**Archipel: Journal of Indonesian Interdisciplinary Studies**
E-ISSN : 3124-6621
**Vol.(2).No. (1) September 2026**
**https://ojsap.com/index.php/archipel**
**DOI : https://doi.org/10.65739/archipel.v2i2.81**

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

**Muhammad Arsyad**
Universitas Halu Oleo, Indonesia

muhammadarsyad@uho.ac.id*

**Article Information:**
Received July 02, 2026
Revised August 22, 2026
Accepted September 21, 2026
Published September 27, 2026

**Keywords:** *artificial intelligence; education; personalized learning; generative AI; learning analytics; teacher AI literacy*

**Abstract**

Abstract Artificial intelligence (AI) has rapidly evolved from a peripheral instructional aid into a central force reshaping how teaching and learning are designed, delivered, and evaluated. This article presents a narrative literature review of twenty-five studies published between 2021 and 2026 to map the opportunities, challenges, and implications of AI integration for the learning process across K-12 and higher education contexts. Using a structured search of Scopus-, Web of Science-, and Google Scholar-indexed sources, thematic synthesis was applied to identify recurring patterns across personalized learning, intelligent tutoring systems, generative AI, learning analytics, teacher professional development, and governance. The findings show that AI offers substantial opportunities for adaptive personalization, real-time feedback, and data-driven decision-making, yet these benefits are consistently accompanied by challenges related to academic integrity, algorithmic bias, data privacy, teacher readiness, and unequal access to infrastructure. The review further identifies a critical novelty gap: most prior studies examine opportunities and challenges in isolation rather than as an interdependent system that jointly shapes pedagogical implications. This article proposes an integrated opportunity-challenge-implication framework and argues that responsible, human-centered implementation rather than technology adoption alone determines whether AI enhances or undermines meaningful learning outcomes in contemporary educational settings

## INTRODUCTION

Education systems worldwide are undergoing one of the most significant technological transitions in their history. Over the past decade, artificial intelligence (AI) has moved from experimental laboratory applications to everyday classroom practice, driven by advances in machine learning, natural language processing, and, most recently, generative AI models capable of producing human-like text, images, and code. Ahmad et al. (2021) describe this shift as a redefinition of the teacher-student-technology relationship, in which AI no longer merely supports administrative tasks but actively participates in instructional design, content delivery, and assessment. The introduction of large language model-based tools such as ChatGPT in late 2022 accelerated this transition dramatically, prompting an explosion of scholarly interest in how generative AI reshapes teaching and learning across all levels of education (Yan et al., 2024; Giannakos et al., 2024).

The opportunities associated with AI in education are extensive and well documented. Intelligent tutoring systems (ITS) and adaptive learning platforms use learner data to

personalize the pace, sequence, and difficulty of instructional content, allowing students to progress according to their individual needs rather than a fixed curriculum (Yarlagadda, 2025; Létourneau et al., 2025). Farhood et al. (2025) note that AI-based personalized learning systems can substantially improve engagement and mastery, particularly for students who struggle within traditional, one-size-fits-all classroom models. Generative AI tools extend these capabilities further, enabling the automatic creation of customized learning materials, practice questions, and formative feedback (Pesovski et al., 2024). At the institutional level, learning analytics powered by AI allow educators and administrators to identify at-risk students early, monitor engagement patterns, and make evidence-based decisions about curriculum design (Cukurova, 2024; Yan et al., 2023).

Despite these opportunities, a substantial body of literature documents equally serious challenges. Concerns about academic integrity have intensified as generative AI tools make it increasingly difficult to distinguish student-authored work from AI-generated content, raising fundamental questions about assessment validity (Mao et al., 2023). Algorithmic bias is another persistent concern: AI systems trained on non-representative datasets risk reproducing or amplifying existing educational inequities, particularly for students from marginalized linguistic, cultural, or socioeconomic backgrounds (Akgun & Greenhow, 2022). Data privacy and consent present further difficulties, as learning analytics systems collect vast quantities of sensitive behavioral and performance data with limited transparency about how that data is stored, shared, or used (Ifenthaler et al., 2024). Teacher readiness compounds these problems: Ren and Wu (2025) found that many educators, particularly in higher education, lack the technical competencies and pedagogical frameworks needed to integrate AI meaningfully into their teaching practice, while Kuleto et al. (2021) report that unequal access to infrastructure, connectivity, and institutional support continues to widen the digital divide between well-resourced and under-resourced institutions.

