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BALANCING EFFICIENCY AND HUMANITY IN THE ADOPTION OF ARTIFICIAL INTELLIGENCE AMONG INDONESIAN PRIMARY SCHOOL TEACHERS

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Abstract

The potential of Artificial Intelligence (AI) in streamlining teachers' tasks is often unattainable for some primary school teachers in developing countries due to the wide digital divide, ethical issues, and AI hallucinations. This study aims to explore the views and strategies of primary school teachers in Indonesia for balancing the drive to improve work efficiency with the need to uphold pedagogical ethics and protect student safety. Through a reflective questionnaire, this descriptive-exploratory qualitative study collected in-depth narratives from 100 primary school teachers in Indonesia. Open-ended answers were anBatubaraalyzed to understand their views and life experiences. The results of this study reveal that teachers have carefully used AI as a tool to speed up the completion of administrative tasks and design creative learning scenarios and media, while maintaining students' privacy and independence of thinking. Although the use of AI is incompatible with inadequate infrastructure, large skills gaps, algorithmic bias, and less supportive regulations and policies, teachers demonstrate their active role as ethical and reflective agents who constantly cross-validate AI results rigorously and continue to learn how to use AI appropriately. These findings suggest that the use of AI among primary school teachers requires not only technical training but also policies that foster ethical and critical awareness in the use of technology, thereby reinforcing human values.

Keywords: Ethical and reflective agents, Intent to use AI, Benefits of AI, Barriers to AI Adoption, AI Risks, mitigation strategies.

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INTRODUCTION

Regulating the appropriate use of artificial intelligence (AI) in the field of education can support the achievement of Sustainable Development Goal 4 (SDG 4) through pedagogical transformation and mitigation of unexpected risks (Sevilla et al., 2025). Recent studies show that the effective use of AI can improve creativity, critical thinking, collaboration, and communication skills that are essential for the 21st century (Tian & Zheng, 2025). In addition, AI is offered as a solution to expand access, personalize learning, and support data-driven decisions (Lin et al., 2023). This potential also supports Indonesian government policies that recommend the use of digital technology to support deep learning approaches and differentiated learning (Enjang Yusup Ali et al., 2025; Noviyana et al., 2025). This data shows that AI can be used to improve learning outcomes and expand students' access to the latest learning resources.

However, some primary schools in developing countries are unable to fully reap the benefits of AI due to the lack of supporting infrastructure, structured training, and support from the surrounding environment (Farisia et al., 2025; Huang & Yu, 2025). The results of the study in Estonia also found that although 53% of teachers have used AI, many are constrained by systemic readiness and support (Granström & Oppi, 2025). In addition, a study in Kenya found that the adoption of AI in schools was hindered by teachers' confidence, ethical concerns, and peer influence (Fundi et al., 2024). Research in Indonesia has also shown that practical skills, support facilities, and peer support often hinder teachers from integrating AI, even though they are highly motivated (Batubara et al., 2025; Harsanti et al., 2025). This data shows that while the use of AI offers great potential, it also carries serious risks, especially in the context of developing countries such as Indonesia. Therefore, research on how teachers balance work efficiency with humanity and ethics is urgently needed.

Unlike universities, using AI in primary school classrooms is considered more challenging and complex. Children in primary school are particularly vulnerable to the risk of algorithmic bias and personal data leakage (Ansari & Qamari, 2025; Boulhrir & Hamash, 2025a). Therefore, the use of AI without filters and clear ethical guidelines can inadvertently reduce student involvement in the process of deep thinking and also threaten moral education, such as honesty, diligence, and rigor, which are highly emphasized at the primary school level (Barus et al., 2025; Gerlich, 2025; Reiter et al., 2025). Teachers are also faced with the problem of inaccurate AI answers that require teachers to validate them (Chen & Yang, 2025). This data shows that the use of AI in primary schools should not be treated as a free-to-use advanced tool, but should be regulated by clear ethical guidelines to improve children's moral, cognitive, and emotional development, rather than weaken their honesty, perseverance, and independent thinking.

