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Artificial Intelligence in Education: Opportunities, Challenges, and Implications for the Learning Process

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Abstract

Artificial intelligence (AI) is reshaping education faster than pedagogical theory and institutional policy can absorb it. Although reviews of AI in education (AIEd) are multiplying, most catalogue applications or list risks separately, leaving unclear how opportunities and challenges jointly reconfigure the learning process. This study addresses that gap through a systematic literature review guided by the PRISMA 2020 statement. Records were identified through the Consensus academic search engine using two search strings and supplemented by citation searching, then screened against criteria covering publication between 2021 and 2026, peer-reviewed status, an active DOI, and direct relevance to teaching and learning. Twenty-four studies were retained and analysed through thematic synthesis. The results reveal four clusters of opportunity: personalised and adaptive learning, intelligent tutoring and feedback, AI-supported assessment, and augmentation of teachers' work. These are counterbalanced by five clusters of challenge: academic integrity, algorithmic bias and data privacy, overreliance and the erosion of higher-order thinking, unequal infrastructure and AI literacy, and weak institutional governance. Mapping both clusters onto the stages of the learning process, the study proposes a Learner–Teacher–AI Agency Framework, which holds that AI improves learning only when it redistributes, rather than replaces, human agency. Implications are drawn for pedagogy, assessment redesign, teacher professional development, and policy, particularly in developing-country contexts such as Indonesia

INTRODUCTION

Artificial intelligence (AI) has moved from the margins of educational technology to the centre of everyday teaching and learning. Over the past five years, adaptive platforms, intelligent tutoring systems, automated assessment tools and, since late 2022, generative AI chatbots have entered classrooms at every level of schooling (Crompton & Burke, 2023; Wang et al., 2024). Crompton and Burke (2023) recorded that publications on AI in higher education in 2021 and 2022 reached two to three times the volume of previous years, a sign that research is racing to keep pace with practice. This acceleration has turned AI in education (AIEd) from a specialist niche of computer science into a mainstream concern for teachers, institutional leaders, and policymakers (Ifenthaler et al., 2024). The question is no longer whether AI will be used in education, but how its use will reshape what it means to

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teach and to learn.

The promise of AI is substantial. AI systems can model what a learner knows, adapt the sequence and difficulty of content, and deliver immediate feedback at a scale that no individual teacher can match (Gligorea et al., 2023; Tapalova et al., 2022). Systematic reviews associate AI-based personalised learning with gains in achievement, engagement, and motivation (Farhood et al., 2025; Strielkowski et al., 2024). In science education, Almasri (2024) found that AI tools supported conceptual understanding and inquiry, particularly when embedded in deliberate pedagogical designs rather than used as stand-alone add-ons. AI also extends into educational measurement, where it can automate scoring, generate test items, and flag learning difficulties early (Owan et al., 2023). For teachers, generative AI promises to lighten routine work such as drafting materials, rubrics, and feedback, freeing time for mentoring and higher-order instruction (Eager & Brunton, 2023; Kasneci et al., 2023). Earlier conceptual work had already positioned AI as a lever for more efficient, inclusive, and sustainable education systems (Ahmad et al., 2021; Hamal et al., 2022).

Yet the same literature documents serious concerns. Generative AI unsettles conventional assessment because students can now produce fluent text without the cognitive work that the assessment was designed to evidence. In a large survey of teachers, Bower et al. (2024) found broad agreement that both teaching and assessment must change in response to increasingly capable generative models. Ethical risks include algorithmic bias, opaque decision-making, surveillance, and the misuse of student data (Akgun & Greenhow, 2022). Holmes et al. (2022) argue that the good intentions of AIEd developers are not sufficient on their own and that fairness, accountability, transparency, autonomy, and inclusion must be addressed explicitly. Other studies warn of overreliance, in which learners delegate reasoning to machines and gradually weaken their capacity for critical and creative thought (Gafur et al., 2026; Ghunio et al., 2026). Institutional readiness is also uneven: infrastructure, teacher competence, and governance frameworks lag behind adoption, especially in lower-resource settings (AlBlooshi, 2026; Ocen et al., 2025).