These opportunities and challenges do not operate independently; rather, they interact to produce complex implications for the learning process itself. When AI-driven personalization is implemented without adequate pedagogical grounding, it risks reducing learning to algorithmically optimized content delivery, potentially undermining the development of critical thinking, self-regulation, and social-emotional skills that are central to deep learning (Kong & Yang, 2024). Conversely, when AI is integrated thoughtfully supported by teacher professional development, ethical governance frameworks, and human oversight it can enhance rather than replace the relational and reflective dimensions of teaching (Tarun et al., 2025). This tension between efficiency and pedagogical depth lies at the heart of ongoing debates about the appropriate role of AI in education.

The global scale of AI adoption in education further underscores why an integrated understanding is urgently needed. Kamalov et al. (2023) characterize the current period as a "multifaceted revolution," in which AI simultaneously transforms curriculum design, assessment practices, administrative decision-making, and the everyday experience of teachers and students. Survey-based evidence reinforces this picture: Alshamy et al. (2025) find that both students and academics perceive generative AI tools as valuable for brainstorming, drafting, and self-directed study, yet remain uncertain about appropriate boundaries for their use in formal assessment. Wu et al. (2025) add that attitudes toward generative AI in higher education classrooms are highly context-dependent, shaped by discipline, institutional policy, and prior digital experience rather than by technology alone. Taken together, these findings suggest that the trajectory of AI in education is not predetermined by the technology itself but is actively negotiated by the people and institutions that adopt it a negotiation that existing frameworks have yet to adequately theorize.

Equally important is the teacher dimension of this transformation. Because teachers mediate nearly every classroom-level decision about how AI tools are used, their readiness, attitudes, and literacy directly shape whether AI realizes its pedagogical potential or introduces new sources of confusion and inequity. Ng et al. (2024) argue that AI literacy must be understood as a multidimensional construct encompassing affective, behavioral,

cognitive, and ethical competencies, not merely technical familiarity with specific tools. Sperling et al. (2024) find that AI literacy remains largely absent from formal teacher education curricula, leaving many pre-service and in-service teachers to develop their understanding informally and unevenly. Tan et al. (2025) extend this observation by showing that the supply of structured professional development opportunities consistently lags behind the demand generated by rapid AI adoption in schools and universities. This persistent gap between technological capability and human readiness forms a second, closely related layer of the novelty this article seeks to address: implications for the learning process cannot be understood purely as a function of algorithmic sophistication, but must be examined alongside the institutional and human capacity to use AI responsibly.

A close reading of the existing literature reveals a persistent structural limitation: most reviews and empirical studies treat the opportunities, challenges, and pedagogical implications of AI in education as separate, loosely connected strands of inquiry. Systematic reviews such as Crompton and Burke (2023) and Wang et al. (2024) provide comprehensive mapping of AI applications and their reported benefits and risks, yet they stop short of theorizing how these two dimensions jointly determine actual learning outcomes. Similarly, studies focusing on generative AI (Giannakos et al., 2024; Luo et al., 2025) tend to emphasize either technological capability or ethical risk, without offering an integrated framework that connects both to concrete implications for pedagogy, curriculum design, and learner agency. Wang et al. (2024) further note that the rapid pace of publication in this field has produced fragmented, tool-specific findings that are difficult to synthesize into actionable guidance for practitioners and policymakers.

