Artificial Intelligence in Education: A Systematic Review of Pedagogical Impacts, Ethical Challenges, and Implications for Teacher Competencies and Educational Policy

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Abstract

Background: Artificial intelligence (AI) is rapidly transforming educational settings worldwide, yet comprehensive reviews that simultaneously examine its pedagogical, ethical, and policy dimensions remain scarce. This systematic review addresses this gap by synthesizing evidence on how AI technologies are being integrated across educational levels and what implications emerge for student learning, ethical governance, teacher preparation, and institutional policy.

Methods: Following PRISMA 2020 guidelines, we conducted a systematic search across the Elicit academic corpus (encompassing Semantic Scholar and OpenAlex, over 138 million papers) using three semantically complementary queries targeting pedagogical impacts, ethical challenges, and teacher competencies. From 210 initially retrieved records, 161 passed abstract-level screening against three predefined criteria (educational focus, publication quality, and thematic relevance). Eighty studies published between 2020 and 2025 underwent structured data extraction across eight dimensions, and 35 were selected for the final synthesis based on citation verification and thematic contribution.

Results: Adaptive learning systems (52.5% of studies), intelligent tutoring systems (35.0%), and learning analytics (31.3%) constitute the dominant AI technologies examined. Forty-five studies (56.3%) report positive impacts on student outcomes, while 14 (17.5%) document mixed results contingent upon implementation context. Data privacy (56.3% of studies), digital equity (53.8%), and algorithmic bias (48.8%) emerge as the three most frequently cited ethical concerns. Teacher digital competency requirements appear in 68.8% of studies, yet only 40% of educators actively use AI tools, primarily due to insufficient training (60%), funding limitations (50%), and ethical concerns (40%). Policy frameworks remain fragmented, with 35 studies (43.8%) identifying regulatory gaps and 28 (35.0%) proposing new governance frameworks.

Conclusions: AI holds substantial transformative potential for education, but its effectiveness is contingent upon adequate teacher preparation, robust ethical governance, equitable infrastructure, and coherent policy frameworks. Without simultaneous investment across these dimensions, AI risks exacerbating rather than reducing educational inequalities. This review provides a consolidated evidence base and conceptual

framework to guide policymakers, institutional leaders, and researchers toward responsible AI integration in education.

Keywords: artificial intelligence, education, systematic review, pedagogical impact, algorithmic bias, teacher digital competencies, educational policy, personalized learning, data privacy, academic integrity

1. Introduction

Artificial intelligence has emerged as one of the most consequential technological developments in contemporary education, fundamentally altering instructional methods, institutional administration, and academic assessment practices. Over the past decade, AI-driven platforms have transitioned from supplementary tools to integral components of digital learning ecosystems, enabling unprecedented capabilities in learning personalization, automated assessment, and predictive analytics (Chen et al., 2020; Kamalov et al., 2023). This transformation has been further accelerated by the widespread adoption of generative AI tools, which have introduced new modalities for content creation, student feedback, and pedagogical innovation (Francis et al., 2025).

Despite this rapid expansion, the integration of AI in education presents a complex landscape of opportunities and challenges. On the pedagogical front, adaptive learning systems and intelligent tutoring platforms offer demonstrable benefits for personalized instruction, enabling students to learn at individualized paces according to their specific cognitive profiles and learning needs (Coppin, 2025; Wang et al., 2025). Learning analytics platforms facilitate early identification of at-risk students, enabling timely interventions that can improve retention and academic performance (Baker & Hawn, 2021; Dieterle et al., 2022).

However, these technological capabilities coexist with significant ethical, social, and institutional challenges. Concerns regarding data privacy, algorithmic bias, academic integrity, and digital equity have intensified as AI systems become more deeply embedded in educational processes (Farooqi et al., 2024; Xu et al., 2025). The absence of comprehensive regulatory frameworks and standardized governance mechanisms creates uncertainty about how to balance innovation with the protection of student rights and educational values (Stracke et al., 2025a; Britchenko, 2025).

