Social Science Chronicle

OPEN ACCESS

Peer-Reviewed, International, Academic Research Journal

ISSN : 3048-6297

Citation
Bakar, S., & Tapsoba, R. (2026). Artificial Intelligence in Classroom Teaching: Prospects, Challenges and Framework for Responsibly Orchestrated Mediation. *Social Science Chronicle*, Vol. 6, Issue - 1, pp. 1-21.

Digital Object Identifier (DOI)
https://doi.org/10.56106/ssc.2026.002

Received - September 16, 2025
Accepted - January 23, 2026
Published - Online First

Web-Link
All contents of this peer-reviewed article, along with other relevant details are available at:
http://socialsciencechronicle.com/article-ssc-2026-002

REVIEW ARTICLE

Artificial Intelligence in Classroom Teaching: Prospects, Challenges and Framework for Responsibly Orchestrated Mediation

Suleiman Bakar[1]* and Rokia Tapsoba[2]

[1] Université Joseph Ki-Zerbo, Ouagadougou, Burkina Faso.
[2] South China University of Technology, Guangzhou, China.

* *Corresponding Author*
E-mail: suleimanbakar1990@rediffmail.com

Abstract

This narrative review develops a conceptual-theoretical architecture for interpreting Artificial Intelligence in classroom teaching as orchestrated epistemic mediation rather than discretionary tool adoption. It reframes AI as a multi-layer socio-technical stack whose capability, system, infrastructure and practice layers jointly re-configure instructional design, interactional order, formative feedback ecologies and assessment legitimacy. The analysis specifies how probabilistic generation and recommendation logics perturb classroom epistemics by amplifying fluency, accelerating artifact production and re-shaping attention allocation, while simultaneously intensifying warrant collapse, automation bias, proxy drift, dependency formation and equity drift. Drawing on cross-disciplinary constructs spanning cognitive load theory, universal design for learning, self-regulated learning, dialogic participation, validity-as-argument, contextual integrity, and contestable accountability, the review maps the prospects as conditional opportunity structures that require verification pedagogy, scaffold-with-fading routines, dialogic integrity protections and validity-preserving assessment re-design. It also formulates a structurally grounded challenge typology that treats privacy, dignity and procedural fairness as first-order constraints under classroom power asymmetries and platform political economy. The synthesis yields an actionable framework of responsible classroom AI as high-reliability orchestration, operationalizing governance minima, documentation artifacts and role-based autonomy boundaries that preserve teacher professional authority and student agency. The paper is designed to support academics, policymakers, workforce development professionals and learning technologists in specifying mechanisms, boundary conditions and implementation commitments without relying on tool-specific claims.

Keywords
Artificial Intelligence in Education, Generative AI, Large Language Models, Intelligent Tutoring Systems, Learning Analytics, Formative Assessment, Automated Feedback, Assessment Validity, Academic Integrity, Self-Regulated Learning, Universal Design for Learning, Human-AI Interaction, Data Privacy, Algorithmic Bias.

1. Introduction

Classroom teaching is a high-stakes, time-compressed decision ecology in which epistemic authority, relational trust, distributed attention, and assessment legitimacy must be sustained under binding constraints of curriculum pacing, heterogeneous readiness, multilingual repertoires, disability accommodations, and institutional accountability (Ali et al., 2024; Park & Kwon, 2024). Artificial Intelligence enters this ecology not as a neutral add-on, but as a probabilistic mediation layer that can reconfigure what counts as knowledge, how explanations are legitimated, how feedback circulates, and how learning evidence is produced and audited. A conceptual-theoretical narrative review is necessary because classroom AI is frequently discussed as a product category rather than as a socio-technical reconstitution of instructional design, interactional order, and professional responsibility (Yadav, 2024; Jafari & Keykha, 2024; Wang et al., 2025). This article frames prospects and challenges as inseparable, since every productivity gain in planning or feedback introduces corresponding demands for verification, governance, equity assurance, and norm-setting. The paper is written for global stakeholders across educational research, policy, workforce development, and learning technology practice, with a focus on actionable constructs rather than anecdotal cases.

Problem Space and Classroom Teaching as the Unit of Analysis

Classroom teaching is best modeled as an orchestrated coupling of design work, interaction work, interpretive work, care work, and evaluative work, each executed under bounded rationality and asymmetric information. AI systems, especially generative and recommendation architectures, perturb this coupling by injecting high-velocity outputs into lesson planning, explanation production, discourse scripting, and assessment feedback. The pedagogical stakes are unique because classrooms are not laboratories of individual cognition but normative spaces that distribute voice, recognize identity, and allocate opportunities through everyday judgments (Kong & Yang, 2024; Sağın et al., 2024; Mikeladze et al., 2024). The unit of analysis therefore must be classroom teaching rather than generic learning improvement, because the same AI capability can be beneficial in one classroom routine and harmful in another depending on norms, pacing, language demands, and assessment regimes. This paper treats classroom AI as a mediated practice that modifies the didactic contract, the credibility economy of explanations, and the accountability chain of decisions, thereby requiring a teaching-centered conceptual architecture rather than tool-centric enthusiasm.

Review Modality and Deliberate Non-Empirical Orientation

This narrative review is conceptual-theoretical, meaning it constructs an explanatory framework that specifies mechanisms, boundary conditions, and governance obligations without relying on effect-size aggregation or outcome claims that depend on local implementation fidelity. The objective is to replace promotional generalities with a disciplined vocabulary that differentiates augmentation from automation, personalization from tracking, and feedback abundance from feedback usefulness. A non-empirical orientation is not an evasion of rigor, but a strategy for sharpening constructs that later empirical work can operationalize, such as epistemic vigilance, trust calibration, validity-as-argument, and human-in-command oversight. The review treats AI outputs as proposals that must be warranted through pedagogical routines, assessment redesign, and institutional safeguards, rather than as authoritative answers. The analytic stance is systems-theoretic and cross-disciplinary, integrating learning science, sociolinguistics, measurement theory, ethics, and platform governance to explain why classroom AI is simultaneously a capability expansion and a risk amplifier.

Operational Definitions, Inclusion Boundaries and Prospect Challenge Coupling

Artificial intelligence in classroom teaching is defined here as any computational system that generates, recommends, transforms, scores, summarizes, or otherwise mediates instructional artifacts and learning interactions during planning, enactment, discourse, assessment, feedback, or reflection. Prospects are specified as conditional improvements in instructional quality, access, or efficiency that arise when AI is embedded within coherent routines aligned with Cognitive Load Theory, Universal Design for Learning, dialogic pedagogy, and defensible assessment principles. Challenges are specified as structurally predictable failure modes arising from probabilistic generation, proxy optimization, data extraction incentives, interface-induced overreliance, and institutional pressures for standardization. The scope includes teacher-facing and student-facing classroom uses, including tutoring dialogues, formative feedback drafting, differentiation supports, and metacognitive coaching, while excluding administrative analytics unless they directly shaped pedagogical decisions. The review is global in outlook by treating language diversity, resource asymmetry, disability rights, and governance variability as first-order design constraints rather than contextual footnotes.

Conceptual Gaps That Motivate Teaching-Centered Synthesis

A dominant gap is the conflation of personalization with pedagogical responsiveness, where systems that optimize engagement proxies are misread as systems that cultivate understanding, agency, or transfer. A second gap is the tendency to discuss AI benefits at the level of content production while neglecting the epistemic and interactional infrastructure that makes content instructionally meaningful, including teacher questioning, classroom talk norms, and feedback uptake. A third gap is the integrity discourse that treats AI as a detection problem, thereby intensifying surveillance logics and eroding trust, instead of treating integrity as a validity and task-design problem that demands assessment redesign and explicit learning contracts. A fourth gap concerns governance, where classroom teachers are positioned as accountable for AI-mediated harms without being granted the levers of transparency, version stability, data minimization, or contestability pathways. These gaps justify a conceptual framework that ties AI to classroom work, professional ethics, and institutional responsibility in one integrated argument.

Guiding Questions and Theoretical Commitments

The review is organized around four guiding questions that function as design constraints for all subsequent sections. First, which components of classroom teaching are being reconfigured, including planning, explanation, discourse orchestration, formative assessment, feedback circulation, and reflective practice. Second, through what mechanisms might AI-mediated routines improve or degrade learning processes, drawing on constructs such as distributed cognition, self-regulated learning, Self-Determination Theory, dialogic participation, and cognitive load management. Third, what governance commitments are necessary to protect dignity, privacy, and equity under classroom power asymmetries, using constructs such as contextual integrity, contestability, and accountability partitioning across teachers, institutions, and vendors. Fourth, what propositions are sufficiently precise to guide later empirical and design-based work without being dependent on local tool brands or transient model versions. These questions prioritize actionable conceptual clarity over generic optimism or generic caution.