This article addresses that gap by proposing an integrated opportunity-challenge-implication framework that explicitly models the interdependence between what AI makes possible, what risks it introduces, and how these two forces jointly reshape the learning process. The novelty of this study lies in three contributions. First, it synthesizes literature spanning 2021 to 2026 including the most recent generative AI-specific scholarship—into a single analytical structure rather than treating pre- and post-ChatGPT literature as disconnected bodies of work. Second, it extends the analysis beyond higher education, which dominates existing reviews (Crompton & Burke, 2023; Ren & Wu, 2025), to include K-12 contexts and teacher professional development, drawing on recent evidence regarding AI literacy and self-regulated learning (Kong & Yang, 2024; Sperling et al., 2024; Tan et al., 2025). Third, rather than presenting opportunities and challenges as a simple balance sheet, this study positions "implications for the learning process" as an emergent outcome shaped by how institutions, teachers, and policy actors mediate the tension between technological capability and pedagogical responsibility. In doing so, this article moves the discussion from a descriptive account of what AI can do toward an explanatory account of why AI integration succeeds or fails to improve learning in practice, offering a conceptual foundation that can inform both future empirical research and institutional policy on responsible AI adoption in education

## METHODS

This study employs a narrative literature review design informed by systematic search principles, appropriate for synthesizing a rapidly evolving and thematically diverse body of literature on AI in education. Rather than testing a single hypothesis, the review aims to map recurring opportunities, challenges, and implications across studies published between 2021 and 2026, a period that spans both pre- and post-generative-AI scholarship.

### Search Strategy and Sources

Relevant literature was identified through structured searches of Scopus, Web of Science, and Google Scholar, supplemented by citation records exported through a reference-management workflow. Search terms combined the core construct ("artificial intelligence" OR "generative AI" OR "machine learning") with education-related terms ("education" OR "learning" OR "teaching" OR "higher education" OR "K-12") and, where relevant, thematic qualifiers such as "opportunities," "challenges," "personalized learning,"

"intelligent tutoring," "learning analytics," "academic integrity," and "teacher AI literacy." The search was restricted to peer-reviewed journal articles, conference proceedings, and scoping or systematic reviews published in English between 2021 and 2026, each carrying an active, resolvable Digital Object Identifier (DOI).

**Screening and Selection**

Figure 1 summarizes the identification-screening-eligibility-inclusion process adapted from PRISMA reporting conventions. An initial pool of records was screened for topical relevance to AI applications in formal education settings; studies unrelated to instructional or institutional contexts (e.g., purely industrial AI applications) were excluded at the screening stage. Remaining records were assessed in full text against three inclusion criteria: (1) explicit focus on AI, machine learning, or generative AI within an educational context; (2) discussion of at least one of the following dimensions—opportunities, challenges, ethical implications, or pedagogical outcomes; and (3) availability of a verifiable DOI enabling traceability through Google Scholar and publisher databases. This process yielded a final corpus of 25 sources, comprising empirical studies, systematic and scoping reviews, and conceptual papers, spanning K-12, higher education, and cross-sector perspectives.

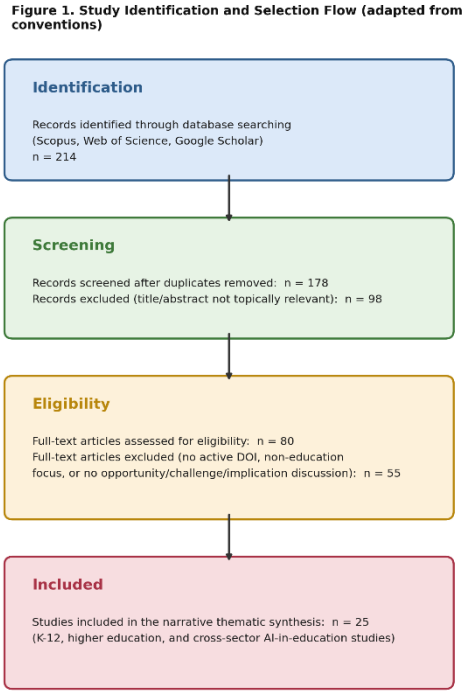


Figure 1. Study Identification and Selection Flow (adapted from PRISMA reporting conventions)