Furthermore, the successful integration of AI depends critically on teacher readiness and institutional capacity. Research consistently demonstrates that teachers play an essential mediating role in determining whether AI tools enhance or diminish learning quality (Ng et al., 2023; Galindo-Dominguez et al., 2024). Yet evidence suggests that many educators lack the digital competencies, training opportunities, and institutional support necessary to leverage AI effectively in their practice (Morze et al., 2024; Azahar et al., 2025).

While several reviews have examined individual dimensions of AI in education, few have attempted to synthesize evidence across all three critical axes simultaneously: pedagogical impact, ethical challenges, and the teacher competency-policy nexus. This fragmentation limits the capacity of educational stakeholders to develop integrated strategies for responsible AI adoption. The present systematic review addresses this gap by providing a comprehensive, multi-dimensional analysis grounded in 35 rigorously selected studies, offering an evidence base that connects pedagogical outcomes with ethical governance and professional development requirements.

The guiding research question is: How is artificial intelligence being integrated into educational settings, and what are its pedagogical impacts, ethical challenges, and implications for teacher competencies and educational policy?

2. Methods

2.1 Study Design and Protocol

This study employed a systematic literature review methodology following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. The protocol was designed to capture the breadth and depth of contemporary research on AI integration in formal educational settings across primary, secondary, and higher education contexts.

2.2 Search Strategy

The systematic search was conducted using the Elicit academic search engine, which encompasses over 138 million papers from Semantic Scholar and OpenAlex databases. Three semantically complementary queries were formulated to ensure comprehensive coverage of the field:

Query 1 (Pedagogical axis): "artificial intelligence in education pedagogical impact personalized learning student outcomes"

Query 2 (Ethical axis): "AI ethics in education data privacy academic integrity algorithmic bias equity"

Query 3 (Competency-Policy axis): "teacher digital competencies artificial intelligence educational policy regulation higher education"

Each query was configured to retrieve approximately 70 papers through semantic search, yielding a combined total of 210 records. The search was limited to papers published between 2020 and 2025 to capture the most current evidence while maintaining sufficient temporal scope.

2.3 Screening Criteria

Three predefined screening criteria were applied at the abstract level: (1) Educational focus, requiring that studies address AI applications, impacts, or ethical implications within formal educational contexts; (2) Publication quality, requiring peer-reviewed journal articles or conference proceedings presenting empirical data, systematic reviews, or substantive theoretical analyses; and (3) Thematic relevance, requiring that studies address at least one of the three analytical axes (pedagogical impact, ethical challenges, teacher competencies, or educational policy).

2.4 Data Extraction

Structured data extraction was performed across eight predefined dimensions: AI Technology Type, Educational Level, Pedagogical Dimension, Ethical Dimension Addressed, Impact on Student Outcomes, Teacher Role/Competency Focus, Policy/Regulatory Framework, and Study Methodology. Each dimension employed fixed categorical options to ensure consistency and enable quantitative synthesis.

2.5 Citation Verification

All citations included in the final selection were verified for authenticity using the Consensus and Scite academic verification platforms. Papers were cross-referenced against their DOIs, publication venues, and citation counts to ensure bibliographic accuracy. The final selection of 35 studies was curated based on citation verification, thematic contribution, and methodological rigor.