Contribution Claim and Sectional Roadmap

The contribution is a classroom-specific field architecture that offers definitional precision, a mechanism vocabulary, and a responsibility framework that can be adopted across curricula, languages, and resource settings. Section 2 constructs a teaching-centered typology of AI by capability, classroom role, autonomy level, and epistemic risk, consolidated in Table 1 for direct operational use. Section 3 develops the theoretical toolkit needed to interpret AI-mediated teaching, with Table 2 mapping theories to mechanisms, benefits, harms, and boundary conditions. Section 4 specifies prospects as conditional opportunity structures and routine designs, supported by Table 3 that links teaching domains to mechanisms and safeguards. Section 5 specifies challenges as structural tensions and failure modes, with Table 4 translating risks into response levers. Section 6 synthesizes responsible classroom AI as orchestrated mediation, formalized in Table 5 as a principle-to-routine-to-governance matrix. Section 7 closes by articulating an integrated claim about how classrooms can remain epistemically rigorous, ethically defensible, and instructionally effective under pervasive AI mediation.

2. Defining AI in Classroom Teaching Through Epistemic and Socio-Technical Lenses

Artificial intelligence in classroom teaching is best conceptualized as a multi-layered mediation stack rather than a monolithic tool class, because classroom impacts emerge from couplings among computational affordances, interface constraints, institutional policies, and situated routines. At the capability layer, AI performs statistical inference, representation learning, language generation, recommendation, and multimodal transformation that can accelerate instructional design and feedback circulation (Marengo et al., 2024; Celik et al., 2024; Sova et al., 2024). At the system layer, these capabilities are operationalized through model selection, retrieval augmentation, safety filtering, telemetry, version updates, and interaction protocols that shape error surfaces and reliability envelopes. At the infrastructure layer, device access, network latency, identity management, and data retention policies condition who benefits and who is excluded. At the practice layer, teachers and learners construct norms of acceptable reliance, verification rituals, and accountability boundaries that regulate epistemic authority in real time. This layered framing prevents category errors and is operationalized in the classroom-function taxonomy consolidated in Table 1.

Modalities of Classroom-Relevant AI (Beyond Single Category)

Classroom AI modalities should be differentiated by their epistemic posture, controllability, and failure phenomenology, because each modality implies distinct pedagogical opportunities and governance duties. Rule-constrained systems privilege stability and domain-bounded determinacy, which supports predictable scaffolding but can be brittle under novel student reasoning (Nedungadi et al., 2024; Yang et al., 2024; Ma & Lei, 2024). Predictive machine learning emphasizes classification and risk estimation, enabling triage and prioritization yet inviting proxy drift and feedback loops that can reify inequities. Deep representation systems encode latent features that can support pattern recognition in student work, while remaining opaque to classroom sensemaking. Generative language and multimodal models introduce high-throughput explanation and drafting capacity, while expanding the plausibility trap and the risk of fabricated warrants. Agentic orchestration systems can chain tools and actions across resources, raising autonomy and contestability challenges within classroom accountability regimes. Table 1 encodes these modality distinctions as classroom roles with explicit oversight and documentation minima, preventing naive substitution of one modality's governance assumptions for another.

Role-Theoretic Mapping of AI Within Classroom Activity Systems

AI alters classroom teaching most decisively through the role it is authorized to perform within the instructional activity system, because roles regulate authority, dependence, and legitimacy. When AI is positioned as a co-designer, it shapes task ecology, representational diversity, and pacing decisions, which can elevate instructional precision if constrained by curricular alignment and verification pedagogy (Wu, 2024; Vistorte et al., 2024; Yang, 2024). When AI is positioned as a tutor or critic, it mediates feedback timing and granularity, risking over-scaffolding and motivational externalization if students treat feedback as a substitute for self-explanation. When AI is positioned as an assessor or recommender, it becomes a gatekeeping instrument that can silently restructure opportunity-to-learn through thresholds and rankings, thereby requiring contestable decision pathways. When AI is positioned as an accessibility mediator, it can widen participation by transforming modality and language, yet it can also introduce cultural and semantic distortions if fidelity constraints are absent. These role consequences are summarized compactly in Table 1 to support classroom-facing specification.

Table 1. Classroom AI Taxonomy by Function, Role, and Risk

Classroom Role Configuration	Pedagogical Workstream Signature	Autonomy and Oversight Burden	Epistemic and Equity Risk Signature	Governance and Documentation Minimum
Generative Co-Designer	*Instructional design, task variation, differentiation without tracking, concept progression calibration*	*Low autonomy with high verification load, teacher-in-command review, prompt and output auditing*	*Plausibility bias, curricular misalignment, cultural-linguistic incongruence, representational stereotype leakage*	*Version awareness, local curriculum constraints, prompt-output logs, error annotation protocol*
Dialogic Tutor and Socratic Interlocutor	*Guided inquiry, self-explanation elicitation, misconception surfacing, dialogic participation scaffolding*	*Medium autonomy with continuous monitoring, reliance calibration, fading schedule design*	*Over-scaffolding, dependency formation, discourse homogenization, epistemic deference under fluent language*	*Classroom reliance norms, student agency safeguards, transparency of limitations, escalation to teacher review*
Formative Feedback Drafter and Critique Engine	*Feedback triage, rubric-aligned commentary, revision prompting, next-step specification*	*Low autonomy with quality assurance, teacher moderation, feedback sampling for drift*	*Feedback inflation, tone bias, false precision, unequal benefit by language proficiency*	*Rubric governance, feedback quality checklist, bias screening, documentation of teacher final authority*
Recommendation Orchestrator for Pathways and Resources	*Pacing suggestions, resource sequencing, practice set assignment, attention allocation signals*	*Medium to high autonomy risk, proxy monitoring, periodic recalibration, contestability requirement*	*Proxy drift, self-fulfilling stratification, hidden labeling, opacity in prioritization*	*Contestable recommendations, data minimization, threshold transparency, review and appeal workflow*
Multimodal Accessibility and Language Mediator	*Translation, modality transformation, captioning, simplified re-expression with rigor preservation*	*Low autonomy with fidelity checks, teacher validation for semantic equivalence*	*Semantic distortion, cultural erasure, disability stigmatization, unequal access to accommodations*	*Accessibility-by-design policy, fidelity verification routine, privacy controls for sensitive inputs*

Autonomy Spectrum and Precision of Human-in-the-Loop Governance

Classroom oversight must be specified with granularity because human-in-the-loop is often invoked as a rhetorical safeguard rather than a designable control regime. A human-in-command configuration preserves teacher authority by requiring that AI outputs remain contestable, revisable, and subordinate to professional judgment, while a human-on-the-loop configuration shifts teachers into a monitoring posture where attentional bandwidth becomes the limiting factor and silent errors can propagate into grading, feedback, or discourse scripts (Famaye et al., 2024; Al-Abdullatif, 2024; Thorat et al., 2024). A human-out-of-the-loop configuration is incompatible with defensible classroom accountability for high-consequence functions such as evaluation and placement because it creates responsibility without control and undermines due process for learners. Oversight is not costless, since verification labor competes with interaction time, relational care, and instructional responsiveness, thereby producing an oversight burden that must be budgeted as part of pedagogical design. Table 1 embeds autonomy expectations and oversight burden for each classroom role, enabling explicit decisions about when automation is acceptable and when augmentation is the only defensible posture.

Epistemic Status of AI Outputs

The epistemic status of AI outputs in classrooms should be treated as defeasible proposals whose legitimacy depends on warranted justification rather than surface coherence, because generative fluency can mimic explanation without securing truth conditions (Adams & Thompson, 2025; Yuan & Liu, 2025; Shailendra et al., 2024). In classroom knowledge regimes, the central risk is a shift from evidential reasoning to testimonial acceptance, where students and teachers internalize the output as authoritative because it is rhetorically polished. This motivates a pedagogy of *epistemic vigilance* that requires explicit warrants, counterexamples, uncertainty labeling, and triangulation routines, thereby strengthening learners' calibration and reducing automation bias. The distinction between correctness and justifiability becomes operational when teachers require reasoning traces, error analysis, and reflective acceptance or rejection of AI suggestions as part of classroom norms (Ma et al., 2024; Aguilar-Cruz & Salas-Pilco, 2025; Roshanaei, 2024). In Table 1, epistemic risk signatures are differentiated across roles, since a co-designer primarily risks curricular misalignment and cultural distortion, while an assessor configuration risks false precision and stratifying decisions that are difficult to contest.

Classroom Integration Levels as Pedagogical Embedding

AI integration should be theorized as degrees of pedagogical embedding that alter the classroom contract, rather than as usage frequency or device availability. Peripheral integration treats AI as a discretionary resource generator that does not change assessment or discourse norms, which reduces systemic risk but can confine value to superficial productivity (Bender, 2024; Mouta et al., 2024; Topaz et al., 2025). Embedded integration reconfigures lesson design, feedback cadence, and differentiation routines, requiring explicit verification pedagogy and role clarity to prevent dependency and equity drift. Transformative integration reorganizes assessment architectures and participation norms, which can expand access and responsiveness yet demands institutional-grade governance, contestability pathways, and sustained teacher capacity building (Fadlelmula & Qadhi, 2024; Storey & Wagner, 2024; Erduran & Levrini, 2024). Integration levels also interact with discipline epistemologies, since procedural domains may tolerate more automation in practice generation, while interpretive domains require stronger safeguards around authorship, voice, and reasoning warrants. Table 1 is designed to be used as an integration planning instrument by mapping roles to autonomy and governance minima, preventing premature transformation without legitimacy infrastructure.