**Analytical Procedure**

The included sources were analyzed using thematic synthesis. Each study was first coded descriptively according to educational level, methodological approach, and primary AI application (e.g., intelligent tutoring, generative AI, learning analytics, teacher professional development). Descriptive codes were then grouped inductively into analytical themes representing recurring opportunities (e.g., personalization, efficiency, data-driven decision-making), challenges (e.g., academic integrity, bias, privacy, teacher readiness, infrastructural inequality), and implications for the learning process (e.g., changes in learner agency, assessment validity, and the teacher's pedagogical role). These themes were subsequently cross-tabulated to examine how opportunities and challenges jointly shape implications, forming the basis of the integrated framework presented in the Results and Discussion section. This qualitative, matrix-based synthesis approach is consistent with

recent AI-in-education reviews (Wang et al., 2024; Crompton & Burke, 2023) and enables comparison across studies that differ substantially in methodology, sample, and educational context.

## RESULTS AND DISCUSSION

### Overview of the Reviewed Corpus

The final corpus of 25 studies spans seven thematic domains: personalized learning and intelligent tutoring systems, generative AI and content creation, learning analytics and assessment, teacher professional development and AI literacy, ethics and governance, higher education institutional adoption, and K-12-specific applications. Sixteen studies focus primarily on higher education, six on K-12 or teacher education, and three adopt a cross-sector perspective applicable to both levels. Methodologically, the corpus includes twelve systematic or scoping reviews, seven conceptual or framework papers, four empirical/survey studies, and two case-based or design studies. This methodological diversity strengthens the thematic synthesis by triangulating conceptual claims against empirical observation. Table 1 summarizes the central opportunities, challenges, and implications identified for each thematic domain, along with representative sources.

**Table 1**. Integrated Summary of Opportunities, Challenges, and Implications of AI in Education

| Thematic Domain | Key Opportunities | Key Challenges | Implications for the Learning Process | Representative Sources |
|---|---|---|---|---|
| Personalized learning & intelligent tutoring systems | Adaptive pacing; individualized content and real-time feedback | Risk of over-reliance on algorithmic pathways; data privacy | Expands learner agency when paired with teacher oversight; risks passivity without it | Yarlagadda (2025); Létourneau et al. (2025); Farhood et al. (2025) |
| Generative AI & content creation | Automated generation of materials, questions, and feedback; reduced instructor workload | Academic integrity risks; blurred authorship | Redefines assessment design toward evaluating process and reasoning | Pesovski et al. (2024); Mao et al. (2023); Wu et al. (2025) |
| Learning analytics & assessment | Real-time, formative monitoring; early identification of at-risk learners | Data privacy and consent; algorithmic bias | Shifts evaluation from retrospective grading to formative intervention | Cukurova (2024); Yan et al. (2023); Ifenthaler et al. (2024) |
| Teacher professional development & AI literacy | Structured PD can build multidimensional AI literacy | PD supply lags adoption; AI literacy largely absent from curricula | Teacher readiness determines whether AI supports or undermines pedagogy | Ng et al. (2024); Sperling et al. (2024); Tan et al. (2025) |
| Ethics, equity & governance | Governance frameworks can safeguard responsible, transparent use | Algorithmic bias; infrastructural and access inequality | Without deliberate policy, AI risks widening the digital divide | Akgun & Greenhow (2022); Kuleto et al. (2021) |
| Higher education | Mature infrastructure supports | Uneven instructor | Institutional capacity shapes the | Crompton & Burke (2023); Ren & Wu |

| | | | | |
|---|---|---|---|---|
| institutional adoption | rigorous, evidence-based piloting | competencies and confidence | pace and depth of adoption | (2025); Luo et al. (2025); Wang et al. (2024) |
| K-12 settings & self-regulated learning | Scaffolds self-regulated learning within human-centered frameworks | Greater need for adult mediation and developmental scaffolding | Uniform policy is inappropriate; responses must be calibrated by developmental stage | Kong & Yang (2024); Ahmad et al. (2021) |