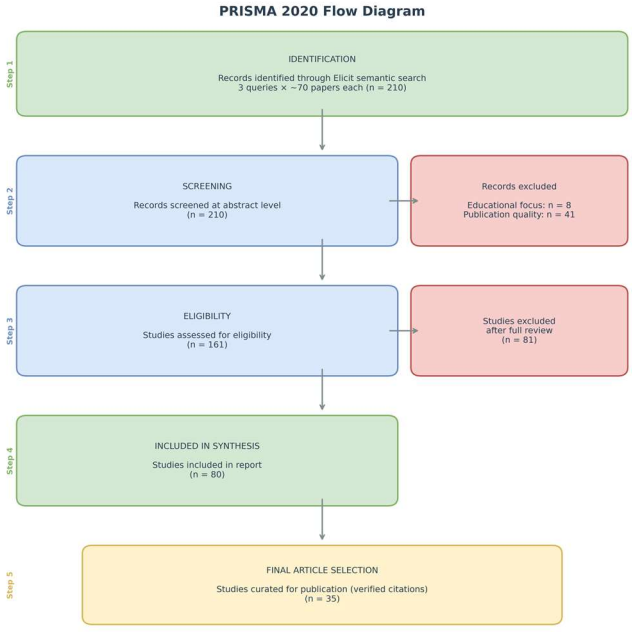

Figure 1. PRISMA 2020 flow diagram illustrating the study selection process.

3. Results

3.1 Study Selection and Characteristics

The three semantic searches yielded 210 records. After abstract-level screening, 49 records were excluded (8 for lack of educational focus and 41 for insufficient publication quality), leaving 161 studies for eligibility assessment. Following full-text evaluation and structured data extraction, 80 studies met all inclusion criteria and were included in the synthesis report. From this pool, 35 studies were selected for the final article based on citation verification and contribution to the three analytical axes. The PRISMA flow diagram is presented in Figure 1.

The included studies span multiple educational levels, with 46.3% addressing multiple levels simultaneously, 35.0% focusing exclusively on higher education, and the remainder examining secondary (3.8%) or primary/K-12 education (3.8%). Methodologically, systematic reviews constitute the dominant approach (55.0%), followed by qualitative studies (33.8%), mixed-methods designs (16.3%), and quantitative/survey approaches (7.5%). The geographical distribution encompasses contributions from Europe, Latin America, Asia, Africa, and North America, reflecting the global nature of AI integration in education.

3.2 AI Technologies in Education

The analysis reveals that adaptive learning systems are the most frequently studied AI technology, appearing in 42 of the 80 reviewed studies (52.5%). These systems dynamically adjust instructional materials based on student performance, cognitive abilities, and engagement levels (Chen et al., 2020; Coppin, 2025). Intelligent tutoring systems follow with 28 studies (35.0%), offering real-time interactive support with immediate assistance and adaptive teaching methods (Wang et al., 2025; Jiali, 2024). Learning analytics platforms appear in 25 studies (31.3%), excelling in identifying at-risk students and enabling data-driven interventions (Baker & Hawn, 2021). Generative AI and chatbots, including ChatGPT-based platforms, are examined in 12 studies (15.0%), representing the most rapidly growing category since 2023 (Francis et al., 2025). Figure 2 illustrates the distribution of technology types.

