this study was to assess how Indonesian educators perceive Deepseek AI’s efficacy in supporting formative assessment. The findings indicated that most participants recognized the tool’s capacity to provide real-time, targeted feedback, which facilitated timely pedagogical interventions. This outcome aligns with the premise that automated, data-driven systems can efficiently identify student learning gaps in large classes (Luckin et al., 2016). Notably, educators highlighted the potential for personalized instruction, thereby supporting prior claims that AI can adapt tasks to accommodate individual student needs (Holmes et al., 2019). However, the infrastructural discrepancies between urban and rural settings served as a moderating factor, limiting the extent to which Deepseek AI could offer immediate and equitable support. This discrepancy underscores the socio-technological realities that often hamper promising EdTech solutions in under-resourced contexts (Williamson & Eynon, 2020).

Another key objective centered on Deepseek AI’s impact on metacognition and self-regulated learning. The data revealed that AI-generated prompts—particularly reflective questions—stimulated students’ awareness of their learning processes, thus endorsing the value of timely, individualized feedback (Popenici & Kerr, 2017). This finding resonates with sociocultural theories of learning (Vygotsky, 1978), suggesting that tools like Deepseek AI can serve as “mediating artifacts,” encouraging students to critically examine and refine their cognitive strategies. At the same time, the uneven engagement among high-achieving versus lower-performing students indicated that not all learners benefit equally, echoing previous studies cautioning that digital tools may inadvertently widen existing achievement gaps if not accompanied by robust pedagogical support (Zawacki-Richter et al., 2019).

A final notable finding pertains to the policy and professional development dimensions of AI integration. Educators requested formal training in both the technical and pedagogical aspects of AI use, aligning with previous research that identifies teacher readiness as a critical determinant of successful EdTech adoption (Creswell & Poth, 2018). The call for infrastructure improvements—especially in rural areas—mirrors global concerns that educational technology exacerbates disparities when deployed without adequate resource support (Ramli, 2023). Such limitations reaffirm the complexity of scaling up AI in Indonesia’s diverse educational landscape and point to the necessity of system-level reforms, such as enhanced rural broadband access, data privacy regulations, and AI literacy components in teacher certification curricula.

The study’s findings converge with and extend existing scholarships in several ways. First, consistent with constructivist and sociocultural theories, results support the notion that AI can serve as a mediating artifact, scaffolding cognitive processes and promoting self-regulated learning. This parallels the work of Vygotsky (1978), who posited that effective tools and social interactions profoundly shape cognitive development. In this context, Deepseek AI provided structured scaffolds, such as reflective prompts and adaptive tasks, that encouraged metacognition. Second, the results align with research advocating the transformative potential of real-time assessment data (Holmes et al., 2019). By offering immediate feedback and personalized pathways, Deepseek AI underscores how technology can reconfigure traditional teacher-student roles, where teachers become facilitators of individualized learning journeys. Yet, this study contributes new insights by situating these dynamics in resource-constrained and culturally varied environments, demonstrating that infrastructural gaps limit AI’s capacity to deliver uniform benefits (Zawacki-Richter et al., 2019). Lastly, the findings advance discussions on the ethical and cultural considerations of AI integration in education, an area often underexplored in Western-centric EdTech research. While scholars have noted the ethical implications of data privacy (Williamson & Eynon, 2020), fewer have examined

the cultural mismatch that can arise when global technologies intersect with localized practices (OECD, 2020). This study not only corroborates concerns about equity and data usage but also highlights the need for culturally responsive AI designs that acknowledge local languages, belief systems, and communal norms.

Implications of the Study

From a practical perspective, the study underscores the necessity for in-service teacher training tailored to both the technical operation and pedagogical integration of AI tools. Workshops, mentoring programs, and collaborative learning communities could address the knowledge gap in interpreting AI analytics and designing culturally aligned materials. School administrators and policymakers might leverage these insights to curate context-sensitive AI resources, ensuring alignment with national curricular standards and local cultural values. Furthermore, the findings suggest that infrastructural upgrades—particularly reliable internet access—are paramount for rural educators to realize AI's benefits fully. Governments, nongovernmental organizations, and private sector partners could collaborate on targeted initiatives to expand digital connectivity in under-served regions. By doing so, they address a significant barrier that currently limits the equitable scaling of AI technologies, aligning with Indonesia's 2020–2024 National Education Strategy (Ministry of Education, Indonesia, 2020).