Data Regimes and Classroom Power Asymmetries

Classroom data regimes are not merely technical compliance issues, because they are embedded in power asymmetries where learners have constrained capacity to refuse collection, profiling, or retention. Data minimization and purpose limitation should function as pedagogical ethics that preserve dignity and psychological safety, especially when classroom artifacts include sensitive disclosures, identity narratives, or disability-related accommodations. Proxy optimization and feedback loops are predictable when predictive systems ingest behavioral traces and then shape teacher attention or resource allocation, thereby producing performative compliance and stratified trajectories (Singha & Singha, 2024; Merchán Sánchez-Jara et al., 2024; Williamson, 2024). Contextual integrity is therefore a governance necessity, requiring that data flows remain appropriate to classroom purposes and that secondary use, cross-context repurposing, and indefinite retention are constrained by explicit policy and enforceable technical controls. Table 1 specifies documentation minima that support auditability and contestability, since without logs, version awareness, and clear accountability boundaries, classrooms cannot defensibly adjudicate harm, bias, or error when AI-mediated decisions influence learning opportunities.

3. Theoretical Foundations for Interpreting AI-Mediated Classroom Teaching

Classroom teaching is a high-frequency judgment enterprise in which educators operate under bounded rationality, partial observability, and adversarial time constraints, while optimizing for learning, equity, and institutional legitimacy. Conceptually, this resembles a dynamic control problem with stochastic signals, where teacher noticing, ecological rationality, and situated sensemaking determine which cues become actionable and which remain noise (Gökçearslan et al., 2024; Ayanwale et al., 2024; Tassoti, 2024). AI changes the informational topology by injecting predictive summaries, generated explanations, and recommendation signals that can compress deliberation but also amplify proxy-based attention allocation. The crucial construct is decision accountability under uncertainty, since AI can increase apparent precision while masking model fragility, domain shift, and incentive misalignment (Sanusi et al., 2024; Katsamakas et al., 2024; Pack & Maloney, 2024). A theoretically defensible stance treats AI as a cognitive prosthesis that must be governed by calibration routines, contestability pathways, and interpretive transparency, not as an oracle. This framing anticipates the theory-to-mechanism mapping in Table 2 and aligns with Table 1 by tying role authorization to oversight burden and epistemic risk.

Cognitive Architectures of Learning and Instructional Design Under AI Abundance

Learning in classrooms is constrained by cognitive bottlenecks in working memory, attentional gating, and schema acquisition, so AI value depends on whether it reduces extraneous load, strengthens germane processing, and supports retrieval-based consolidation (Ruiz-Rojas et al., 2024; Obenza et al., 2024; Khreisat et al., 2024). The relevant constructs include *Cognitive Load Theory*, desirable difficulties, spacing-retrieval dynamics, worked-example fading, dual-channel representation, and conceptual change under misconception inertia. Generative systems can rapidly produce explanations, analogies, and practice sets, but without careful task design they can induce solution exposure, shallow processing, and illusion-of-understanding effects that destabilize durable learning (Gkintoni et al., 2025; Ivanashko et al., 2024; Sanusi et al., 2024). The pedagogical imperative is to reconfigure AI outputs into generative learning routines that require learners to predict, justify, self-explain, and error-analyze, thereby converting fluency into epistemic work. From a cognitive ergonomics perspective, AI must be harnessed to structure attention, not fragment it, because overproduction of options can increase choice overload and erode coherence. Table 2 formalizes these cognitive mechanisms alongside boundary conditions that prevent cognitive offloading from becoming cognitive bypassing.

Socio-Cultural and Interactional Grammars of Classroom Participation and Meaning-Making

Classroom learning is not merely intrapsychic processing but an interactional accomplishment produced through mediated participation, discourse norms, and legitimacy allocations that determine who speaks, whose reasons count, and how knowledge is jointly stabilized. Sociocultural theory frames tools as mediational means that reorganize the division of labor, while *Distributed Cognition* and activity-theoretic perspectives treat cognition as distributed across persons, artifacts, and representational infrastructures (Lan, 2024; Li, 2025; Naixin et al., 2024). AI therefore functions as a semiotic actor that can scaffold dialogic participation, translate across linguistic repertoires, and structure argumentation scripts, while also risking discourse homogenization, voice standardization, and epistemic marginalization. Positioning theory, classroom discourse analysis, and community-of-practice constructs clarify how AI-mediated talk can either widen legitimate participation or privatize learning into silent, individualized exchange with a machine (Liu et al., 2024; Karataş et al., 2025). Table 2 operationalizes these interactional mechanisms by linking sociocultural lenses to AI mediation pathways and to explicit boundary conditions that protect classroom voice, dignity, and deliberative pluralism.

AI-mediated participation becomes pedagogically defensible when classroom routines convert AI from a substitute interlocutor into a catalyst for collective reasoning, structured disagreement, and reflective uptake. A robust design stance treats AI prompts as discourse catalysts that must be re-embedded into classroom interaction orders such as turn-taking norms, accountable talk expectations, and justification requirements, thereby preventing the machine from becoming the de facto arbiter of correctness. The key governance concept is semiotic accountability, meaning that the provenance, limitations, and uncertainty of AI contributions must remain legible within the classroom so that learners can contest, revise, and re-voice ideas without deference. This implies that teachers must author a participation contract that specifies when AI is permissible as a translation mediator, when it is permissible as a critique engine, and when it is prohibited as a replacement for peer deliberation. The sociocultural logic also requires attention to language rights and cultural fidelity, because accessibility transformations can either widen participation or subtly erase local epistemologies. Table 2 supplies a compact crosswalk from sociocultural mechanisms to failure modes that must be preempted by design.

Table 2. Theory-Mechanism Crosswalk for AI-Mediated Classroom Teaching Decisions and Safeguards

Theoretical Lens Cluster	Classroom Construct Focus	AI Mediation Mechanism	Pedagogical Design Imperative	Boundary Condition and Failure Mode
Cognitive Instructional Systems	*Attention allocation, working-memory economy, schema stabilization*	*Representation optimization, scaffold generation, feedback timing compression*	*Embed desirable difficulty, retrieval-elicitation, and fading schedules*	*Failure mode is solutionism, cognitive bypassing, and illusion-of-understanding*
Sociocultural Interactional Ecologies	*Participation rights, discourse norms, tool-mediated meaning-making*	*Dialogic scripting, translanguaging support, interactional prompt orchestration*	*Preserve dialogic reciprocity, peer-to-peer reasoning, and voice pluralism*	*Failure mode is discourse homogenization, voice erasure, and privatized learning*
Motivational Identity Dynamics	*Autonomy, competence signals, belonging, self-efficacy calibration*	*Adaptive encouragement, goal scaffolding, affect-sensitive prompting*	*Protect agency, support competence without over-control, normalize productive error*	*Failure mode is dependency, controlled motivation, and stigmatizing personalization*
Measurement Validity and Consequential Assessment	*Construct representation, fairness, interpretive legitimacy*	*Rubric mediation, scoring proxies, feedback automation, evidence summarization*	*Redesign assessment for traceable reasoning and contestable judgments*	*Failure mode is construct contamination, proxy drift, and inequitable misclassification*
Socio-technical Ethical Governance	*Privacy integrity, accountability partitioning, rights-based constraints*	*Data pipeline configuration, access control, audit log generation*	*Enforce contextual integrity, contestability, and human-in-command authority*	*Failure mode is surveillance creep, responsibility without control, and platform lock-in*

Motivation, Agency, Identity and Affective Dynamics in AI-Saturated Classrooms

Motivation in classrooms is an emergent property of autonomy affordances, competence feedback, belonging cues, and identity recognition, so AI becomes consequential when it modulates any of these motivational substrates at scale. *Self-Determination Theory* clarifies how AI can support competence through timely feedback and scaffolded challenges, while simultaneously threatening autonomy if recommendations become compulsory or opaque (Sarwar & Ms Saima, 2024; Dai & Liu, 2024; Cheah et al., 2025). Expectancy-value dynamics and attributional patterns matter because AI can externalize success and failure, making learners attribute outcomes to the system rather than to effortful strategy selection, thereby undermining self-efficacy and resilience. Identity and belonging constructs highlight that AI-generated norms of good language, good reasoning, and good participation can privilege dominant discursive registers, producing subtle recognition gaps for multilingual learners and culturally diverse expression styles (Rane, 2024; Ezeoguine & Eteng-Uket, 2024; Ng et al., 2025). Affective regulation is also implicated, since AI interactions can reduce help-seeking friction yet cultivate avoidance of teacher-mediated vulnerability. Table 2 frames these motivational-identity mechanisms and specifies failure modes such as dependency, controlled motivation, and stigmatizing personalization, which must be mitigated through agency-preserving routines and transparency norms.