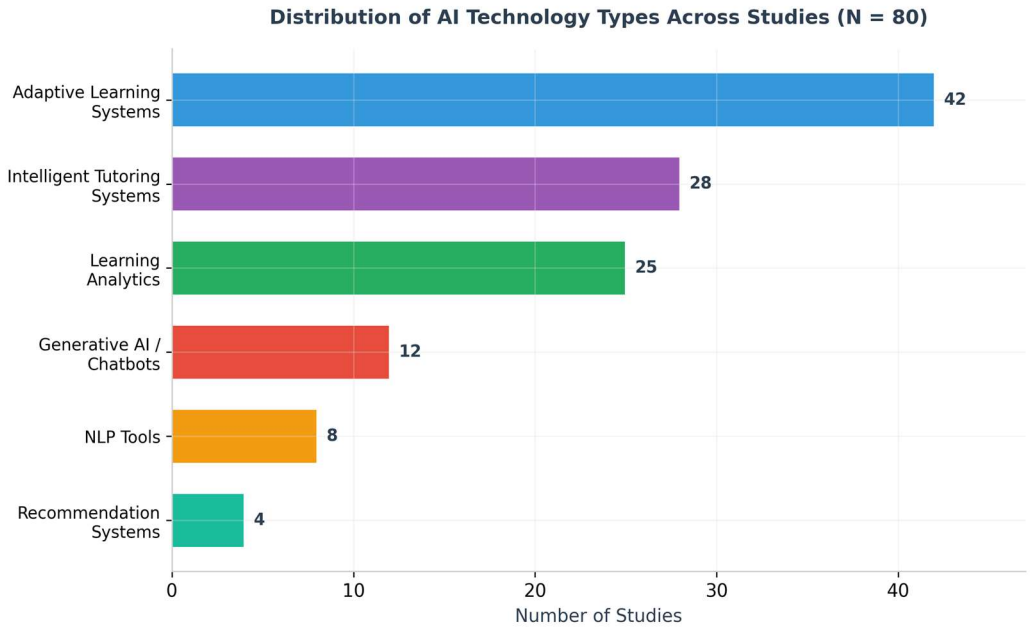

Figure 2. Distribution of AI technology types across included studies (N = 80). Studies may address multiple technologies.

3.3 Educational Level Distribution

Higher education represents the most studied context (35.0%), reflecting both the greater institutional capacity for technology adoption and the concentration of research activity within universities. Studies addressing multiple educational levels simultaneously (46.3%) provide cross-cutting insights into how AI integration challenges and outcomes vary by educational stage. The relatively small proportion of studies focused exclusively

on primary (3.8%) and secondary education (3.8%) suggests a significant evidence gap in these critical contexts. Figure 3 presents the distribution.

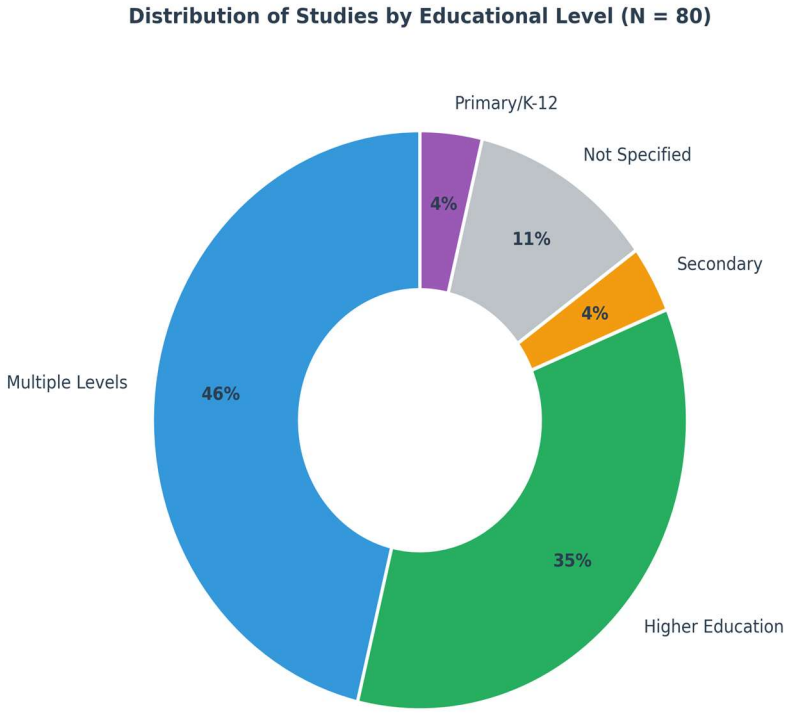

Figure 3. Distribution of studies by educational level (N = 80)

3.4 Pedagogical Impacts and Student Outcomes

The evidence reveals predominantly positive but context-dependent impacts of AI on student learning. Forty-five studies (56.3%) report favorable effects, documenting improvements in academic performance, student engagement, motivation, and learning autonomy (Coppin, 2025; Wang et al., 2025; Malagoudar & Karadi, 2025). Adaptive learning systems demonstrate particularly consistent benefits, enabling students to learn at individualized paces with content dynamically adjusted to their proficiency levels (Chen et al., 2020; Jiali, 2024).