These tensions matter for the learning process itself, not merely for technology management. Learning is a cognitive and social process in which learners construct knowledge, regulate their own effort, and receive guidance and feedback from teachers and peers. When AI enters this process, it alters who sets learning goals, who generates explanations, who judges the quality of work, and who bears responsibility for errors. Kong and Yang (2024) therefore propose a human-centred framework in which generative AI supports students' self-regulated learning through domain knowledge learning rather than substituting for it. Jaldemark et al. (2025) similarly call for a multidisciplinary research agenda that examines how AI reshapes learning and instruction as social practices, instead of evaluating AI tools only in terms of short-term performance gains. The central issue, in other words, is the distribution of agency among learners, teachers, and machines.

Existing reviews have mapped the field but leave important gaps. Chiu et al. (2023) identified thirteen roles of AI across learning, teaching, assessment, and administration, together with seven learning outcomes and ten major challenges; however, their corpus ended in 2021, before generative AI became widely accessible. Crompton and Burke (2023) reviewed AI in higher education from 2016 to 2022 and documented its main uses, from assessment and prediction to intelligent tutoring and AI assistants. More recent syntheses by Wang et al. (2024) and Garzón et al. (2025) chart trends, benefits, and challenges across educational levels, while AlBlooshi (2026) and Ocen et al. (2025) focus on higher education institutions. Ifenthaler et al. (2024) translate the evidence into implications for policymakers, researchers, and practitioners.

Three limitations nevertheless recur across this body of work. First, opportunities and challenges are usually reported as separate lists. Readers learn what AI can do and what can go wrong, but not how the two interact within the same learning activity, for instance how instant AI feedback can simultaneously accelerate practice and encourage superficial engagement. Second, most reviews are organised around technologies (chatbots, tutoring systems, learning analytics) or around stakeholders (students, teachers, institutions) rather than around the stages of the learning process, such as planning, instruction, practice,

feedback, assessment, and reflection. This makes it difficult for teachers to translate findings into lesson-level decisions. Third, evidence from the generative AI period after 2023 has not yet been fully integrated with the earlier literature on adaptive learning and intelligent tutoring, so it remains unclear which findings carry over and which must be revised.

These gaps are particularly consequential for developing countries. In Indonesia, policy has shifted towards student-centred and differentiated learning, an agenda to which AI-based personalisation appears well suited. At the same time, adoption is occurring amid wide regional disparities in connectivity, devices, and teachers' digital competence, and with limited institutional guidance on the acceptable use of generative AI. Reviews dominated by evidence from well-resourced systems may therefore overstate the opportunities and understate the preconditions on which they depend (AlBlooshi, 2026; Ocen et al., 2025). A synthesis that makes those preconditions explicit is needed to inform realistic policy and practice.

This study offers three contributions that constitute its novelty. First, it integrates evidence published between 2021 and 2026, bridging the adaptive AI and generative AI phases of the field within a single review. Second, rather than listing opportunities and challenges separately, it maps them as paired tensions onto the stages of the learning process, producing an opportunity–challenge matrix that teachers and curriculum designers can apply directly. Third, it proposes a Learner–Teacher–AI Agency Framework, which argues that AI improves learning only when it redistributes human agency across the learning cycle rather than replacing it, and derives from this framework concrete implications for pedagogy, assessment, professional development, and governance.

Accordingly, this study addresses three research questions. RQ1: What opportunities does recent literature identify for the use of AI in teaching and learning? RQ2: What challenges and risks accompany these opportunities? RQ3: What are the implications of these opportunities and challenges for the learning process, and how can they be organised into a coherent framework for practice and policy? The remainder of the article is organised as follows. Section 2 describes the review method, Section 3 presents and discusses the results, and Section 4 concludes with recommendations and directions for future research.