Assessment, Measurement and Validity Under Generative Conditions

Assessment in AI-saturated classrooms must be theorized as a validity enterprise rather than a scoring enterprise, because generative systems destabilize traditional artifacts as evidence of independent competence and increase the risk of construct contamination. The relevant constructs include validity-as-argument, construct representation, measurement invariance across language groups, fairness as non-discrimination plus opportunity-to-learn protection, and consequential validity that anticipates how assessment reshapes instruction and student identity (Musolin et al., 2024; Wang & Li, 2024; Lim, 2024). AI-supported scoring and feedback drafting can increase throughput and consistency, yet it can also encode proxy drift, produce false precision, and amplify rubric rigidity that penalizes creative reasoning or culturally distinct rhetorical forms. A defensible framework therefore shifts assessment toward traceable reasoning, iterative justification, oral and interactive verification, and reflective disclosure norms that treat AI use as a design parameter rather than a moral exception (Salloum, 2024; Baltezarević & Baltezarević, 2024; Opesemowo & Adekomaya, 2024). Governance must include audit logs, version stability expectations, and contestability pathways so that students can challenge AI-mediated judgments. Table 2 formalizes these measurement and validity mechanisms and foregrounds boundary conditions needed to maintain legitimacy.

Human-AI Interaction, Trust Calibration and Cognitive Ergonomics for Teaching

Human factors and cognitive ergonomics are central because classroom AI adoption is mediated by trust calibration, mental model formation, and reliance dynamics that are often misaligned with actual system reliability. Automation bias can produce overreliance on fluent outputs, while algorithm aversion can generate erratic rejection after salient errors, both of which destabilize classroom consistency and equity (Opesemowo & Ndlovu, 2024; Saatchi et al., 2025; Kazanidis & Pellas, 2024). Explainability should be treated as pedagogically usable transparency rather than technical exposition, meaning that teachers and learners need actionable cues about uncertainty, limitations, and appropriate verification steps. Interaction design must therefore support calibrated reliance through uncertainty labeling, structured critique prompts, and friction that slows high-stakes decisions such as grading or placement (Mahmoud & Sørensen, 2024; Karakose & Tülübas, 2024; Yue et al., 2024). Oversight burden is also a workload construct, since verification labor competes with relational teaching, and hidden monitoring costs can accumulate into burnout and uneven adoption across classrooms. Table 1 specifies role-based oversight expectations, while Table 2 maps trust dynamics to boundary conditions so that reliance becomes a designed routine rather than an accidental habit.

Critical-Political Economy, Ethics and Rights-Based Governance as Pedagogical Pre-conditions

AI in classrooms is embedded in platform governance, procurement regimes, and data economies that can externalize risk onto teachers and students while internalizing value for vendors and institutions, so ethical analysis must include political economy and rights-based constraints. Contextual integrity frames privacy as appropriateness of data flow within classroom purposes, while data justice constructs foreground how differential surveillance and unequal access can reproduce structural inequities (Lye & Lim, 2024; Xia et al., 2024). *Epistemic Justice* and care-ethics perspectives show that classroom AI can generate testimonial injustice by discounting certain voices, or hermeneutical injustice by forcing experiences into impoverished interpretive categories. Professional accountability becomes precarious when institutions demand AI-enabled efficiency without providing transparency, auditability, or contestability, producing responsibility without control (Grájeda et al., 2024; Dieterle et al., 2024; Jatileni et al., 2024). Governance must therefore specify data minimization, version-change discipline, grievance pathways, and non-negotiable boundaries against surveillance creep, especially for multimodal sensing. Table 2 consolidates these governance mechanisms as sociotechnical imperatives, preparing the transition to Section 4 where prospects are defined as conditional opportunity structures under these constraints.

4. Prospects in Classroom Teaching Through Theory-Grounded Design Logics

The most defensible classroom prospect is AI as a design amplifier that accelerates task engineering while preserving teacher sovereignty over curricular intent, epistemic rigor, and cultural salience. When situated within *instructional alignment* and *Cognitive Load Theory*, generative capacity can be harnessed to produce isomorphic task variants, worked-example progressions, and misconception-sensitive prompts that reduce design friction without diluting intellectual demand (Zhang et al., 2025; Joel Augustus et al., 2025; Abbasi et al., 2025). The core mechanism is constrained generativity, where teachers specify concept boundaries, success criteria, and representational constraints, then curate outputs through verification pedagogy to avoid hallucinated facts and stereotype leakage. This prospect is strongest when AI is treated as a co-designer that expands representational repertoire, not as an autonomous curriculum writer, consistent with the role-autonomy distinctions encoded in Table 1 and the mechanism boundaries framed in Table 2. Table 3 operationalizes this prospect as a routine blueprint that converts high-throughput content into high-leverage learning tasks.

Explanatory Pluralism and Representational Transcoding for Deep Understanding

AI can strengthen classroom teaching by enabling explanatory pluralism, the systematic provision of multiple explanations that are semantically convergent yet rhetorically and representationally diverse, thereby supporting heterogeneous learners without tracking. Under *dual coding*, *generative learning*, and *conceptual change* logics, teachers can use AI to generate alternative analogies, counterexamples, and bridging explanations that surface latent misconceptions and reduce brittle memorization (Yang et al., 2024; Shamsuddinova et al., 2024; Storozhyk, 2024). The pedagogical value is not the explanation itself, but the orchestrated comparison, critique, and selection process that requires students to articulate warrants, identify hidden assumptions, and test boundary cases. This converts AI fluency into epistemic work, counteracting the plausibility trap highlighted in Section 3. The prospect becomes more reliable when representational transcoding is governed by fidelity constraints, meaning any simplification must preserve inferential structure and disciplinary semantics. Table 3 captures this as a design pattern that combines explanation generation with student-facing justification routines and teacher-controlled uncertainty labeling.

Differentiation Without Stratification Through Universal Access Architectures

Classroom differentiation becomes pedagogically legitimate when it is reframed as universal access architecture rather than stratification, where the target construct remains invariant while pathways, modalities, and scaffolds flex to learner needs. AI can operationalize this through *Universal Design for Learning* transformations, multilingual re-expression, accessibility mediation, and scaffolded hinting that respects autonomy and dignity (Samala et al., 2025; Ozodakhon, 2024; Fullan et al., 2024). The mechanism is not personalized difficulty alone, but adaptive representational access that reduces extraneous barriers, particularly for multilingual learners and students requiring accommodations, while preserving rigorous epistemic targets. A crucial safeguard is to prevent covert labeling, where systems infer latent traits and then silently gate learners into narrowed trajectories (Tan et al., 2024; Franco D'Souza et al., 2024; Yadav & Shrawankar, 2025). Teachers can counter this by making scaffolds transparent, time-bounded, and fadeable, with explicit student choice, thereby aligning with *Self-Determination Theory* and calibrated reliance. Table 3 specifies a differentiation routine that combines access expansion with anti-tracking guardrails, thereby translating equity principles into classroom-operational design.

Formative Assessment and Feedback Ecologies

Formative assessment is a primary prospect because AI can compress feedback latency, increase diagnostic granularity, and support teacher triage, provided that feedback remains interpretable, contestable, and oriented toward actionable next steps. Under *validity-as-argument* and formative feedback ecologies, AI can draft criterion-referenced feedback stems, generate misconception probes, and propose hinge questions that reveal conceptual bottlenecks, while teachers retain final judgment and tone stewardship (Mah & Groß, 2024; Zarei et al., 2024; Fundi et al., 2024). The pedagogical mechanism is high-velocity iteration, where students receive structured prompts for self-explanation, revision, and error analysis, and teachers allocate attention to high-leverage misunderstandings rather than surface errors. This prospect requires explicit controls against false precision and rubric rigidity, since automated feedback can overfit to superficial textual features and penalize culturally variant expression (Zohuri & Mossavar-Rahmani, 2024; Al-Zahrani & Alasmari, 2024). Table 3 provides a compact prospects matrix that links feedback routines to theoretical mechanisms and safeguards, and it should be read in conjunction with Table 1 role constraints and Table 2 trust-calibration requirements.

When implemented as specified in Table 3, formative AI functions as an instructional catalyst rather than an assessment surrogate, because it strengthens the feedback loop without collapsing assessment into automated judgment. The table highlights a design principle that is frequently neglected in practice, namely that feedback must be coupled to student action, not merely delivered, so the routine blueprint explicitly embeds justification logs, revision cycles, and sampling for drift. The governance column also foregrounds that seemingly pedagogical choices, such as tone and rubric structure, have distributive consequences for equity and belonging, especially in multilingual settings. This prospect therefore depends on teachers constructing classroom contracts that specify acceptable use, disclosure norms, and verification steps, thereby keeping accountability legible. The matrix also implies a workload calculus, since verification and sampling are labor, so implementation should prioritize high-leverage feedback moments rather than universal automation.