Although studies on AI adoption in schools are rapidly increasing in Asia (Irwanto, 2025), the previous studies are dominated by the context of higher education and secondary school level in developed countries, such as the United States, China, Australia, and the United Kingdom (Akhmadieva et al., 2024; Zhou et al., 2025). In addition, the majority of studies on the use of AI in primary schools are still in the form of global reviews or focus on the design/effectiveness of AI tools, not on teachers' experiences in the field (Ahmad Fauzi et al., 2025; Aravantinos et al., 2024; Boulhrir & Hamash, 2025b; Purba et al., 2025). Therefore, the first novelty of this study is the mapping of views and strategies for the use of AI among primary school teachers in Indonesia, a developing country context with limited infrastructure and skills gaps.

In addition, previous research has highlighted the benefits and challenges of using AI, but it generally stops at the list of pros and cons and calls for regulation (Govindarajoo et al., 2025). Therefore, the second novelty of this study is that it focuses on exploring how primary school teachers' strategies to utilize AI for efficiency (administration, learning design), while protecting the autonomy of thinking, morality, and safety of primary school students. This focus is important to explore how primary school teachers' strategies ensure that the integration of AI is balanced between improving the efficiency of teachers' duties while upholding learning integrity and human values. In addition, research emphasizing the importance of teacher agency and AI ethics has not addressed them simultaneously (Aravantinos et al., 2024; Mouta et al., 2025). Therefore, the third novelty of this study is the proposal of the concept of teachers as ethical and reflective agents in the use of AI, which explicitly positions teachers as filters, critics, and guardians of human values in human-AI collaboration.

The theoretical basis of this research combines several theories. The Technology Acceptance Model (TAM) and UTAUT were applied to understand teachers' perceptions of the risks and benefits of AI (Mistry et al., 2025). TPACK was studied to explore how teachers improve their competence (Ning et al., 2024). Diffusion of Innovation is used to discuss the factors influencing the adoption rate of AI (Rogers et al., 2014). Through the synthesized theoretical framework, this study aims to explore the intentions and perceived benefits of primary school teachers' use of AI, as well as the obstacles they encounter, the risks they are concerned about, and the strategies they employ to overcome these challenges and mitigate their concerns. This research is important for providing a strong argument for policymakers to design AI training and regulatory programs that are human-centered, focus on more than technical skills, and are tailored to the needs of primary school teachers.

METHODS

This study used a qualitative descriptive-exploratory design to obtain the authentic voice of Indonesian primary school teachers (Creswell & Creswell, 2018). This design was chosen because teachers' views and the methods of AI application in many primary schools are highly diverse and can only be fully understood through their voices on the ground, not just through numerical metrics. In addition, this design is more appropriate to uncover the nuanced realities of how primary school teachers view the benefits, challenges, and risks of using AI, as well as how their adaptive strategies in negotiating the ethical dilemmas of using AI to optimize its benefits and mitigate the risks of its use properly.

The participants of this study were 100 primary school teachers in Indonesia who have used AI tools (i.e., ChatGPT, Canva AI, or Wayground) in the last 12 months. They consisted of 68 women and 32 men. Of the ages, 7 were under 30, 64 were between 30 and 40, 24 were between 41 and 50, and 5 were over 50. The majority of them are bachelor's graduates, and only 5 are master's graduates. The location of their school covers the city center and the suburbs.

To ensure that participants could express their feelings in detail and without time constraints, this study used an open-ended reflective questionnaire. The questionnaire questions have been designed based on three different frameworks: TAM & UTAUT, to investigate teachers' views of risks and benefits of AI (Mistry et al., 2025), questions on the methods of teachers improving their competencies are designed based on the TPACK approach (Ning et al., 2024), and the Innovation Diffusion theory is used to determine how they adapt to the challenges, risks, and benefits offered by AI (Rogers et al., 2014). This instrument has been reviewed by two educational technology experts to ensure its validity, and the clarity and readability of the questions have been confirmed with five teachers from outside the research informant.