METHODS

Research design

This study is a systematic literature review (SLR) with a qualitative thematic synthesis. An SLR was chosen because the research questions concern the state and direction of a rapidly expanding body of evidence rather than the effect of a single intervention. The identification, screening, and reporting of studies followed the PRISMA 2020 statement for systematic reviews (Page et al., 2021), adapted to a narrative rather than meta-analytic synthesis because the included studies differ widely in design, setting, and outcome measures.

Data source and search strategy

Records were retrieved from Consensus (consensus.app), an AI-assisted academic search engine that indexes peer-reviewed literature and returns records with bibliographic metadata and DOIs. Two search strings were run and exported in RIS format on 29 October 2026. The first used the English formulation of the topic, "Artificial Intelligence in Education: Opportunities, Challenges, and Implications for the Learning Process", and returned 13 records. The second used the Indonesian formulation, "Artificial Intelligence dalam Pendidikan: Peluang, Tantangan dan Implikasi terhadap Proses Pembelajaran", and returned 19 records. Because Consensus retrieves predominantly English-language literature, the second string broadened semantic coverage rather than restricting results to Indonesian publications. To compensate for the limited size of the database yield, citation searching (backward and forward) was conducted on the review articles retained after full-text assessment.

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Eligibility criteria

Studies were assessed against the inclusion and exclusion criteria in Table 1.

Table 1. Inclusion and exclusion criteria

Criterion	Inclusion	Exclusion
Publication period	2021–2026 (last five years)	Published before 2021
Publication type	Peer-reviewed journal article or review	Preprints, theses, editorials, unreviewed reports
Topic	AI applied to teaching, learning, or assessment	AI in education administration only, or AI outside education
Accessibility	Active, resolvable DOI; indexed in Google Scholar	DOI not resolvable or indexing not verifiable
Analytical depth	Addresses opportunities, challenges, or implications for the learning process	Descriptive tool lists without analysis of learning
Language	English	Other languages

Study selection

The two exports yielded 32 records. Six records appeared in both exports and were removed as duplicates, leaving 26 unique records for title and abstract screening. Three records were excluded at this stage: one preprint that had not undergone peer review, one article whose title is identical to that of the present study and was excluded to avoid overlap, and one record whose indexing could not be verified. Of the 23 full texts assessed, three were excluded because they described AI tools without substantive analysis of the learning process. Twenty studies from the database search were therefore eligible. Citation searching added four widely cited reviews and position papers published within the time window (Chiu et al., 2023; Crompton & Burke, 2023; Holmes et al., 2022; Kasneci et al., 2023), producing a final corpus of 24 studies. Figure 1 summarises the process.