Table 3. Prospects Matrix for Classroom AI Design and Safeguards

Prospect Domain Signature	Teaching Function Lever	Theoretical Mechanism Anchor	Classroom Routine Blueprint	Safeguard and Boundary Condition
Constrained Co-Design Amplification	*Lesson planning, task variation, misconception anticipating*	*Instructional alignment, Cognitive Load Theory, variation theory*	*Teacher specifies concept boundary, success criteria, error exemplars, AI generates variants, teacher curates and annotates*	*Verification pedagogy, curriculum fidelity checks, stereotype and bias screening*
Explanatory Pluralism and Transcoding	*Multi-explanation teaching, analogy crafting, representation switching*	*Dual coding, Generative learning, Conceptual change*	*Students compare AI-generated explanations, identify warrants, test counterexamples, refine into class-owned explanation*	*Uncertainty labeling, prohibition of authoritative claims without warrants, semantic fidelity constraints*
UDL-Oriented Access Expansion	*Accessibility, translanguaging, modality transformation*	*Universal Design for Learning, agency preservation, equity-by-design*	*AI produces alternative modalities, teacher validates equivalence, students choose access route*	*Anti-tracking guardrails, transparent scaffolds, privacy minimization for sensitive inputs*

Feedback Ecology Acceleration	*Formative checks, rubric-aligned feedback, revision prompting*	*validity-as-argument, feedback uptake, self-explanation routines*	*AI drafts feedback stems, teacher approves, students revise with justification log, teacher samples for drift*	*Bias and tone governance, false precision controls, teacher final authority documentation*
Dialogic Orchestration and Participation Scaling	*Discussion prompts, argumentation scripting, turn-taking support*	*dialogic participation, distributed cognition, accountable talk*	*AI generates role prompts, evidence frames, rebuttal templates, students debate in groups, teacher moderates norms*	*Voice pluralism protection, anti-homogenization norms, explicit ban on AI as debate arbiter*

Dialogic Orchestration and Participation Scaling Without Discourse Homogenization

AI can enhance classroom discourse by generating structured prompts, argumentation frames, and role scripts that raise the proportion of student talk devoted to justification, counterargument, and evidence integration, which aligns with dialogic and sociocultural models of learning. The key prospect is participation scaling, meaning the teacher can seed multiple groups with coherent epistemic roles and discussion trajectories while preserving local autonomy and peer-to-peer meaning-making (Zhou et al., 2024; Fitrianto et al., 2024; Forero-Corba & Bennasar, 2024). The risk is discourse homogenization, where AI templates standardize voice and narrow rhetorical diversity, thereby undermining epistemic pluralism and identity recognition. This can be mitigated by treating AI scripts as provisional scaffolds, requiring students to localize examples, introduce counterpositions, and co-author norms of what counts as a good reason (Tzirides et al., 2024; Nikolopoulou, 2024; Weidener & Fischer, 2024). Table 3 formalizes this balance by pairing dialogic orchestration with explicit protections for voice pluralism and by prohibiting AI from functioning as a correctness arbiter. This prospect is strongest when teachers design turn-taking norms and accountability structures that keep deliberation collective rather than privatized.

Self-Regulated Learning, Metacognitive Scripting and Help-Seeking

A high-value prospect is AI as a metacognitive scaffold that supports planning, monitoring, reflection, and calibrated help-seeking, thereby strengthening learner autonomy while reducing unproductive floundering. Under *self-regulated learning* architectures, AI can prompt goal decomposition, generate study schedules aligned with spacing and retrieval, and elicit error analyses that distinguish conceptual misunderstanding from procedural slips (Afzaal et al., 2024; Rabiatu & Shehu, 2024; Lérias et al., 2024). The mechanism is not motivational cheerleading, but structured metacognitive scripting that externalizes strategy selection and encourages learners to articulate what they know, what they do not know, and what evidence would close the gap. The boundary condition is dependency control, since always-available hints can collapse productive struggle and weaken self-efficacy (Sana et al., 2024; Nguyen et al., 2024; Obidovna, 2024). A defensible classroom routine therefore uses graded hinting, delay constraints, and fading, alongside explicit reflection prompts that require students to justify why a hint was needed and how it changed their reasoning. Table 3 can be adapted to this domain by applying its agency-preserving safeguards and its insistence on traceable reasoning as the core artifact of learning.

Teacher Reflective Practice, Noticing Augmentation and Workload Recomposition

AI can strengthen teaching through noticing augmentation, meaning it helps teachers detect latent patterns in student reasoning, surface common error classes, and prioritize instructional responses, while teachers remain the interpretive authority. This prospect is aligned with professional vision and cybernetic regulation, where the teacher uses feedback signals to adjust instruction, pacing, and representation in near real time. The mechanism is workload recomposition, shifting time from repetitive drafting and sorting toward higher-order diagnosis, conferencing, and relational teaching, provided that verification overhead is managed (Choi et al., 2024; Al-Shorman et al., 2025; Stolpe & Hallström, 2024). The risk is managerial appropriation, where reflective analytics are repurposed for surveillance, performance scoring, or punitive accountability, which erodes trust and distorts teaching priorities. A rights-preserving implementation therefore isolates reflective AI from high-stakes evaluation systems, enforces data minimization, and frames outputs as hypotheses requiring teacher confirmation (Annuš, 2024; Chen, 2024; Rahiman & Kodikal, 2024). Table 3 anticipates these governance constraints by specifying documentation and contestability minima, and by emphasizing that teacher final authority must remain explicit, not implied.

Creativity, Inquiry and Epistemic Apprenticeship Through Structured Divergence and Convergence

AI can support creativity and inquiry when it is used to expand hypothesis space, simulate alternative perspectives, and provoke critique, thereby enabling structured divergence followed by disciplined convergence toward warranted claims. In inquiry pedagogies, the relevant construct is epistemic apprenticeship, where learners practice formulating questions, generating conjectures, evaluating evidence, and revising models, rather than merely consuming explanations (Cordero et al., 2024; Wang et al., 2024; Alier et al., 2024). AI can catalyze this by producing candidate hypotheses, counterfactual scenarios, and critique prompts that force learners to articulate assumptions, identify missing evidence, and design tests or arguments. The boundary condition is epistemic discipline, because unregulated generation can flood classrooms with low-quality conjectures and encourage shallow plausibility selection (Abuhassna et al., 2024; Yılmaz, 2024). A defensible routine therefore requires evidence mapping, uncertainty labeling, and argumentation constraints, where students must justify acceptance, rejection, or revision of AI suggestions using classroom-appropriate warrants. This prospect links back to the epistemic vigilance principles in Section 3 and aligns with

Table 3 by treating AI as a catalyst for critique and knowledge building, not as a shortcut to conclusions.

5. Challenges in Classroom Teaching Through Structural Tensions and Failure Modes

AI-mediated classroom work is structurally vulnerable to epistemic fragility because probabilistic fluency can impersonate warranted knowledge, thereby converting explanation into performance and justification into rhetoric. The central failure mode is warrant collapse, where learners accept outputs as testimony rather than as claims requiring evidence, counterexamples, and boundary testing, which weakens *epistemic vigilance* and destabilizes disciplinary standards of truth, proof, and interpretation (Sasikala & Ravichandran, 2024; Amdan et al., 2024; Alqahtani & Wafula, 2025). This risk is amplified by automation bias, anchoring to first outputs, and the illusion-of-explanatory-depth, especially when generative systems produce high-coherence narratives that conceal missing premises. Teachers face an epistemic workload dilemma, since verification labor competes with dialogic teaching, relational care, and formative noticing, creating conditions for silent error propagation into lesson plans, exemplars, and feedback (Bulathwela et al., 2024; Amado-Salvatierra et al., 2024; Abulibdeh et al., 2024). The role-autonomy distinctions in Table 1 and the cross-lens constraints in Table 2 indicate why epistemic risk is not a usability bug, but a predictable property of fluent generation, and it is codified as a first-order category in Table 4.

Pedagogical Dependency, Deskilling, and Cognitive Bypassing Dynamics

A second structural challenge is pedagogical dependency, where learners outsource generative cognition, and teachers outsource task design, leading to a gradual deskilling of both self-explanation and instructional reasoning. The underlying mechanism is cognitive bypassing, distinct from benign cognitive offloading, because core learning operations such as retrieval, elaboration, error diagnosis, and strategy selection are replaced rather than scaffolded (Suryanarayana et al., 2024; Özer, 2024; Galindo-Domínguez et al., 2024). In motivational terms, this can shift learners from mastery-oriented agency to externally regulated compliance, reducing *self-efficacy*, productive struggle, and metacognitive calibration. In classroom management terms, the availability of immediate answers can narrow the space for exploratory talk, thereby weakening peer-to-peer reasoning and shrinking collective sensemaking (Sharma et al., 2024; Robert et al., 2024; Bukar et al., 2024). The safeguard is not prohibition, but scaffold design with fading schedules, delay constraints, and justification routines that require learners to articulate why an AI suggestion is acceptable, what alternatives were rejected, and what evidence supports the final claim. Table 4 formalizes this challenge as a coupled pedagogical and governance problem, since dependency risk intensifies when institutions normalize AI as default rather than as disciplined augmentation.

Assessment Legitimacy, Construct Contamination and Authenticity Drift

Assessment becomes structurally unstable under generative conditions because conventional artifacts can no longer be assumed to index independent competence, thereby producing authenticity drift and legitimacy erosion. The technical challenge is not merely unauthorized assistance, but construct contamination, where the measured construct shifts from reasoning competence to tool orchestration competence, while grading practices continue to claim interpretive continuity (Zadorina et al., 2024; Iqbal et al., 2024). This creates fairness distortions, since unequal access to premium features, differential language fit, and variable teacher tolerance can generate inequitable opportunities to demonstrate learning. The defensible response is assessment redesign grounded in *validity-as-argument*, emphasizing traceable reasoning, iterative revision with justification logs, in-class synthesis, and oral or interactive verification that foregrounds epistemic work rather than polished prose (Zawacki-Richter et al., 2024; Mouta et al., 2024; Davis et al., 2024). Integrity enforcement framed as surveillance can further harm psychological safety and trust, so legitimacy depends on transparent classroom contracts that specify permissible AI roles by task type and preserve contestability for grading decisions. The risk typology in Table 4 treats assessment failure as a high-consequence domain where governance controls must be explicit, auditable, and aligned with pedagogical intent.