The data for this study were collected by sending participants the URL of the online form via WhatsApp. This method was chosen because it is considered more paper-friendly, teachers are freer to determine the filling time, and teachers are freer to tell their opinions and experiences in depth without being limited to a short time. The data collection for this study has complied with applicable research ethics procedures, including obtaining participant consent, avoiding conflicts of interest, and protecting each participant's identity.

This study applied the thematic analysis technique of Braun and Clarke (2006) to interpret and explore the reflective answers of primary school teachers. The application of this technique consists of six stages: familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and writing the report of the findings critically. To maintain honesty and minimize researcher bias, an audit trail is

maintained throughout the research process, and an intra-rater reliability assessment is performed on coding.

RESULTS AND DISCUSSION

Initial Goals and Benefits of AI Perceived by Primary School Teachers

The findings of this study have revealed the categories and patterns of shifting teachers' initial goals with their views on the benefits of AI. As shown in Table 1, the main goal of primary school teachers' use of AI is to speed up the completion of teachers' administrative burdens, such as drafting lesson plans, creating teaching materials, processing student data, and writing learning reports. For example, one teacher (R90) stated their initial goal as: "to make it easier to work so that you do not understand yet." Meanwhile, another teacher (R17) expressed the goal as a benefit of AI, saying: "Help make it easier to create teaching materials and administrative interests."

Table 1. The Matrix of Initial Goals Versus Discovered Benefits

Domain	Initial Goal (f)	Perceived Benefit (f)	The Shift (Analysis)
Administrative efficiency	68	73	+5 (Consolidated). Benefits are realized in line with initial expectations; AI is effective as a routine assistant.
Instructional media development	28	42	+14 (Unanticipated Gain). Many teachers did not initially plan this, but found AI to be very beneficial for developing learning media.
Pedagogical quality enhancement	27	22	-5 (Implementation Gap). Improving the quality of learning is more difficult than simply improving administrative efficiency.
Knowledge & idea expansion	27	24	-3 (Stable). The function of inspiration remains relevant yet secondary.
Assessment & evaluation	12	18	+6 (Functional Gain). Increased efficiency in making varied questions.
Professional development	11	15	+4 (Growth). The increase in digital literacy occurs organically.

The results of this study also showed a strong correlation between teachers' initial goals and the benefits they felt from AI's role in developing learning media. This means that many teachers initially planned to use AI only for administrative tasks, but they quickly realized its power to improve their teaching media and materials. For example, R52 revealed their goals by saying: "make it easy to quickly create presentation teaching materials, organize learning tools, and organize questions easily." On the other hand, R49 expressed it as a benefit of AI, saying: "makes it easier to prepare learning videos and create student worksheets."

In contrast to the domain of administrative efficiency and the development of learning media, the votes stating the benefits of AI for improving pedagogical quality actually decreased by 5 votes. This implies that although teachers have a strong desire to improve the quality of student learning through the use of AI, doing so is considered more challenging than improving administrative efficiency or developing learning media. R20 stated their initial goal as: "create a more effective and enjoyable learning experience in the classroom." On the other hand, R36 highlighted the benefits of AI in achieving these goals, stating: "AI helps improve learning quality by providing accurate, relevant, and engaging materials."

In addition to the domain of improving learning quality, the number of teachers' voices about the benefits of AI as a tool for finding references and inspiration decreased relative to the frequency of teachers' initial goals relevant to these benefits. This means that AI's function in providing new ideas, inspiration, and references is only secondary. This aligns with the R38 participant's expression, who stated his goal as "looking for additional references related to my work." On the other hand, R44 participants reported the benefits of AI relevant to their goals by saying: "as a comparative reference or additional information in the field of education".

Furthermore, this study found that AI plays an important role in supporting evaluation implementation by helping teachers create questions at a specific difficulty level and facilitating quizzes and other assessment instruments in a digital format. Compared with objective data, teachers reported greater benefits from using AI in supporting evaluation activities. This means that AI's function in facilitating evaluation activities has exceeded teachers' expectations. For example, R77 participants stated their goal as: "to create problems with different levels of difficulty according to the student's ability." On the other hand, R26 participants expressed the benefits of AI in this domain by saying: "assists teachers in grading assignments and making exam questions easier to prepare."