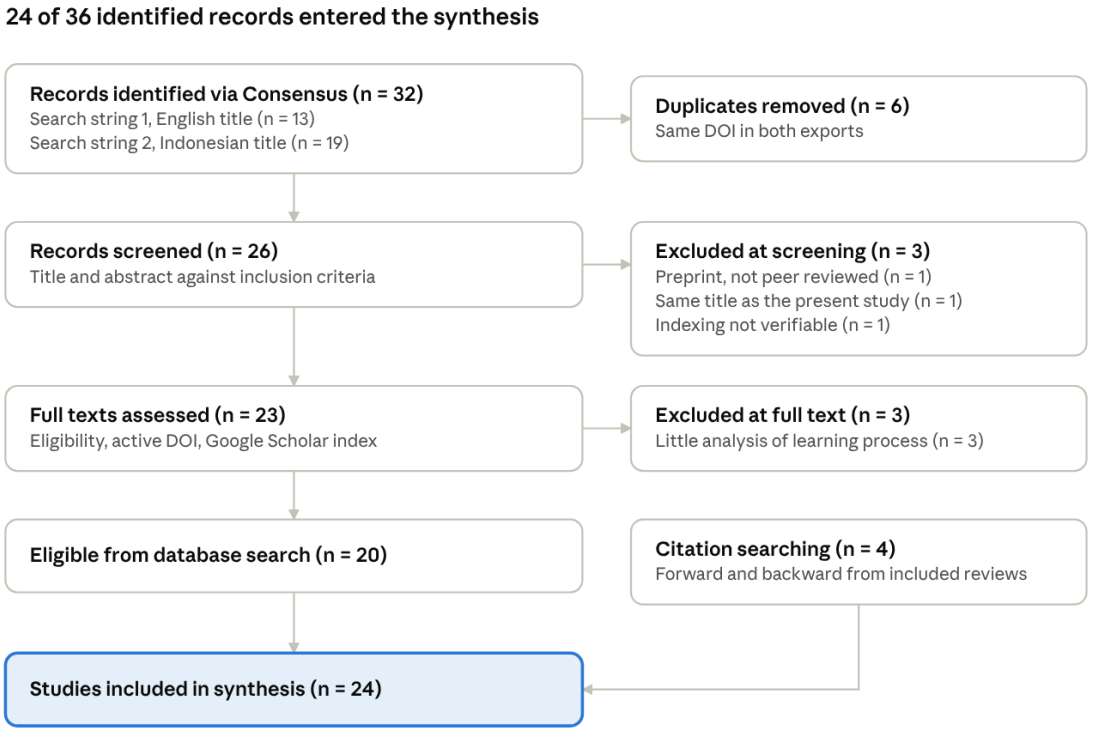


Figure 1. PRISMA 2020 flow diagram of study identification, screening, and inclusion

Data extraction and analysis

For each study, the following data were extracted into a coding matrix: author and year, publication venue, study type, educational level, AI technology examined, reported opportunities, reported challenges, and stated implications. The analysis then proceeded through thematic synthesis in three steps. First, findings were coded inductively at sentence and paragraph level. Second, codes were grouped into descriptive themes, which yielded the opportunity and challenge clusters reported in Section 3. Third, these themes were mapped deductively onto six stages of the learning process (planning, instruction, practice, feedback, assessment, and reflection) to identify where each opportunity and challenge arises. To strengthen trustworthiness, coding decisions were documented in an audit trail, and each theme was retained only when it was supported by at least three independent studies. The DOI of every included study was resolved and its Google Scholar record checked before the final analysis.

RESULTS AND DISCUSSION

Profile of the included studies

The final corpus comprises 24 studies published between 2021 and 2026. One study was published in 2021, four in 2022, six in 2023, six in 2024, four in 2025, and three in 2026. Sixteen of the 24 studies (67%) appeared in or after 2023, the first full year after generative AI chatbots became publicly available, which confirms that the evidence base has been reshaped by the arrival of large language models. Review designs dominate the corpus, complemented by a teacher survey, an empirical study of personalised learning pathways, a design framework, and several position papers that set ethical and research agendas. Higher education is the most frequently studied level, while K–12 settings are addressed mainly in work on ethics and self-regulated learning. Table 2 summarises the characteristics of each study.

Table 2. Characteristics of the included studies (n = 24)

No	Study	Venue	Type	Main focus
1	Ahmad et al. (2021)	Sustainability	Conceptual review	Roles of AI in education and sustainability
2	Akgun & Greenhow (2022)	AI and Ethics	Ethical analysis	Ethical challenges of AI in K–12
3	AlBlooshi (2026)	Frontiers in Education	Review	Opportunities and challenges in higher education
4	Almasri (2024)	Research in Science Education	Systematic review	AI in science teaching and learning
5	Bower et al. (2024)	Education and Information Technologies	Teacher survey	Changing teaching and assessment for generative AI
6	Chiu et al. (2023)	Computers and Education: Artificial Intelligence	Systematic review	Roles, outcomes, and challenges of AIEd
7	Crompton & Burke (2023)	Int. J. of Educational Technology in Higher Education	Systematic review	AI in higher education, 2016–2022
8	Eager & Brunton (2023)	J. of University Teaching and Learning Practice	Practice paper	Prompting and AI-augmented teaching
9	Farhood et al. (2025)	Discover Artificial Intelligence	Systematic review	AI-based personalised learning