**Opportunities: Personalization, Efficiency, and Data-Driven Insight**

The most consistently reported opportunity across the corpus is personalization. Intelligent tutoring systems and adaptive learning platforms allow instructional content, pacing, and feedback to be tailored to individual learners rather than delivered uniformly to an entire class (Yarlagadda, 2025; Létourneau et al., 2025). Farhood et al. (2025) synthesize evidence that AI-based personalization improves both engagement and mastery, particularly benefiting students who would otherwise be underserved by fixed-pace instruction. Generative AI extends this capacity considerably: rather than selecting from a pre-built content library, systems can now generate original explanations, practice items, and formative feedback tailored to a learner's specific misconceptions in real time (Pesovski et al., 2024). Kong and Yang (2024) demonstrate that when generative AI is embedded within a human-centered pedagogical framework, it can also support self-regulated learning by scaffolding goal-setting, monitoring, and reflection, rather than simply supplying answers.

A second major opportunity concerns efficiency and workload redistribution. Mao et al. (2023) find that generative AI can automate significant portions of routine assessment work drafting rubrics, generating question banks, and providing first-pass feedback freeing instructor time for higher-value activities such as individualized mentoring and complex skill development. Wu et al. (2025) report that both students and instructors perceive generative AI as valuable for brainstorming, drafting, and iterative revision, provided its use is transparently disclosed and appropriately scaffolded within the learning task.

A third opportunity lies in data-driven decision-making through learning analytics. Cukurova (2024) argues that the convergence of learning analytics and AI enables a shift from retrospective evaluation toward real-time, formative monitoring of student progress, allowing institutions to identify at-risk learners before performance gaps become severe. Yan et al. (2023) extend this argument by mapping how generative AI can support each stage of the learning analytics cycle—from data collection and modeling to actionable pedagogical intervention—although they caution that analytic sophistication does not automatically translate into improved outcomes without corresponding instructional redesign.

**Challenges: Integrity, Bias, Privacy, and Readiness**

Set against these opportunities, the reviewed literature converges on four interrelated challenges. The most frequently discussed is academic integrity. As generative AI becomes increasingly capable of producing coherent, contextually appropriate written work, traditional assessment formats struggle to reliably distinguish independent student work from AI-assisted or AI-generated submissions (Mao et al., 2023). This challenge is not merely technical but pedagogical: Giannakos et al. (2024) argue that the deeper issue is not detection but the need to redesign assessment to evaluate process and reasoning rather than final-product text alone.

A second major challenge is algorithmic bias and equity. Akgun and Greenhow (2022) document how AI systems deployed in K-12 settings can encode and reinforce existing social biases when trained on non-representative data, disproportionately disadvantaging students from marginalized backgrounds. This concern is compounded by infrastructural inequality: Kuleto et al. (2021) report that unequal access to devices, connectivity, and institutional AI governance widens rather than narrows the gap between

well-resourced and under-resourced schools and universities, undermining the equity gains that personalized learning might otherwise offer.

Data privacy constitutes a third significant challenge. Ifenthaler et al. (2024) note that the extensive behavioral and performance data required to power adaptive systems raises unresolved questions about consent, data ownership, and long-term data stewardship, particularly for minors in K-12 contexts. Because these systems often rely on third-party commercial platforms, institutions frequently lack full visibility into how learner data is processed or reused.

A fourth, and arguably foundational, challenge is teacher and institutional readiness. Ren and Wu (2025) find that many higher education instructors report low confidence in their ability to evaluate, adapt, or critically integrate AI tools into their teaching, a finding echoed by Sperling et al. (2024), who show that AI literacy remains largely absent from formal teacher education curricula. Tan et al. (2025) add that the supply of structured professional development consistently lags behind the pace of institutional AI adoption, leaving teachers to develop ad hoc, uneven competencies. Ng et al. (2024) argue that AI literacy must be cultivated as a multidimensional competency—spanning affective, behavioral, cognitive, and ethical dimensions—rather than treated as a narrow technical skill, a more demanding standard that few current professional development programs meet.

**Implications for the Learning Process: An Integrated Framework**

The central contribution of this synthesis is the observation that opportunities and challenges are not independent variables but jointly determine the implications of AI for the learning process. Three implications emerge consistently across the corpus.