Personalized learning pathways emerge as the most frequently documented pedagogical application, appearing in 51 studies (63.8%). AI-driven platforms leverage machine learning algorithms to analyze learning patterns and create differentiated instructional paths that enhance commitment, understanding, and retention (Vorobyeva et al., 2025; Silva et al., 2024). Assessment and feedback enhancement represents the second major application area (43 studies, 53.8%), with automated grading systems reducing educator workload while providing immediate, formative feedback to students (Kovalchuk et al., 2025; Lopez-Meneses et al., 2025).

However, 14 studies (17.5%) report mixed or context-dependent outcomes, and 10 studies (12.5%) document negative effects. Implementation context, technological infrastructure quality, and pedagogical integration coherence emerge as critical moderating variables (Farooqi et al., 2024; Svoboda, 2024). Notably, concerns about AI-induced reduction of critical thinking, creativity, and student autonomy appear in contexts where AI is used as a replacement for cognitive effort rather than as scaffolding (Britchenko, 2025; Balalle & Pannilage, 2025). Short-term novelty effects also represent a confounding factor, with initial engagement gains potentially diminishing over time without sustained pedagogical support (Tang & Su, 2024). Figure 5(A) presents the distribution of reported student outcomes.

3.5 Ethical and Social Challenges

Ethical challenges constitute a pervasive theme across the reviewed literature, with four primary domains identified. Data privacy emerges as the most frequently cited concern, addressed in 45 studies (56.3%). AI systems require extensive data collection, raising risks of breach, misuse, and unethical exploitation through

analytics (Xu et al., 2025; Imohimi, 2025). Students express significant concerns about data leakage and lack of transparency in how their information is processed (Farooqi et al., 2024). Recommended mitigations include privacy-preserving techniques such as federated learning and differential privacy, enforcement of GDPR and COPPA compliance, and clear institutional data governance protocols (Imohimi, 2025).

Digital equity concerns appear in 43 studies (53.8%), highlighting systemic barriers including infrastructure gaps, technology access disparities, and insufficient institutional resources, particularly in developing regions (Dieterle et al., 2022; Akgun & Greenhow, 2021). The five divides framework proposed by Dieterle et al. (2022) demonstrates how equity challenges accumulate across access, representation, algorithms, interpretations, and citizenship dimensions, creating cyclical patterns that can exacerbate existing educational disparities.

Algorithmic bias is documented in 39 studies (48.8%), manifesting through unrepresentative training datasets, proxy variables, and feedback loops that reinforce prior disparities (Baker & Hawn, 2021; Hanifa, 2025). Bias arises across demographic, cultural, linguistic, and ideological dimensions, and can significantly impact students' educational trajectories (Dieterle et al., 2022). Addressing bias requires diverse datasets, regular algorithm audits, and human-in-the-loop review mechanisms for high-stakes educational decisions (Hanifa, 2025).

Academic integrity concerns appear in 16 studies (20.0%), primarily centered on generative AI's capacity to facilitate plagiarism and reduce authentic cognitive engagement (Balalle & Pannilage, 2025; Daniel et al., 2025). The evidence suggests a dual-edged dynamic: AI simultaneously threatens and enhances educational quality depending on implementation design. Institutions with transparent policies, AI literacy programs, and assessments emphasizing critical thinking report fewer integrity violations (Francis et al., 2025; Daniel et al., 2025). Figure 4 presents the frequency of ethical dimensions.