Finally, data on the purpose and benefits of AI have identified its role in supporting teachers' professional development. For example, teachers can use AI to understand the latest technological developments, complex subject matter concepts, and techniques for developing learning media. Eleven votes reported it as a teacher's goal to use AI, while the number of votes reporting it as a benefit of AI increased to 15. This means that the benefits of AI for developing teacher professionalism have exceeded teachers' expectations. For example, R68 participants have expressed their goals by saying: "to keep up with the times and technology." On the other hand, R94 participants viewed it as a benefit of AI, stating: "Enhances teachers' skills and knowledge in using instructional media."

This study reveals a shift in the perception of teachers who initially adopted AI for pragmatic (administrative) reasons but later developed to find higher benefit values in the development aspect of learning media. These findings expand the perspective of the TAM and

UTAUT model by implying that perceptions of perceived benefits of technology may evolve beyond initial expectations as user experience and interaction with the technology (Abuhassna et al., 2023; Assad et al., 2025). In contrast to the results of previous studies, which found the benefits of AI in focusing on efficiency in completing administrative tasks (Mistry et al., 2025; Mitchell, 2025). These findings indicate that teachers' perceptions of AI are dynamic; Although early adoption was driven by administrative needs, hands-on experience significantly expanded the benefits of AI into the realm of creative media development and digital literacy that went beyond their initial expectations.

Typology of Barriers to AI Integration in Primary Schools

Although teachers showed enthusiasm for the benefits of AI, the results of this study revealed significant gaps that hinder teachers in using AI. There are 12 categories identified as barriers to teachers' use of AI, ranging from physical barriers to ethical and regulatory issues (see Figure 1).

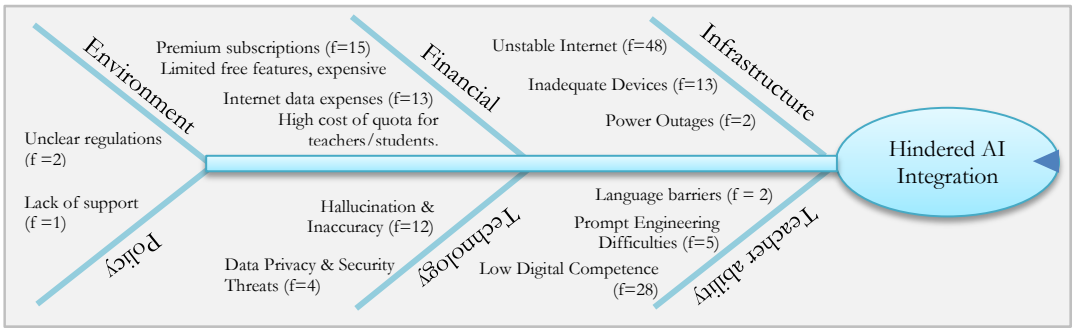


Figure 1. Fishbone Diagram of Barriers to AI Integration in Primary Schools

As illustrated in Figure 1, teachers' biggest obstacle to AI integration is the problem of infrastructure unpreparedness. Almost half of the respondents (n=48) cited unstable internet issues as their main obstacle (R38). This constraint is not just a matter of inconvenience, but a structural blockade that makes cloud-based AI tools inaccessible. In addition to connectivity, the problem of the availability of digital devices is also very acute. Thirteen teachers reported this problem, saying: "the device specs are inadequate, students are not allowed to bring cellphones to school, and the number of Chromebook laptops is limited" (R79). In addition, two teachers reported power outages, saying, "The problem is that if the electricity is off, the AI platform cannot be accessed" (R25).

Some external barriers were previously exacerbated by the presence of internal barriers (teacher ability). A total of 28 teachers were admitted due to their limited ability to use digital devices. In addition, 5 teachers feel insecure in writing prompts or effective messages to rule the AI. Furthermore, teachers also face language barriers in understanding the interface of AI applications that use English. These internal constraints were expressed by teachers,

among others, by saying: "lack of understanding how to use AI applications" (R11), "choosing the right prompts" (R55), and "understanding AI applications that look in English" (R90).