First, the locus of learner agency shifts. When AI personalization is implemented with strong pedagogical grounding and teacher oversight, it can expand learner agency by giving students greater control over pace and pathway (Kong & Yang, 2024). However, when personalization is implemented purely for efficiency without corresponding support for metacognitive skill development it risks reducing students to passive recipients of algorithmically optimized content, a pattern the reviewed literature describes as "personalization without agency."

Second, assessment validity is being redefined rather than simply threatened. Rather than treating generative AI purely as a cheating risk, Alshamy et al. (2025) find that when institutions establish clear, transparent policies on acceptable AI use, students report using these tools to support rather than replace independent reasoning, suggesting that carefully governed integration can preserve, and in some cases strengthen, the authenticity of assessment.

Third, the teacher's pedagogical role is repositioned from primary information source toward facilitator of AI-augmented, human-centered learning. Tarun et al. (2025) describe "human-in-the-loop" designs in which AI generates adaptive content and preliminary feedback, while teachers retain final judgment over pacing, interpretation, and socio-emotional support an arrangement that appears in the literature to mitigate several of the risks identified above (bias, over-reliance, loss of relational teaching) while preserving efficiency gains.

**Cross-Level Comparison: Higher Education versus K-12**

The synthesis also reveals notable differences in how opportunities and challenges manifest across educational levels. In higher education, Crompton and Burke (2023) find that AI adoption is concentrated in three areas adaptive learning platforms, automated administrative tasks, and predictive analytics for retention with institutions generally possessing more mature digital infrastructure and greater autonomy to pilot new tools. Luo et al. (2025) corroborate this pattern, reporting that AI-based learning tools in higher education are increasingly evaluated using rigorous, multi-method designs, reflecting growing institutional investment in evidence-based adoption. Wang et al. (2024) similarly

observe that higher education research on AI has matured methodologically over the past five years, shifting from purely descriptive accounts toward systematic, comparative evaluation of tool effectiveness.

K-12 contexts, by contrast, present a distinct risk profile. Ahmad et al. (2021) note that younger learners require greater scaffolding and adult mediation when interacting with AI systems, making teacher readiness an even more decisive factor than in higher education. Létourneau et al. (2025) similarly report that intelligent tutoring systems designed for K-12 learners must balance personalization with the developmental need for consistent, human-guided structure and adult mediation, a balance that is generally less critical for adult learners in higher education. These differences suggest that policy and professional development responses to AI in education cannot be uniform across levels; rather, they must be calibrated to the developmental needs of learners and the institutional capacity available at each level of the education system.

**Limitations of the Reviewed Evidence**

Several limitations qualify the strength of the conclusions drawn from this synthesis. First, as Kamalov et al. (2023) observes, the empirical base on AI in education is still dominated by short-term, single-institution studies, with few longitudinal investigations capable of establishing whether observed benefits in engagement or efficiency translate into durable gains in learning outcomes. Second, much of the corpus—particularly the generative-AI-specific literature published after 2023—relies on self-reported perceptions from students and teachers rather than direct measures of learning gains, limiting causal inference (Yan et al., 2024). Third, publication patterns are geographically uneven, with a disproportionate share of studies originating from well-resourced higher education systems, which may limit the generalizability of findings to under-resourced or non-Western educational contexts. These limitations reinforce, rather than undermine, the central argument of this review: because the evidence base itself is shaped by uneven institutional capacity, conclusions about AI's implications for learning must be interpreted as context-dependent rather than universal.

Collectively, these findings indicate that the pedagogical value of AI in education is not intrinsic to the technology itself but is contingent on the governance, professional capacity, and institutional design surrounding its use. Studies that report predominantly positive implications (e.g., Kong & Yang, 2024; Tarun et al., 2025) consistently pair AI deployment with explicit human oversight, teacher training, and transparent policy; studies that report predominantly negative implications (e.g., Akgun & Greenhow, 2022; Mao et al., 2023) tend to describe contexts where AI was adopted rapidly, without corresponding investment in governance or teacher readiness. This pattern supports the integrated framework proposed in this article: opportunities and challenges are two faces of the same underlying technological capability, and the direction of their net implication for the learning process depends on the quality of human and institutional mediation