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10	Gafur et al. (2026)	Journal La Edusci	Review	Implications of AI for future learning
11	Garzón et al. (2025)	Multimodal Technologies and Interaction	Systematic review	Trends, benefits, and challenges of AIEd
12	Ghunio et al. (2026)	ACADEMIA Int. J. for Social Sciences	Research article	AI in enhancing teaching and learning
13	Gligorea et al. (2023)	Education Sciences	Literature review	Adaptive learning in e-learning
14	Hamal et al. (2022)	Sustainability	Research article	AI applications for learning
15	Holmes et al. (2022)	Int. J. of Artificial Intelligence in Education	Expert survey	Community-wide ethics framework
16	Ifenthaler et al. (2024)	Technology, Knowledge and Learning	Position paper	Implications for policy, research, practice
17	Jaldemark et al. (2025)	Postdigital Science and Education	Position paper	Multidisciplinary research agenda
18	Kasneci et al. (2023)	Learning and Individual Differences	Commentary	Large language models in education
19	Kong & Yang (2024)	IEEE Transactions on Learning Technologies	Framework design	Generative AI for self-regulated learning in K–12
20	Ocen et al. (2025)	Frontiers in Education	Review	AI innovations in higher education institutions
21	Owan et al. (2023)	Eurasia J. of Mathematics, Science and Technology Education	Review	AI in educational measurement and assessment
22	Strielkowski et al. (2024)	Sustainable Development	Review	AI-driven adaptive learning
23	Tapalova et al. (2022)	Electronic Journal of e-Learning	Empirical study	Personalised learning pathways
24	Wang et al. (2024)	Expert Systems with Applications	Systematic review	Broad review of AIEd research

Opportunities of AI for the learning process (RQ1)

The synthesis identified four clusters of opportunity. The first and most strongly supported is personalised and adaptive learning. Adaptive systems use learner data to adjust content, pace, and difficulty, so that each student works within a zone of productive challenge rather than following a single linear path (Gligorea et al., 2023; Strielkowski et al., 2024). Tapalova et al. (2022) showed how AI can generate individual learning pathways, and the review by Farhood et al. (2025) reports that AI-based personalisation is frequently associated with higher achievement, engagement, and motivation. Hamal et al. (2022) and Ahmad et al. (2021) frame personalisation as a route to more inclusive and sustainable education systems, because it allows large and heterogeneous classes to receive differentiated support.

The second cluster is intelligent tutoring and immediate feedback. Before 2023, this function was performed mainly by domain-specific tutoring systems; generative AI has since made conversational tutoring available in almost every subject (Crompton & Burke, 2023; Kasneci et al., 2023). Learners can ask follow-up questions, request alternative explanations, and receive feedback on drafts at any hour. In science education, AI tools supported inquiry and conceptual understanding when they were embedded in structured tasks (Almasri, 2024). Kong and Yang (2024) further show that generative AI can scaffold goal setting, monitoring, and reflection, the core phases of self-regulated learning, when its role is defined in advance by the teacher.

The third cluster is AI-supported assessment and learning analytics. AI can

automate the scoring of objective and open-ended responses, generate test items, and detect patterns that signal difficulty or disengagement (Owan et al., 2023). Chiu et al. (2023) and Wang et al. (2024) identify prediction of performance and early warning as recurring applications, which allow teachers to intervene before failure rather than after it. The pedagogical value lies less in faster grading than in shifting assessment from a summative event to a continuous source of formative information.

The fourth cluster is the augmentation of teachers' work. Generative AI can draft lesson plans, examples, rubrics, and differentiated materials, reducing routine workload (Eager & Brunton, 2023). Teachers surveyed by Bower et al. (2024) anticipated using AI for preparation and feedback, while Ifenthaler et al. (2024) and AlBlooshi (2026) emphasise that the freed time should be reinvested in mentoring, discussion, and complex tasks that machines handle poorly. Across the four clusters, the common thread is that AI expands the capacity of the learning environment to respond to individual learners.