Equity Drift, Proxy Stratification and Cultural-Linguistic Misrecognition

Equity risk is not peripheral, since AI can produce equity drift by differentially amplifying advantage through access asymmetries, linguistic fit, and proxy-stratification loops that allocate opportunities based on noisy signals. A predictable mechanism is stratified personalization, where recommendations and scaffolds become silent tracking pathways, narrowing curriculum exposure for some learners under the guise of support (Martin et al., 2024; Kong et al., 2025; Vieriu & Petrea, 2025). Cultural-linguistic misrecognition is equally consequential, because generative norms of clarity, politeness, and argument structure may privilege dominant rhetorical registers, thereby penalizing multilingual expression, culturally situated narrative forms, and alternative epistemologies. These risks interact with disability accommodations, since inconsistent availability of accessibility mediation can stigmatize learners and generate procedural inequity (Walter, 2024; Adeleye et al., 2024; Kumar et al., 2024). Table 4 consolidates equity drift as a distinct challenge domain with both pedagogical countermeasures and governance controls, since classroom-level norms alone cannot neutralize platform-level incentives and data regime asymmetries. The prospects in Table 3 remain attainable only when equity is treated as a design constraint with explicit anti-tracking guardrails, transparent scaffolds, and purposeful fading.

The mitigation matrix in Table 4 should be read as an integrated control stack rather than as a menu of optional interventions, because classroom pedagogy and governance infrastructure co-determine risk exposure. A classroom can implement warrant routines, fading schedules, and traceable reasoning tasks, yet still experience harm if platform telemetry, retention creep, or version drift undermines privacy integrity and contestability. Conversely, institutional controls without pedagogical redesign can generate compliance theater, where policies exist but classroom practices still reward uncritical reliance and polished output over epistemic work. The matrix therefore foregrounds complementary levers, pedagogical countermeasures that shape cognition and participation, and governance controls that constrain data flows, autonomy, and accountability. This framing also clarifies workload realism, since verification and documentation are labor, so mitigation must prioritize high-consequence points such as grading, placement, and sensitive disclosures. The transition to Section 6 follows directly, because responsible classroom AI requires principles that translate Table 4 controls into repeatable routines and enforceable institutional commitments.

Table 4. Classroom AI Risk Typology and Mitigation Levers Matrix

Challenge Domain Archetype	Classroom Manifestation Pattern	Underlying Mechanism Driver	Pedagogical Countermeasure Design	Governance Control Requirement
Epistemic Reliability and Warrant Integrity	*Fluent but unjustified explanations, authoritative error adoption*	*Plausibility bias, automation bias, weak uncertainty signaling*	*Epistemic vigilance routines, warrant articulation, counterexample generation*	*Version awareness, audit logs, high-stakes friction, contestability pathway*
Dependency and Cognitive Bypassing	*Hint addiction, reduced self-explanation, teacher design deskilling*	*Unbounded assistance, premature solution exposure, motivational externalization*	*Fading schedules, delay constraints, justification logs, productive struggle norms*	*Acceptable-use contract, role restrictions, monitoring for overreliance signals*
Assessment Validity and Authenticity Drift	*Construct contamination, inconsistent grading legitimacy*	*Tool-mediated production, proxy scoring, opaque rubric enforcement*	*Traceable reasoning tasks, oral verification, iterative drafts with reflection*	*Transparency of criteria, documentation of AI role, appeal and review workflow*
Equity Drift and Proxy Stratification	*Silent tracking, unequal benefit by language and access*	*Access asymmetry, proxy optimization, feedback loops*	*UDL-aligned access expansion, anti-tracking guardrails, scaffold equivalence checks*	*Data minimization, fairness audits, procurement equity standards, feature parity*
Privacy Integrity and Surveillance Creep	*Chilling effects, sensitive data leakage, participation suppression*	*Telemetry extraction, retention creep, cross-context repurposing*	*Psychological safety norms, privacy-aware task design, minimal sensitive input*	*Purpose limitation, retention limits, access control, vendor accountability clauses*

Privacy, Dignity, and Classroom Psychological Safety Under Data Extraction

Privacy in classrooms is a rights-bearing constraint, not an administrative afterthought, because student expression is situated within authority relations where refusal is costly and disclosure can be coerced by grading, participation, or belonging pressure. The structural risk is surveillance creep, where routine instructional interactions become datafied through telemetry, retention, and secondary use, producing chilling effects that reduce exploratory talk, vulnerability, and intellectual risk-taking (Mustafa et al., 2024; Ng et al., 2024; Alwaqdani, 2025). Even when content is benign, metadata such as timing, frequency, and revision patterns can be repurposed as behavioral proxies, inviting misinterpretation and stigmatization. A defensible classroom stance treats privacy as contextual integrity, emphasizing purpose limitation, minimal sensitive input, and psychological safety norms that separate learning from monitoring (Sperling et al., 2024; Lin & Chen, 2024; Tashtoush et al., 2024). Pedagogically, teachers must design tasks that do not require personal disclosure to function, and must explicitly normalize opting out of AI-mediated channels for sensitive work. Table 4 codifies privacy integrity as a governance-heavy domain because classroom norms cannot substitute for enforceable retention limits, access controls, and vendor accountability.

Accountability Partitioning, Contestability, and Responsibility Without Control

Accountability failures arise when AI-mediated judgments influence feedback, grading, or opportunity allocation while responsibility remains diffuse, producing responsibility without control for teachers and due-process deficits for learners. Contestability is the core construct, since students require a procedural pathway to challenge AI-influenced evaluations, demand reasons that are pedagogically legible, and obtain human reconsideration (Guo et al., 2024; Galindo-Domínguez et al., 2024). The technical complication is version drift and hidden configuration changes, which can alter output behavior mid-term and undermine comparability across learners and cohorts. In professional ethics terms, teacher authority must remain explicit, meaning that AI suggestions are advisory and must never become de facto mandates embedded in dashboards or workflow constraints (Linderoth et al., 2024; Almasri, 2024; Perkins et al., 2024). Governance must therefore specify role clarity, documentation minima, and friction for high-stakes actions, aligning with the auditability requirements in Table 4. Pedagogically, transparency routines must be classroom-usable, where students understand when AI is involved, what it can do, and what limits apply, thereby reducing epistemic deference and preserving procedural fairness.

Platform Political Economy, Vendor Lock-In and Hidden Labor Externalities

Political economy constraints shape classroom AI through platform dependence, subscription stratification, opaque safety regimes, and monetization incentives that privilege engagement metrics over educational validity. Vendor lock-in can narrow pedagogical options by restricting interoperability, embedding proprietary formats, and making exit costly, which reduces institutional bargaining power and constrains teacher autonomy (Guettala et al., 2024; Memarian & Doleck, 2024; Filgueiras, 2024). Hidden labor is a structural externality, since teachers must perform prompt engineering, verification, adaptation, differentiation management, and documentation, often without workload recognition or professional development support. These labor shifts can widen inequity across classrooms because capacity varies, producing differential quality of implementation and unequal learner experiences (Bulut et al., 2024; Murdan & Halkhoree, 2024; Sămărescu et al., 2024). A defensible approach treats procurement as pedagogy, requiring feature parity planning, version stability expectations, and explicit support for teacher capacity-building as part of adoption governance. Table 4 situates these dynamics indirectly through governance controls, yet the deeper implication is that classroom AI cannot be treated as a discretionary convenience, it is an infrastructural commitment with long-run costs, risks, and accountability obligations.

Normative Drift in Educational Purposes, Epistemic Diversity, and Civic Formation

A final challenge is normative drift, where the purposes of education shift toward productivity, compliance, and output polish, thereby narrowing epistemic diversity, interpretive agency, and civic formation (Farooqi et al., 2024; Tang, 2024; Edwards-Fapohunda & Adediji, 2024). AI can implicitly redefine what counts as good work by optimizing toward standardized language, conventional argument structures, and easily scored formats, which can suppress creative reasoning, culturally diverse expression, and exploratory inquiry. When classroom success becomes aligned with prompt orchestration and stylistic refinement, learners may internalize instrumental rationality rather than disciplinary understanding and ethical responsibility. This drift is intensified by high-stakes testing cultures and accountability regimes that reward measurable proxies, creating pressure to deploy AI for score optimization rather than for deep learning. A defensible counter-design centers epistemic apprenticeship, requiring warrants, evidence mapping, reflective justification, and dialogic deliberation that preserves plurality and contestability. The mitigation logic in Table 4 thus extends beyond technical safeguards into purpose protection, since responsible classroom AI must be evaluated against what education is for, not merely how efficiently it produces artifacts.