Furthermore, the burden of the cost of using AI also hinders the use of AI among primary school teachers. Fifteen teachers have highlighted the high cost of AI app subscriptions. For example, R20 participants noted that "the free version of AI features is limited, and it requires a hefty subscription fee to access all features". In addition, the daily cost of internet quota also adds to the burden of operational costs for schools and teachers. For example, R15 participants reported this by saying: "the cost of providing internet or wifi quota" (R15).

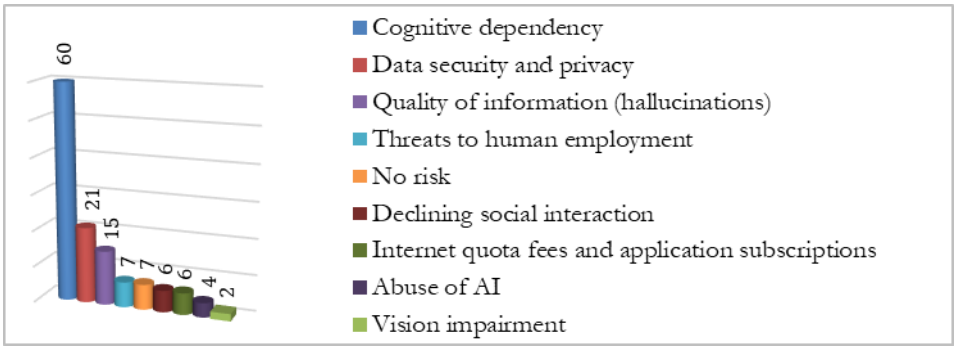
Furthermore, teachers expressed significant skepticism regarding the quality and safety of AI. Twelve teachers flagged the problem "Hallucinations," in which AI generates answers that are irrelevant, inaccurate, or linguistically inappropriate for primary school-age children. For example, R16 participants emphasized the need for vigilance: "[Output] must be corrected again because AI language is sometimes not easy for primary school children to understand." Another teacher who revealed the problem of AI hallucinations said: "Sometimes the answer is not appropriate" (R35). In addition, there are concerns about the leakage of privacy and personal data of teachers or students. R47 participants warned of this by saying: "[AI] could pose a serious threat to personal data privacy".

Finally, teachers are also concerned about unclear regulations governing AI use in certain schools or regions. This anxiety is reinforced by social pressure from policies or people around teachers. R5 participants mentioned these regulatory constraints, saying: "... regulations are inadequate." R22 participants also expressed concerns about social pressure, saying: "There are teachers who do not allow the use of cellphones to study in class because it can interfere with the learning process".

The findings that infrastructure barriers, such as "unstable internet" and "inadequate devices," are the main obstacles of this study, confirm Rogers' theory of innovation diffusion, which emphasizes the adoption environment as a factor that influences the adoption rate of innovations (Abulail et al., 2025; Wiggill & Batchelor, 2024). The findings also indicated that the challenges of AI integration in Indonesia are not much different from the challenges faced in other developing countries (Mustopa et al., 2024; Shafik, 2025). In contrast, these findings are in stark contrast to the AI integration challenges faced in developed countries such as China, South Korea, or the United States, where the barriers described are more often leadership, curriculum knowledge, or epistemic beliefs, rather than infrastructure issues (Arcesati, 2024; Karataş et al., 2025; Kim & Kwon, 2023). These findings confirm that the main barriers to AI integration in Indonesia remain fundamental—namely, infrastructure and accessibility—which, in contrast, distinguish it from challenges in developed countries, where issues have shifted towards curriculum and epistemic beliefs.

Teachers' anxiety about the risks of using AI in Primary Schools

The most profound finding from the study is the increasing "ethical anxiety" felt by teachers about the long-term impact of AI. A sense of moral responsibility has driven them not only to improve students' knowledge but also to feel responsible for their cognitive development (see Graph 1).