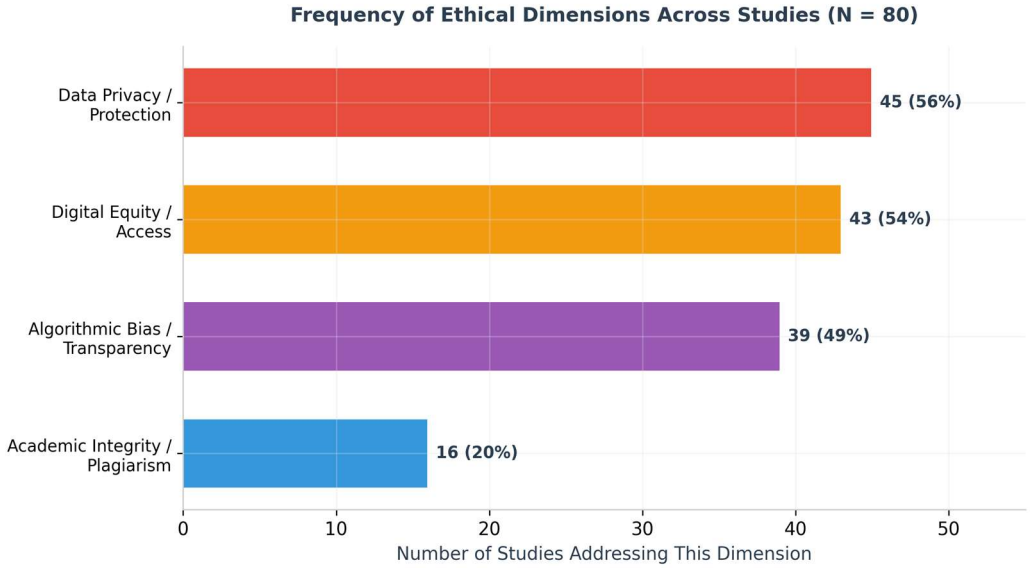

Figure 4. Frequency of ethical dimensions addressed across included studies (N = 80).

3.6 Teacher Competencies and Professional Roles

The need for enhanced teacher digital competencies emerges as a dominant theme across 55 studies (68.8%). Research demonstrates a significant positive association between teacher digital competence and favorable attitudes toward AI, regardless of educational stage, gender, age, or teaching experience (Galindo-Dominguez et al., 2024). Teachers require multidimensional competencies encompassing technical proficiency, pedagogical integration skills, ethical reasoning, and data literacy to effectively leverage AI in their practice (Ng et al., 2023; Morze et al., 2024).

The reviewed evidence reveals a fundamental transformation in teacher roles, from knowledge transmitters to integrated learning designers, value shapers, and data-informed decision-makers (Hu et al., 2024; Scarci et al., 2024). Forty-three studies (53.8%) document this evolving mediator-facilitator role, emphasizing that AI does not replace teachers but rather amplifies their capacity for personalized instruction and targeted intervention (Moylan et al., 2025). Teachers' professional judgment remains essential in determining how AI tools are integrated within pedagogical frameworks (Skibinska, 2025).

Despite widespread recognition of AI's potential, only 40% of educators actively use AI in teaching practices, while 35% use it occasionally (Kovalchuk et al., 2025). Primary barriers include insufficient technical training (60%), lack of funding (50%), and legal-ethical concerns (40%). However, 55% of educators recognize AI's potential to enhance personalized learning and express willingness to integrate tools given adequate support. This pattern suggests a readiness gap rather than fundamental resistance, with professional development quality serving as the critical differentiator (Azahar et al., 2025).

3.7 Policy and Regulatory Frameworks

Policy dimensions are addressed across 51 studies, with three distinct orientations: 28 studies (35.0%) propose new governance frameworks, 35 studies (43.8%) identify regulatory gaps, and 23 studies (28.8%) analyze existing policies. The evidence reveals significant variation in policy maturity across national contexts. European education systems emphasize ethical governance, teacher AI literacy, and digital inclusion, while many developing countries' educational legislation remains silent on AI ethics, online learning governance, and data protection (Hodaj & Lacka, 2025; Stracke et al., 2025a).

Four critical policy elements emerge as essential for effective AI integration: (1) regulatory frameworks establishing clear standards for transparency, accountability, and fairness; (2) stakeholder-specific guidelines addressing the diverse needs of students, teachers, administrators, and policymakers; (3) support for AI in education (AIED) research generating implementation evidence; and (4) AI literacy requirements ensuring informed use across all stakeholder groups (Stracke et al., 2025). Institutions implementing comprehensive governance frameworks that combine technical solutions with ethical oversight and institutional accountability achieve more successful AI integration outcomes (Britchenko, 2025; Chikumbirike & Chifamba, 2025).