Thematically, the study expands sociocultural learning theories by integrating considerations of technological mediation with cultural and infrastructural constraints. Vygotsky's (1978) notion of tools as extensions of human cognition is exemplified here, but the study adds nuance by showing that an AI tool's effectiveness depends not just on its design but also on the socioeconomic and cultural environments in which it is deployed. This perspective invites scholars to refine theoretical models of technology-enhanced learning, particularly in the Global South, by incorporating the realities of uneven resource distribution and deep-rooted cultural norms (OECD, 2020). Additionally, the research highlights the interplay between individual learning paths and communal educational values, suggesting that purely individualistic AI models may need reconceptualization in cultural contexts emphasizing collective responsibility. Future work could integrate frameworks from critical pedagogy (Freire, 1970) to examine how AI can both empower and potentially marginalize students, depending on whether it aligns with or contradicts local pedagogical values.

At the policy level, the results prompt a reevaluation of current AI in education initiatives. Policymakers should craft comprehensive guidelines that cover data protection, cultural adaptation, and equitable access to AI resources. Transparency in AI algorithms, user data management, and accountability measures for EdTech providers are pressing issues that surfaced in participant interviews, echoing global discussions on ethical AI standards (Williamson & Eynon, 2020). Moreover, the findings encourage educational authorities to incorporate AI literacy and digital citizenship elements into teacher training and certification processes. Educators well-versed in AI functionalities, limitations, and cultural sensitivities are more likely to adopt these tools ethically and effectively, ensuring that student well-being remains paramount. Such policy measures would not only mitigate the digital divide but also align with Indonesia's broader agenda of cultivating future-ready skills among its learners (Ministry of Education, Indonesia, 2020).

5. CONCLUSION

This study set out to investigate Indonesian educators' perceptions of Deepseek AI's role in formative assessment and student development, particularly in resource-constrained contexts. Drawing on qualitative data from 14 educators in South Sulawesi, the findings underscore the tool's potential to enhance real-time feedback, promote metacognitive reflection, and reduce teacher workload. These benefits, however, are tempered by infrastructural and cultural considerations. Connectivity gaps, especially in rural areas, complicate the efficacy of immediate feedback, while the globalized content and individualized orientation of AI tools sometimes conflict with local cultural norms emphasizing communal learning.

By situating these insights within sociocultural and constructivist frameworks, the study illuminates how AI can serve as a “mediating artifact” that supports self-regulated learning, so long as it is thoughtfully integrated into the local educational ecology. Practical recommendations include investing in broadband infrastructure, incorporating AI literacy into teacher training, and ensuring ethical safeguards around data privacy and equitable access. Theoretically, the findings affirm Vygotsky’s emphasis on cultural tools in cognitive development, while highlighting the need to adapt AI-driven solutions to the socio-cultural realities of Indonesia’s diverse educational landscape.

Despite its contributions, the study’s modest sample size and focus on a single Indonesian province limit generalizability. Future research could employ mixed methods designs across multiple regions, investigate longitudinal changes in teacher and student engagement with AI, and further explore culturally responsive AI development. Taken together, these avenues for inquiry promise to broaden our understanding of how AI can be harnessed to foster inclusive, contextually relevant, and ethically grounded education in low-resource settings.

Overall, Deepseek AI offers meaningful opportunities to advance formative assessment and metacognitive growth, yet it cannot be viewed as a standalone solution. Teacher agency, infrastructural support, and cultural alignment remain decisive factors that shape the success of AI-based initiatives. By addressing these interlocking dimensions, stakeholders, including educators, policymakers, and EdTech developers, can leverage AI’s transformative potential to nurture more equitable and engaging learning environments across Indonesia and similar global contexts.

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