Challenges and risks (RQ2)

Five clusters of challenge counterbalance these opportunities. The first is academic integrity and assessment validity. Because generative AI produces fluent essays, code, and solutions, products submitted by students no longer reliably evidence the learning they are meant to demonstrate (Bower et al., 2024; Kasneci et al., 2023). Detection tools are unreliable, so the literature increasingly recommends redesigning assessment around process, oral defence, and authentic tasks rather than policing outputs (Eager & Brunton, 2023; Ocen et al., 2025).

The second cluster concerns algorithmic bias, privacy, and transparency. AI systems learn from historical data and may reproduce inequalities related to language, gender, socioeconomic status, or disability (Akgun & Greenhow, 2022). Adaptive and predictive systems also require continuous collection of learner data, raising questions of consent, ownership, and surveillance, particularly for minors. Holmes et al. (2022) stress that ethical AIEd requires attention not only to doing ethical things but also to doing things ethically, including explaining automated decisions to the learners they affect.

The third cluster is overreliance and the erosion of higher-order thinking. When AI supplies answers instantly, learners may bypass the productive struggle through which understanding and critical judgement develop (Gafur et al., 2026; Ghunio et al., 2026). Kasneci et al. (2023) note that large language models can be confidently wrong, so uncritical use risks embedding misconceptions. Kong and Yang (2024) frame the same risk as a threat to self-regulation: if the machine plans, monitors, and evaluates, the learner does not.

The fourth cluster is unequal infrastructure and AI literacy. Benefits depend on devices, connectivity, and the competence of teachers and students to use AI critically (AlBlooshi, 2026; Ocen et al., 2025). Garzón et al. (2025) and Kasneci et al. (2023) identify teacher preparation and AI literacy as preconditions that many systems have not yet met. Without deliberate investment, AI may widen rather than narrow gaps between well-resourced and under-resourced schools, a risk of particular relevance to archipelagic countries such as Indonesia.

The fifth cluster is weak governance and a thin evidence base. Institutional policies on acceptable use are often absent or inconsistent (Ifenthaler et al., 2024). Wang et al. (2024) and Jaldemark et al. (2025) observe that much research remains short-term and technology-centred, with limited longitudinal evidence on learning outcomes and limited participation of educators in system design.

The interplay between opportunities and challenges

A key finding of this review is that opportunities and challenges are not independent lists but paired tensions that arise at the same point in the learning process. Table 3 maps them onto six stages of learning.

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Table 3. Opportunity–challenge matrix across stages of the learning process

Learning stage	AI opportunity	Paired challenge	Pedagogical condition	Key sources
Planning	Diagnosis of prior knowledge; personalised pathways	Profiling and bias in learner models	Transparent learner models open to teacher review	Tapalova et al. (2022); Akgun & Greenhow (2022)
Instruction	Adaptive content and multiple explanations	Fragmented, machine-led sequencing	Teacher-designed learning goals frame AI use	Gligorea et al. (2023); Strielkowski et al. (2024)
Practice	Unlimited guided practice and tutoring	Overreliance; answer-seeking behaviour	Hints and Socratic prompts instead of full solutions	Kasneci et al. (2023); Ghunio et al. (2026)
Feedback	Immediate, individual feedback	Inaccurate or generic AI feedback	Students verify and act on feedback; teacher spot-checks	Almasri (2024); Eager & Brunton (2023)
Assessment	Automated scoring; early warning analytics	Integrity risks; invalid product-based evidence	Process-based, oral, and authentic assessment	Owan et al. (2023); Bower et al. (2024)
Reflection and self-regulation	Prompts for goal setting and monitoring	Outsourcing of metacognition	AI scaffolds that fade as competence grows	Kong & Yang (2024); Chiu et al. (2023)

The matrix shows that the same affordance produces benefit or harm depending on the pedagogical design around it. Immediate feedback, for instance, accelerates practice when students must interpret and apply it, but invites superficial engagement when it simply supplies correct answers. This pattern is consistent with Almasri's (2024) observation that AI was most effective when embedded in deliberate instructional designs, and with Holmes et al.'s (2022) argument that ethics must be built into pedagogical choices rather than added afterwards. It also explains why reviews that list opportunities and challenges separately tend to produce either optimistic or pessimistic conclusions: the decisive variable, pedagogy, sits between the two lists.