Graph 1. The Risks of Using AI from the Perspective of Primary School Teachers

As summarized in Graph 1, the highest risk reported by 60 teachers was over-reliance on technology. Teachers are worried that the convenience offered by AI to students actually lowers their thinking skills. R48 participants warned of the risks of using AI by saying, "becoming dependent on AI to the point of being lazy to read textbooks." At the same time, R62 expressed anxiety by saying: "teachers or students become so dependent on AI that it weakens [their] critical thinking skills or manual abilities." In the context of primary school, the convenience that AI offers can also reduce things that should help train resilience and increase students' intellectual resilience.

The next risk is concern about the security of privacy and personal data, as well as the accuracy of information generated by AI. Twenty-one teachers pointed to "data privacy and security" as a serious threat. Participants R41 stated that: "The use of AI poses a serious threat to privacy and personal data." This concern is quite reasonable because the impact of personal data leaks is more vulnerable and serious on children compared to adults. In addition, the existence of the problem of "AI hallucinations" forces teachers to remain vigilant by validating information derived from AI. R34 participants noted the problem of AI hallucinations by stating: "Sometimes the AI answers are inappropriate and need to be reviewed again."

The next teacher's anxiety highlights the problem of fewer future job openings, declining social interaction, and the high cost of using AI. R14 participants worried about job vacancies by saying: "AI can increase unemployment in the education sector". Next, R89 participants raised the issue of social interaction, saying that AI could "reduce social interaction." In addition, R90 participants complained about the cost of using AI, saying: "Its use costs are expensive."

The next concern is moral and health issues. R40 raised his concerns by saying: "If not paid attention to, [AI] will be misused by students in a bad way (R40)". Furthermore, R32 participants who were worried about the risk of visual impairment said: "It can interfere with eye vision and forget time". The findings show that teachers have a high awareness of the potential risks of AI, both from the technical, pedagogical, ethical, and safety aspects of students.

Teachers' concerns about the decline in students' cognitive abilities due to the use of technology in learning have highlighted the importance of ethical knowledge within the TPACK framework. This ethical knowledge is a new dimension that needs to be considered in the application of AI technology in the field of education (Deng & Zhang, 2023; Lan et al., 2025). This research supports Gerlich's (2025) argument about the risk of cognitive disassembly. However, the novelty of the context offered by this study is that the threat is not only a high level of cognition, but also a decline in basic character traits such as honesty and perseverance. In addition, the findings on teachers' concerns about AI hallucinations and user data security align with research by Boulhrir & Hamash (2025a) and Reiter et al. (2025).

Teachers' Ethical and Reflective Agency Strategies to Manage AI Use

The results of this study found that teachers are not resigned or passive in facing infrastructure obstacles and ethical risks. The results of the data analysis show that teacher competence has evolved into what we call the "Ethical & Reflective AI-Agency". As classified in Table 2, teachers exhibit three dimensions of agency: proactive in building their abilities from TPACK to AI-TPACK, protective in avoiding the dangers of AI use, and proactive in optimizing learning quality through the critical and thoughtful use of AI.

Table 2. Taxonomy of Teachers' Ethical and Reflective Agency Strategies

Dimensions	Specific Type	Freq.	Description
Proactive Agency *(Competence building)*	Self-Determined Learning	67	Self-determined learning through informal platforms (YouTube, TikTok) to fill the gap in formal training.
	Experiential Practice	36	Learn through trial and error methods in daily use.
	Formal Training	25	Participating in structured workshops or webinars (e.g., Pintar app).
	Collaborative Inquiry	23	Asking for help from others, like peers, experts, or communities.
Protective Agency *(Risk Mitigation)*	Human-in-the-Loop Validation	37	Confirming or cross-referencing the outputs of AI products against credible sources and information to mitigate the risk of hallucination.
	Managing use selectively	35	Set strict limits, schedules, and rules to prevent overuse.
	Data Privacy	9	Implement measures that protect the privacy and

	Protection		security of students' personal data.
	Supervision & Monitoring	8	Directly overseeing student AI usage to prevent misuse.
Pedagogical Agency *(Optimization)*	Curriculum Integration	29	Integrate AI into lesson plans to trigger High-Order Thinking Skills (HOTS).
	Teacher-Student Engagement	3	Using AI to boost interaction and participation, not replace it.
	Positioning as a Support Tool	22	Treating AI as a "companion" rather than the main source.