6. Conceptual Framework for Responsible Classroom AI Through Orchestrated Mediation

Responsible classroom AI must begin with normative first principles, because classroom teaching is a rights-bearing practice rather than a productivity pipeline. The governing commitments are *educational purpose primacy*, *teacher professional authority*, *student agency*, *equity-by-design*, and *contestable accountability*, each functioning as a non-negotiable constraint on how AI is authorized to participate in planning, discourse, feedback, and evaluation (Airaj, 2024; Ramirez & Esparrell, 2024). Conceptually, these commitments operationalize the risk typology in Table 4 by converting abstract hazards into enforceable design obligations, thereby preventing responsibility without control and avoiding proxy-based stratification disguised as personalization. This section frames responsibility as orchestrated mediation, meaning AI remains a subordinated epistemic instrument whose outputs are defeasible and whose role is bounded by classroom contracts, verification routines, and institutional safeguards. The translation of principles into classroom routines and governance controls is consolidated in Table 5, which functions as a compact compliance-and-pedagogy bridge rather than a decorative summary.

Pedagogical Design Patterns for Verification, Fading and Dialogic Integrity

Classroom-level responsibility is achieved through pedagogical design patterns that reconfigure AI use into disciplined learning routines, rather than permitting opportunistic reliance. A verification pedagogy is central, requiring *warrant articulation*, counterexample generation, uncertainty labeling, and triangulation habits that institutionalize *epistemic vigilance* and reduce automation bias (Leong et al., 2024; Yim & Su, 2025; Sanusi et al., 2024). Scaffold-with-fading patterns are equally critical, since persistent assistance can induce dependency and cognitive bypassing, so support must be time-bounded, gradually withdrawn, and explicitly linked to strategy learning and self-explanation. Dialogic integrity patterns protect classroom discourse by treating AI prompts as catalysts for peer deliberation, accountable talk, and structured disagreement, while prohibiting AI from becoming a correctness arbiter that homogenizes voice. These patterns must be mapped to role constraints, as specified in Table 1, and aligned with the theory-to-mechanism crosswalk in Table 2, so that cognitive ergonomics, sociocultural participation, and motivational agency remain mutually reinforcing. Table 5 later formalizes these patterns as principle-to-routine commitments that can be audited without collapsing pedagogy into bureaucracy.

Validity-Preserving Assessment Redesign Under Generative Production Regimes

Assessment redesign is not an optional add-on, since generative production regimes destabilize artifact authenticity and elevate construct contamination risk, as outlined in Section 5 and encoded in Table 4. A validity-preserving stance treats assessment as an interpretive argument about competence, requiring that tasks elicit traceable reasoning, decision rationales, and revision logic rather than polished surface form. The most defensible design move is to evaluate epistemic work products such as justification narratives, error analyses, model critiques, and synthesis explanations that demand warrants and boundary testing, thereby converting AI availability into a context for higher-order epistemic performance (Cukurova, 2025; Lee et al., 2024; Tahir et al., 2024). Disclosure norms should be framed as learning contracts rather than punitive admissions, because legitimacy depends on procedural fairness and psychological safety, particularly in multilingual and high-stakes contexts. This redesign logic is aligned with *validity-as-argument*, *consequential validity*, and equity constraints, and it is operationalized in Table 5 through explicit assessment implications that keep teacher authority central while preserving contestability for learners.

Governance and Data-Integrity Architecture for Contextual Integrity and Contestability

Responsible classroom AI requires governance architecture that constrains data flows, stabilizes accountability, and preserves contestability, because classroom power asymmetries make consent and refusal structurally fragile. Data minimization and purpose limitation operationalize *contextual integrity* by ensuring that learning interactions are not repurposed into behavioral profiling, retention creep, or surveillance-by-telemetry (Farahani & Ghasmi, 2024; Mao et al., 2024; Yim, 2024). Version-change discipline and tool configuration transparency are essential for comparability and due process, since silent updates can reconfigure feedback tone, scoring proxies, and recommendation thresholds mid-cycle. Auditability must be framed as classroom-usable, meaning logs and documentation artifacts are sufficiently interpretable to support review, appeal, and remediation without requiring specialized forensic expertise. Governance also includes procurement ethics, interoperability expectations, and feature parity planning to prevent stratified access by subscription tier. The principle-to-control translation is consolidated in Table 5, which specifies minimal documentation artifacts alongside institutional control mechanisms so that responsibility remains coupled to operational levers rather than displaced onto teachers.

Table 5 functions as a compact governance-and-pedagogy integrator that makes responsibility operational by tying classroom routines to institutional controls and documentation minima, thereby reducing the chronic gap between policy rhetoric and classroom reality. The table also clarifies workload realism, since verification, fading, parity checks, and appeals are labor, so institutions must treat these routines as core instructional infrastructure rather than as discretionary compliance tasks. A central implication is that governance must be co-designed with pedagogy, because technical controls without classroom routines produce compliance theater, while classroom routines without platform controls leave teachers accountable for risks they cannot manage. The matrix additionally reinforces that equity and privacy are not merely ethical aspirations, they are design constraints that shape task selection, modality choices, and assessment interpretation. This integration prepares the ground for sustained capacity building, since the routines in Table 5 require shared professional language, stable procedures, and collective calibration across classrooms.

Table 5. Principle-to-Routine Matrix for Responsible Classroom AI Governance and Orchestration

Principle Anchor	Classroom Routine Instantiation	Assessment Design Implication	Institutional Control Mechanism	Minimal Documentation Artifact
Warrant Integrity and Epistemic Vigilance	*Students produce warrants, counterexamples, uncertainty labels, teacher moderates justification norms*	*Grading privileges reasoning trace and evidential linkage over stylistic fluency*	*High-stakes friction, version awareness, error reporting workflow*	*Prompt-output log, correction register, uncertainty annotation record*
Agency Preservation Through Scaffold-with-Fading	*Timed hints, delayed reveal, reflection on why help was needed, gradual removal of supports*	*Credit allocated to strategy articulation, self-explanation, and independent transfer*	*Acceptable-use boundaries, reliance monitoring, opt-out pathways*	*Fading schedule note, student reflection artifact, reliance check record*
Equity-by-Design and Anti-Tracking Guardrails	*Transparent scaffold choices, equivalence checks, culturally and linguistically responsive re-voicing*	*Comparable opportunity-to-demonstrate across modalities and languages*	*Feature parity planning, fairness screening, access provisioning protocol*	*Equivalence checklist, accessibility log, parity assurance note*
Contextual Integrity and Privacy Minimalism	*Privacy-aware task design, minimal sensitive input, explicit psychological safety norms*	*Sensitive disclosures excluded from AI-mediated channels and grading leverage*	*Retention limits, access controls, vendor accountability clauses*	*Data minimization statement, retention schedule, access control record*
Contestable Accountability and Human-in-Command Authority	*Students can challenge AI-influenced feedback, teacher provides reasons, re-evaluation pathway*	*Appeals grounded in criteria and warrants, teacher final judgment documented*	*Auditability standard, appeal workflow, configuration transparency*	*Decision rationale note, appeal outcome record, configuration snapshot*

Teacher Capacity as Collective Competence and Sociotechnical Literacy Infrastructure

Teacher capacity for responsible classroom AI should be conceptualized as collective competence rather than individual heroics, because the work involves epistemic calibration, task redesign, privacy stewardship, and procedural fairness under time pressure. Sociotechnical literacy here includes accurate mental models of probabilistic generation, recognition of proxy drift, understanding of oversight burden, and facility with verification pedagogy that makes uncertainty explicit without undermining classroom confidence (Uygun, 2024; AlAli & Wardat, 2024; Selwyn, 2024). Capacity also includes interactional leadership, the ability to set norms for disclosure, contestability, and dialogic integrity, and to protect student dignity when AI mediates language, accessibility, or feedback tone. Professional learning must therefore be job-embedded and routine-centered, focusing on shared task libraries, peer review of prompts and rubrics, calibration of feedback quality, and rehearsal of appeal workflows, all aligned with the principles in Table 5. This collective approach reduces inequity across classrooms by stabilizing implementation quality and preventing capacity gaps from becoming opportunity gaps. It also supports sustainable workload distribution by routinizing documentation, sampling, and verification rather than improvising them case-by-case.

Integrative Synthesis of Orchestrated Mediation as a High-Reliability Classroom Regime

Orchestrated mediation synthesizes the framework by positioning AI as a bounded mediational resource that is integrated through high-reliability routines, rights-preserving governance, and epistemically disciplined assessment design. In this regime, AI is authorized to amplify design and feedback throughput only when verification pedagogy, fading schedules, and dialogic integrity structures convert outputs into learning work rather than answer substitution (Salloum et al., 2024; Díaz & Nussbaum, 2024; Ifenthaler et al., 2024). Accountability remains legible because contestability, auditability, and teacher human-in-command authority are explicit, documented, and procedurally actionable, preventing responsibility without control. Equity and privacy are treated as structural constraints that shape task choice, modality options, and data flows, thereby avoiding silent tracking and surveillance creep that would erode psychological safety and participation. The framework is internally coherent across Tables 1 through 5, since roles, mechanisms, prospects, risks, and governance controls are aligned in one conceptual chain. Responsible classroom AI, under this synthesis, is not a technology adoption stance, it is a socio-technical operating model that preserves educational purpose while enabling disciplined innovation.