Compared with Chiu et al. (2023), whose corpus predates generative AI, the present review finds that the centre of gravity has shifted. Personalisation and prediction remain important, but integrity, overreliance, and the redesign of assessment have become the dominant concerns since 2023. Earlier findings on adaptive learning therefore carry over, but they must now be read alongside evidence that general-purpose AI is used by students outside any system that teachers control.

Implications: a Learner–Teacher–AI Agency Framework (RQ3)

The synthesis suggests that the impact of AI on learning depends on how agency is distributed among learners, teachers, and AI systems. We therefore propose a Learner–Teacher–AI Agency Framework built on three principles. First, AI should amplify, not replace, learner agency: it scaffolds planning, practice, and reflection, but the learner retains responsibility for reasoning and judgement, and support fades as competence grows (Kong & Yang, 2024). Second, the teacher acts as designer and final judge: teachers set the goals, decide where AI is permitted, and validate AI-generated feedback and assessments (Bower et al., 2024; Ifenthaler et al., 2024). Third, AI must remain an accountable tool: its data use, limitations, and decision logic are made transparent to learners and governed by institutional policy (Holmes et al., 2022; Jaldemark et al., 2025). Table 4 translates these principles into implications for each stakeholder.

Table 4. Implications of the Learner–Teacher–AI Agency Framework by stakeholder

Stakeholder	Implication	Supporting studies
Students	Develop AI literacy: verify outputs, disclose AI use, keep ownership of reasoning	Kasneci et al. (2023); Gafur et al. (2026)
Teachers	Redesign tasks and assessment around process; use AI to differentiate, not to automate judgement	Bower et al. (2024); Eager & Brunton (2023)
Institutions	Issue clear acceptable-use policies; fund infrastructure and continuous professional development	AlBlooshi (2026); Ocen et al. (2025)
Policymakers	Set standards for data protection, algorithmic transparency, and equitable access, including remote regions	Holmes et al. (2022); Ifenthaler et al. (2024)
Researchers	Conduct longitudinal and context-specific studies, including in developing countries, with educators as co-designers	Jaldemark et al. (2025); Wang et al. (2024)

For Indonesia, the framework implies that the integration of AI into student-centred and differentiated learning should be sequenced with investment in connectivity and teacher capability, rather than assuming that access to tools alone will improve learning. Teacher education programmes are a strategic entry point, because teachers who understand both the affordances and the limits of AI are best placed to design the pedagogical conditions identified in Table 3

CONCLUSIONS

This review of 24 studies published between 2021 and 2026 shows that AI offers four substantial opportunities for the learning process: personalised and adaptive learning, intelligent tutoring with immediate feedback, AI-supported assessment and analytics, and the augmentation of teachers' work. These opportunities are matched by five challenges: threats to academic integrity and assessment validity, algorithmic bias and data privacy, overreliance that erodes higher-order thinking, unequal infrastructure and AI literacy, and weak governance supported by a still-thin evidence base.

The principal contribution of the study is to show that these opportunities and challenges are paired tensions arising at the same stages of learning, from planning to reflection, and that pedagogical design determines which side of each tension prevails. On this basis, the proposed Learner–Teacher–AI Agency Framework holds that AI improves learning when it amplifies learner agency, keeps the teacher as designer and final judge, and remains an accountable, transparent tool. Practically, this calls for process-based assessment, sustained teacher professional development, explicit institutional policies on acceptable use, and public investment in equitable access, especially in developing countries such as Indonesia.

The study has limitations. The corpus was drawn from a single AI-assisted search engine supplemented by citation searching, was restricted to English-language publications, and relied on thematic rather than statistical synthesis. Future research should extend the search to Scopus, Web of Science, and Indonesian national indexes such as SINTA and Garuda, test the proposed framework empirically through classroom-based and longitudinal studies, and examine how learners in under-resourced regions actually use generative AI in their daily study.

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