First, teachers show Proactive Agency in building their competencies. The data from this study show that the majority of teachers (n=67) have engaged in self-directed learning through informal channels to address the lack of formal training programs offered by teacher training institutions. For example, R82 participants stated, "I learned on my own through watching YouTube, TikTok, [and] online training." The frequency of self-learning beyond formal training (f=25) indicates that the diffusion of AI innovation in Indonesia is driven more by self-initiated actions than by policies. Thirty-six teachers have also reinforced this act of self-study with the act of learning through "trial and error" exercises and daily use. In addition, they also go beyond their learning process by asking peers and the AI learning community.

Second, teachers implement strict Protective Agencies. Teachers have implemented the "Human-in-the-Loop Validation" protocol as a key strategy to address the risk of hallucinations and inaccuracies in AI outputs. So, teachers do not treat AI as a scientific database, but AI is only treated as a tool and compiler of information whose results need to be validated by humans. R99 participants expressed this by saying: "AI is a learning companion, and not the only learning resource that makes it easier for us". In addition, thirty-five teachers implemented a "selective management" strategy to protect students from reliance and overuse of AI. For example, teachers use AI strictly to develop lesson plans and develop learning media. However, students are prohibited from using it to work on certain assignments and to answer exam questions. In addition, teachers also strengthen student safety by providing directions so that students always use their AI thinking when using AI. For example, Participant R7 explained this by saying: "I filter the AI output and combine my own ideas so that the results are not entirely by AI". In addition, teachers also encourage the implementation of security protocols to protect students' privacy and personal data. R88 participants stated this by saying: "Implement strict data security policies to protect student information". To complement the previous efforts, the teachers also provide guidance to students and supervise them while using AI. For example, R37 participants confirmed this by saying: "[I] teach students about digital security and how to protect their personal data. In addition, R23 Participant revealed: "[I] accompany students in using AI.

Third, teachers engage in Pedagogical Agencies to optimize the benefits of AI and improve the quality of learning. The main strategy of teachers for this aspect is to integrate AI into lesson plans and learning processes. For example, R36 participants described this strategy by saying: "integrating AI into the curriculum and learning processes in the classroom to develop students' ways of thinking in solving more complex problems". In addition, teachers have also increased student engagement when using AI. R82 participants reported this by saying: "encourage student engagement in accessing a wide range of learning resources". Complementing the previous strategy, 22 teachers emphasized the role of AI technology as an additional partner and tool, rather than as a primary reference or a substitute for teachers. R99 participants stated this by saying: "AI is a learning companion, and not the only source of learning that makes it easier for us".

The results of this study are in line with social-cognitive theory, where teachers refuse to passively accept technology by actively participating in validation (Human-in-the-Loop) and selective restriction as a form of self-regulation (Schunk & DiBenedetto, 2023). Teachers who actively use technology and reflect on their experience in using it effectively and ethically have given birth to the concept of "Ethical and Reflective Agents." This concept highlights the importance of ethical reasoning and critical reflection in the educational environment to encourage more appropriate, thoughtful, and responsible use of technology (Langlois & Lapointe, 2010; Pu & Barnard, 2025). The research findings on active validation strategies align with previous literature that underscores the importance of human-machine collaboration (Sidra & Mason, 2025; Viola et al., 2023). The results of this study also highlight the importance of combining formal and informal learning approaches for developing teachers' competencies (Abedi & Ametepey, 2024; Mercado & Shin, 2022).