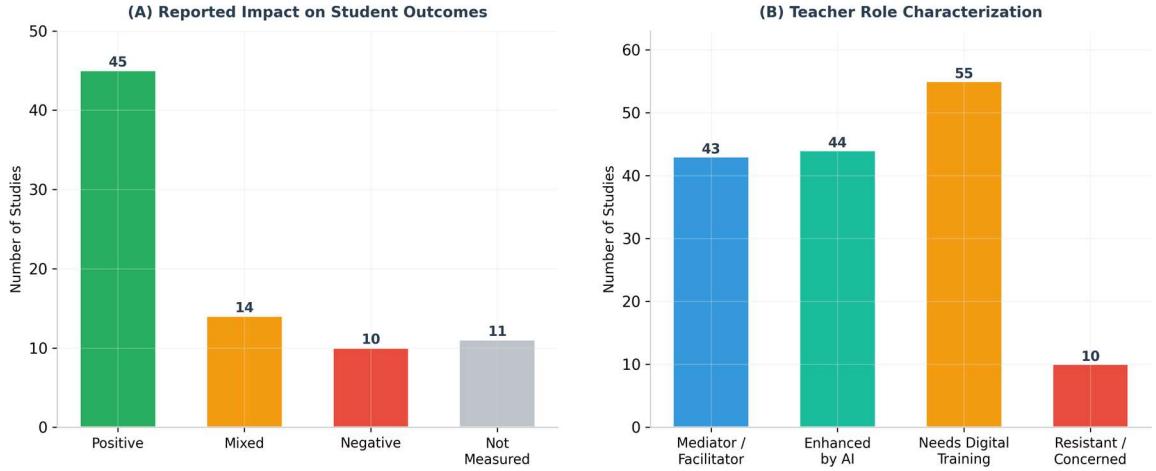

Figure 5. (A) Distribution of reported impacts on student outcomes. (B) Characterization of teacher roles in relation to AI across studies (N = 80).

4. Discussion

4.1 Reconciling Heterogeneous Findings on Effectiveness

The divergent findings regarding AI's impact on student learning reveal context-dependent effectiveness rather than fundamental contradictions. Studies reporting positive outcomes predominantly examine settings with adequate technological infrastructure, systematic teacher training, and intentional pedagogical integration (Chen et al., 2020; Coppin, 2025; Malagoudar & Karadi, 2025). In contrast, negative or mixed results emerge in implementations lacking these foundational elements (Farooqi et al., 2024; Svoboda, 2024). This pattern confirms that educational AI effectiveness is contingent upon implementation design rather than technological capability alone.

Teacher digital competence provides a mechanistic explanation for outcome heterogeneity. The significant association between teacher competence and AI implementation success documented by Galindo-Dominguez et al. (2024) and Ng et al. (2023) suggests that professional development investments yield multiplicative returns by simultaneously improving pedagogical quality, ethical governance, and student outcomes. Disciplinary variation further explains divergent findings: STEM disciplines leverage AI through closed-

loop feedback systems, while humanities contexts depend on models emphasizing ethical reasoning and emotional interaction.

4.2 Ethical Governance as Implementation Enabler

The synthesis reveals that ethical challenges manifest differently based on institutional governance quality. Data privacy concerns prove most acute in settings lacking clear governance frameworks and vendor accountability mechanisms (Xu et al., 2025; Imohimi, 2025). Algorithmic bias effects similarly depend on implementation quality, with institutions employing diverse datasets, regular audits, and human-in-the-loop review demonstrating substantially reduced bias impacts (Baker & Hawn, 2021; Hanifa, 2025). This evidence suggests that ethical governance should not be conceptualized as a constraint on innovation but rather as an enabler that builds stakeholder trust and improves implementation outcomes.

The academic integrity paradox, where AI simultaneously threatens and enhances educational quality, resolves through careful system design. When AI is implemented as scaffolding with appropriate constraints, oversight mechanisms, and transparent institutional policies, it enhances learning quality. When deployed without such guardrails, it can undermine authentic learning and critical thinking (Francis et al., 2025; Daniel et al., 2025; Balalle & Pannilage, 2025).