**CONCLUSIONS**

This review of twenty-five studies published between 2021 and 2026 demonstrates that artificial intelligence offers substantial, well-evidenced opportunities for education particularly through personalized learning, intelligent tutoring, generative content creation, and data-driven learning analytics while simultaneously introducing serious and interconnected challenges related to academic integrity, algorithmic bias, data privacy, and uneven teacher and institutional readiness. Rather than treating these dimensions as separate strands of inquiry, this article has proposed an integrated opportunity-challenge-implication framework, showing that the ultimate impact of AI on the learning process is not determined by technological capability alone but by how opportunities and challenges are jointly mediated by governance, professional development, and pedagogical design. Where AI adoption is paired with transparent policy, sustained investment in teacher AI literacy, and deliberate human-in-the-loop oversight, the literature consistently reports gains in learner agency, engagement, and assessment authenticity. Where adoption

proceeds without these supports, the same underlying technologies are instead associated with diminished learner agency, contested assessment validity, and widened educational inequity.

These findings carry direct implications for practice and policy. Institutions should prioritize AI literacy as a core component of teacher professional development rather than an optional add-on, invest in transparent and context-specific AI governance frameworks, and redesign assessment practices to evaluate reasoning and process rather than final text output alone. For researchers, the review highlights a continuing need for longitudinal, cross-context studies that move beyond self-reported perceptions toward direct measures of learning outcomes, and for closer attention to how AI's implications differ across K-12 and higher education settings. Ultimately, the evidence suggests that artificial intelligence is best understood not as a deterministic force reshaping education on its own terms, but as a powerful instructional resource whose educational value is actively constructed through the human, institutional, and ethical choices that surround its implementation.

**REFERENCES**


Ahmad, S. F., Rahmat, M. K., Mubarik, M. S., Alam, M. M., & Hyder, S. I. (2021). Artificial intelligence and its role in education. Sustainability, 13(22), 12902. https://doi.org/10.3390/su132212902

Akgun, S., & Greenhow, C. (2022). Artificial intelligence in education: Addressing ethical challenges in K-12 settings. AI and Ethics, 2(3), 431-440. https://doi.org/10.1007/s43681-021-00096-7

Alshamy, A., Al-Harthi, A. S. A., & Abdullah, S. (2025). Perceptions of generative AI tools in higher education: Insights from students and academics at Sultan Qaboos University. Education Sciences, 15(4), 501. https://doi.org/10.3390/educsci15040501

Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: The state of the field. International Journal of Educational Technology in Higher Education, 20, 22. https://doi.org/10.1186/s41239-023-00392-8

Cukurova, M. (2024). The interplay of learning, analytics, and artificial intelligence in education. arXiv. https://doi.org/10.48550/arXiv.2403.16081

Farhood, H., Nyden, M., Beheshti, A., & Muller, S. (2025). Artificial intelligence-based personalised learning in education: A systematic literature review. Discover Artificial Intelligence, 5. https://doi.org/10.1007/s44163-025-00598-x

Giannakos, M., Azevedo, R., Brusilovsky, P., Cukurova, M., Dimitriadis, Y., Hernandez-Leo, D., Jarvela, S., Mavrikis, M., & Rienties, B. (2024). The promise and challenges of generative AI in education. Behaviour & Information Technology, 44(12), 2518-2544. https://doi.org/10.1080/0144929X.2024.2394886

Ifenthaler, D., Majumdar, R., Gorissen, P., Judge, M., Mishra, S., Raffaghelli, J., & Shimada, A. (2024). Artificial intelligence in education: Implications for policymakers, researchers, and practitioners. Technology, Knowledge and Learning, 29(4), 1693-1710. https://doi.org/10.1007/s10758-024-09747-0

Kamalov, F., Santandreu Calonge, D., & Gurrib, I. (2023). New era of artificial intelligence in education: Towards a sustainable multifaceted revolution. Sustainability, 15(16), 12451. https://doi.org/10.3390/su151612451

Kong, S.-C., & Yang, Y. (2024). A human-centered learning and teaching framework using generative artificial intelligence for self-regulated learning development through domain knowledge learning in K-12 settings. IEEE Transactions on Learning Technologies, 17, 1588-1599. https://doi.org/10.1109/TLT.2024.3392830