These findings suggest that ethical anxiety about AI risks does not make teachers passive, but rather triggers the birth of the 'Ethical & Reflective AI-Agency'—an evolution of competencies in which teachers play the role of critical validators and moral overseers to ensure that technology reinforces, rather than degrades, students' cognitive abilities and character. In addition, the results of this study also provide important implications that the TPACK framework in primary schools needs to be expanded with dimensions of ethical knowledge and reflective agency, in order to equip teachers in navigating the risks of 'AI hallucinations' and digital dependency through proactive human-in-the-loop strategies.

Practical Implications

The study's findings have several practical implications that stakeholders need to follow up on. First, there are findings that teachers are very concerned about the validity of information from AI and the security of personal data, so teacher training must transform from a curriculum that focuses only on technical components (how to use AI applications) to a curriculum that teaches human-in-the-loop validation strategies, recognizing AI

hallucinations, securing student data, and designing tasks that cannot simply be copied and pasted from AI (Chen & Yang, 2025; Merzifonluoglu, 2025).

Second, research findings showing that the availability and implementation costs of infrastructure are important factors in AI adoption underscore the need for government intervention to help underfunded schools leverage AI effectively (Leong, 2024; Sarvakar & Prajapati, 2025). In this context, local governments and education offices need to issue policies that support schools in having sufficient funds to provide adequate computer devices for teachers and students, a stable internet network in the school environment, and the subscription to AI applications that support learning activities.

Third, schools need to formulate clear rules about the use of AI in schools to balance students' cognitive efficiency and resilience, such as rules for assignments, exams, and administrative tasks (Adelhardt & Eberle, 2025). In addition, schools need to establish ethics committees, inclusive governance, and systems to monitor the ethical use of AI and its impact on educational outcomes (Bozkurt, 2025; Franco D'Souza et al., 2024).

Fourth, given that many teachers experience difficulties with self-learning, teachers' professional development models must integrate formal and informal pathways in a balanced, personalized, and context-sensitive approach (Makhmetova et al., 2025). In this context, principals can facilitate weekly sharing sessions where proficient teachers mentor their peers. In addition, the education office can also curate credible content from education creators so that it is recognized as a legitimate and high-quality alternative learning resource.

Limitations and Future Research

This research presents several limitations that warrant acknowledgment. First, while a sample size of 100 primary school teachers is adequate for a descriptive qualitative study, it may not fully capture Indonesia's geographical diversity. Second, data were collected via self-reported, open-ended, reflective questionnaires. This method may lead participants to provide answers perceived as socially "ideal," despite efforts to mitigate this bias through trial audit steps. Third, this study centers on teachers' perceptions and strategies; it does not quantitatively assess the direct impact of AI usage on student learning outcomes.

Building on the findings of this study, further research is recommended to explore how teachers' digital competencies influence their ethical anxiety. Additionally, the effectiveness of the Human-in-the-Loop strategy in enhancing students' critical thinking skills should be measured. Moreover, investigating local government regulatory support for primary school AI infrastructure to address the "Phenomenological Gap" identified in this study could further enrich the results. Lastly, the findings suggest the need for research on the effectiveness of Ethical Agency-based training modules in improving teachers' TPACK (technological, pedagogical, and content knowledge).

CONCLUSION

This study successfully maps the dynamics of Artificial Intelligence (AI) integration in the elementary school environment, including shifts in perceptions, structural barriers, ethical risks, and the emergence of teacher agency. The study's findings reveal a significant evolution in educators' perceptions, with the initial adoption of AI for administrative efficiency shifting toward its strategic use to develop innovative learning media and assessment instruments. However, this transformative potential is still hampered by fundamental infrastructure barriers, such as unstable connectivity and limited access to digital devices, which stand in contrast to the challenges in Indonesia compared to developed countries. On the other hand, this integration raises ethical concerns among teachers about the risk of students' cognitive dependence and the degradation of originality in learning. As a defense mechanism, teachers demonstrate reflective agency through human-in-the-loop strategies and self-determined learning to mitigate the risk of AI hallucinations and protect data privacy. Theoretically, this research contributes to the expansion of the TPACK framework by integrating the dimension of ethical agency, as well as providing policy implications that the success of digitization of basic education requires synergy between strengthening technological infrastructure and developing critical and reflective pedagogical capacity.

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