4.3 The Teacher Competency-Policy Nexus

The finding that only 40% of educators actively use AI tools despite 55% recognizing its potential (Kovalchuk et al., 2025) highlights a critical readiness gap that can only be addressed through coordinated policy and professional development interventions. Current competency frameworks such as DigCompEdu do not adequately cover the specifics of contemporary AI tools, while newer frameworks extend scope to include ethics, algorithmic awareness, and critical data evaluation (Skibinska, 2025; Morze et al., 2024). The integration of these frameworks into national policy, including systemic training, school-level guidelines, and competence monitoring, represents a necessary condition for closing the readiness gap.

Policy framework maturity significantly influences implementation outcomes. The four-element model proposed by Stracke et al. (2025), encompassing regulatory standards, stakeholder guidelines, AIED research support, and AI literacy requirements, provides a actionable roadmap for institutional leaders. Countries with comprehensive digital education policies demonstrate more successful integration than those lacking such infrastructure (Hodaj & Lacka, 2025; Stracke et al., 2025a). This underscores that policy development is not bureaucratic formality but foundational infrastructure for effective AI adoption.

4.4 Toward an Integrated Framework

The convergence of evidence across all three analytical axes points toward an integrated framework in which pedagogical effectiveness, ethical governance, and teacher-policy readiness function as interdependent rather than independent dimensions. Effective AI integration requires simultaneous investment in: (a) technology infrastructure aligned with pedagogical objectives and ethical requirements; (b) comprehensive teacher professional development encompassing technical, pedagogical, ethical, and social competencies; (c) transparent institutional governance connecting values to procurement, deployment, and monitoring practices; and (d) national and international policy coordination establishing clear standards while allowing contextual adaptation (Britchenko, 2025; Stracke et al., 2025).

4.5 Limitations

Several limitations should be acknowledged. First, the search was conducted through a single platform (Elicit), which, while encompassing over 138 million papers from Semantic Scholar and OpenAlex, may not capture all relevant literature. Second, data extraction was performed using large language models, which may introduce classification variability compared to manual coding. Third, the predominance of systematic reviews among included studies means that much of the evidence is secondary rather than primary. Fourth, the temporal scope (2020-2025) captures a rapidly evolving field where evidence can become outdated quickly. Finally, the geographical distribution, while diverse, may underrepresent perspectives from certain regions.

5. Conclusions

This systematic review provides a comprehensive synthesis of how AI is being integrated across educational settings, revealing a field characterized by substantial promise, significant challenges, and critical implementation dependencies. The evidence demonstrates that AI technologies, particularly adaptive learning

systems, intelligent tutoring platforms, and learning analytics, can meaningfully enhance student learning outcomes, engagement, and personalization when implemented within supportive institutional contexts.

However, realization of this potential requires addressing four interconnected imperatives. First, teacher professional development must be expanded and deepened to encompass not only technical proficiency but also pedagogical integration, ethical reasoning, and data literacy competencies. Second, ethical governance frameworks must move from aspiration to implementation, with clear institutional policies addressing data privacy, algorithmic transparency, academic integrity, and digital equity. Third, policy development must accelerate at national and international levels to establish coherent regulatory standards while supporting contextual adaptation. Fourth, equity considerations must be embedded throughout the AI lifecycle to prevent technology from amplifying existing educational disparities.

The synthesis underscores that AI in education is not merely a technological challenge but a sociotechnical one that demands coordinated responses across pedagogy, ethics, professional development, and policy. Future research should prioritize longitudinal studies evaluating sustained AI impacts, cross-cultural comparative analyses, and intervention studies testing integrated implementation models that simultaneously address multiple dimensions identified in this review. Only through such comprehensive approaches can the educational community ensure that AI serves as an instrument of equity and quality rather than a source of new inequalities.

Acknowledgments

The systematic search and data extraction for this review were facilitated by the Elicit research platform. Citation verification was performed using Consensus and Scite academic verification services.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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