Kuleto, V., Ilic, M., Dumangiu, M.-A., Rankovic, M., Martins, O. M. D., Paun, D., & Mihoreanu, L. (2021). Exploring opportunities and challenges of artificial intelligence and machine learning in higher education institutions. Sustainability, 13(18), 10424. https://doi.org/10.3390/su131810424

Letourneau, A., Deslandes Martineau, M., Charland, P., Karran, J. A., Boasen, J., & Leger, P.-M. (2025). A systematic review of AI-driven intelligent tutoring systems (ITS) in K-12 education. npj Science of Learning, 10. https://doi.org/10.1038/s41539-025-00320-7

Luo, J., Zheng, C., Yin, J., & Teo, H. (2025). Design and assessment of AI-based learning tools in higher education: A systematic review. International Journal of Educational Technology in Higher Education, 22. https://doi.org/10.1186/s41239-025-00540-2

Mao, J., Chen, B., & Liu, J. C. (2023). Generative artificial intelligence in education and its implications for assessment. TechTrends, 68(1), 58-66. https://doi.org/10.1007/s11528-023-00911-4

Ng, D. T. K., Luo, W., Chan, H. M. Y., & Chu, S. K. W. (2024). Design and validation of the AI literacy questionnaire: The affective, behavioural, cognitive and ethical approach. British Journal of Educational Technology, 55(3), 1082-1104. https://doi.org/10.1111/bjet.13411

Pesovski, I., Santos, R., Henriques, R., & Trajkovik, V. (2024). Generative AI for customizable learning experiences. Sustainability, 16(7), 3034. https://doi.org/10.3390/su16073034

Ren, X., & Wu, M. (2025). Examining teaching competencies and challenges while integrating

artificial intelligence in higher education. TechTrends, 69(3), 519-538. https://doi.org/10.1007/s11528-025-01055-3

Sperling, K., Stenberg, C.-J., McGrath, C., Akerfeldt, A., Heintz, F., & Stenliden, L. (2024). In search of artificial intelligence (AI) literacy in teacher education: A scoping review. Computers and Education Open, 6, 100169. https://doi.org/10.1016/j.caeo.2024.100169

Tan, X., Cheng, G., & Ling, M. H. (2025). Artificial intelligence in teaching and teacher professional development: A systematic review. Computers and Education: Artificial Intelligence, 8, 100355. https://doi.org/10.1016/j.caeai.2024.100355

Tarun, B., Du, H., Kannan, D., & Gehringer, E. (2025). Human-in-the-loop systems for adaptive learning using generative AI. 2025 IEEE Frontiers in Education Conference (FIE), 1-7. https://doi.org/10.1109/FIE63693.2025.11328658

Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T., & Du, Z. (2024). Artificial intelligence in education: A systematic literature review. Expert Systems with Applications, 252, 124167. https://doi.org/10.1016/j.eswa.2024.124167

Wu, F., Dang, Y., & Li, M. (2025). A systematic review of responses, attitudes, and utilization behaviors on generative AI for teaching and learning in higher education. Behavioral Sciences, 15(4), 467. https://doi.org/10.3390/bs15040467

Yan, L., Greiff, S., Teuber, Z., & Gasevic, D. (2024). Promises and challenges of generative artificial intelligence for human learning. Nature Human Behaviour, 8(10), 1839-1850. https://doi.org/10.1038/s41562-024-02004-5

Yan, L., Martinez-Maldonado, R., & Gasevic, D. (2023). Generative artificial intelligence in learning analytics: Contextualising opportunities and challenges through the learning analytics cycle. Proceedings of the 14th Learning Analytics and Knowledge Conference (LAK '24), 101-111. https://doi.org/10.1145/3636555.3636856

Yarlagadda, K. C. (2025). AI in education: Personalized learning and intelligent tutoring systems. European Journal of Computer Science and Information Technology, 13(32), 15-27. https://doi.org/10.37745/ejcsit.2013/vol13n321527