7. Conclusion

Artificial intelligence in classroom teaching should be understood as orchestrated epistemic mediation, not as a discrete tool adoption decision, because it reconstitutes instructional design, discourse governance, feedback circulation, and evidential legitimacy through a probabilistic layer that is simultaneously enabling and destabilizing. The central conclusion is that value emerges only when AI is subordinated to pedagogical intent and rights-bearing constraints, meaning outputs are treated as defeasible proposals that must be converted into learning work through *epistemic vigilance*, dialogic integrity, scaffold-with-fading routines, and validity-preserving assessment design. The prospects articulated in Section 4 are therefore not intrinsic properties of generative capacity, but conditional opportunity structures that require governance architecture, workload budgeting, and professional calibration to prevent warrant collapse, dependency formation, equity drift, and surveillance creep. This framing dissolves the false binary of adoption versus rejection by replacing it with a disciplined question of role authorization, autonomy boundaries, and contestable accountability. In practical terms, classroom AI becomes defensible when it strengthens reasoning, participation, and dignity, rather than merely accelerating artifact production.

Implications for Global Educational Research, Policy, and Workforce Development

For educational research, the paper implies a shift from outcome fixation to construct specification, where the unit of analysis is classroom work and the primary objects are mechanisms, boundary conditions, and governance commitments that make AI-mediated teaching stable and legitimate. For policy, the key implication is that responsible AI cannot be legislated solely through compliance language, because classroom protection requires enforceable constraints on data regimes, version-change discipline, feature parity, and contestability pathways that preserve due process under AI-influenced feedback and evaluation. For workforce development, the agenda is sociotechnical capacity building, where educators and learning technologists are trained not only in operational use, but in calibrated reliance, prompt-to-purpose alignment, assessment redesign, and privacy minimalism as routine professional practice. The global outlook matters because language diversity, infrastructure asymmetry, and differential institutional accountability amplify risk and can widen opportunity gaps if equity is not treated as a first-order design constraint. The framework therefore calls for interoperable governance minima that travel across contexts while allowing local pedagogical sovereignty and culturally responsive enactment.

Synthesis of Actionable Design Commitments

A coherent implementation stance follows directly from the chain established across Tables 1 through 5, where classroom roles determine oversight burden, theory clarifies mechanisms, prospects map to routine blueprints, risks translate into mitigation levers, and principles become enforceable governance and documentation minima. The actionable commitments are to institutionalize verification pedagogy so that warrant integrity becomes a classroom norm, to engineer fading schedules so that assistance becomes competence rather than dependency, to protect dialogic integrity so that AI catalyzes peer deliberation rather than privatizing learning, and to redesign assessment so that traceable reasoning, evidential linkage, and reflective justification become the primary learning evidence.

Institutional responsibilities include privacy minimalism, retention limits, access controls, auditability standards, and feature parity planning that prevents stratified learning opportunities by subscription tier or device access. The decisive insight is workload realism, since verification, sampling, and appeals are labor, so responsible use requires resource allocation, professional learning, and procedural routinization rather than informal teacher improvisation. Under these commitments, AI becomes a high-reliability instructional infrastructure rather than a volatile novelty.

Closing Integration and Boundary Conditions for Responsible Progress

The most durable conclusion is that classroom AI is governed less by algorithmic sophistication than by the integrity of the socio-technical operating model in which it is embedded, including norms, tasks, data regimes, and accountability pathways. Responsible progress therefore requires an explicit boundary architecture that restricts autonomous AI involvement in high-consequence functions, preserves human-in-command authority, and guarantees contestability for learners, while enabling constrained generativity where it demonstrably expands access, strengthens feedback uptake, and improves instructional precision. The framework also protects educational purposes by resisting normative drift toward productivity metrics and standardized voice, instead privileging epistemic diversity, civic deliberation, and identity-safe participation as core outcomes of classroom teaching. By treating equity and privacy as design constraints and by centering validity-as-argument in assessment, the paper offers a globally portable, discipline-spanning conceptual grammar for integrating AI without eroding trust, dignity, or learning legitimacy. The final stance is neither technophilic nor technophobic, it is structurally pragmatic, demanding that any classroom AI use be justified by mechanism, bounded by governance, and enacted through repeatable routines that make learning, not output, the unit of value.

Declaration of Interest:
No potential conflict of interest was reported by the authors.

Funding Information:
This research did not receive any specific funding from any public, commercial, or non-profit agency.

Disclosure Statement:
No material or relevant stake relating to this research was disclosed by the author(s).

Competing Interest:
No potential conflict of interest was reported by the author(s).

Data Availability Statement:
Data sharing is not applicable to this research article as no new data were created or analysed in this study.

References

- Abbasi, B. N., Wu, Y., & Luo, Z. (2025). Exploring the impact of artificial intelligence on curriculum development in global higher education institutions. *Education and Information Technologies*, *30*(1), 547-581.
- Abuhassna, H., Awae, F., Adnan, M. A., Daud, M., & Almheiri, A. S. (2024). The information age for education via artificial intelligence and machine learning: a bibliometric and systematic literature analysis. *International Journal of Information and Education Technology*, *14*(5), 700.
- Abulibdeh, A., Zaidan, E., & Abulibdeh, R. (2024). Navigating the confluence of artificial intelligence and education for sustainable development in the era of industry 4.0: Challenges, opportunities, and ethical dimensions. *Journal of Cleaner Production*, *437*, 140527.
- Adams, D., & Thompson, P. (2025). Transforming school leadership with artificial intelligence: Applications, implications, and future directions. *Leadership and Policy in Schools*, *24*(1), 77-89.
- Adeleye, O. O., Eden, C. A., & Adeniyi, I. S. (2024). Innovative teaching methodologies in the era of artificial intelligence: A review of inclusive educational practices. *World Journal of Advanced Engineering Technology and Sciences*, *11*(2), 069-079.
- Afzaal, M., Shanshan, X., Yan, D., & Younas, M. (2024). Mapping artificial intelligence integration in education: a decade of innovation and impact (2013-2023)-a bibliometric analysis. *IEEE Access*.
- Aguilar-Cruz, P. J., & Salas-Pilco, S. Z. (2025). Teachers' perceptions of artificial intelligence in Colombia: AI technological access, AI teacher professional development and AI ethical awareness. *Technology, Pedagogy and Education*, *34*(2), 219-238.
- Airaj, M. (2024). Ethical artificial intelligence for teaching-learning in higher education. *Education and Information Technologies*, *29*(13), 17145-17167.
- Al-Abdullatif, A. M. (2024). Modeling teachers' acceptance of generative artificial intelligence use in higher education: the role of AI literacy, intelligent TPACK, and perceived trust. *Education Sciences*, *14*(11), 1209.

- AlAli, R., & Wardat, Y. (2024). Opportunities and challenges of integrating generative artificial intelligence in education. *International Journal of Religion*, *5*(7), 784-793.
- Ali, O., Murray, P. A., Momin, M., Dwivedi, Y. K., & Malik, T. (2024). The effects of artificial intelligence applications in educational settings: Challenges and strategies. *Technological forecasting and social change*, *199*, 123076.
- Alier, M., Peñalvo, F. J. G., & Camba, J. D. (2024). Generative Artificial Intelligence in Education: From Deceptive to Disruptive. *International Journal of interactive multimedia and artificial intelligence*, *8*(5), 5-14.
- Almasri, F. (2024). Exploring the impact of artificial intelligence in teaching and learning of science: A systematic review of empirical research. *Research in Science Education*, *54*(5), 977-997.
- Alqahtani, N., & Wafula, Z. (2025). Artificial intelligence integration: Pedagogical strategies and policies at leading universities. *Innovative Higher Education*, *50*(2), 665-684.
- Al-Shorman, H. M., Saatchi, S. G., Alanaziand, T., Alzboon, M. S., Alka'awneh, S. M. N., Wahed, M. K. Y. A., ... & Al-Momani, A. A. M. (2025). Evaluating Artificial Intelligence Integration in Education Through Integrating TAM and S–O–R. In *Intelligence-Driven Circular Economy: Regeneration Towards Sustainability and Social Responsibility–Volume 1* (pp. 353-367). Cham: Springer Nature Switzerland.
- Alwaqdani, M. (2025). Investigating teachers' perceptions of artificial intelligence tools in education: potential and difficulties. *Education and Information Technologies*, *30*(3), 2737-2755.
- Al-Zahrani, A. M., & Alasmari, T. M. (2024). Exploring the impact of artificial intelligence on higher education: The dynamics of ethical, social, and educational implications. *Humanities and Social Sciences Communications*, *11*(1), 1-12.
- Amado-Salvatierra, H. R., Morales-Chan, M., Hernandez-Rizzardini, R., & Rosales, M. (2024, March). Exploring educators' perceptions: Artificial intelligence integration in higher education. In 2024 IEEE World Engineering Education Conference (EDUNINE) (pp. 1-5). IEEE.
- Amdan, M. A. B., Janius, N., Kasdiah, M. A. H. B., Amdan, M. A. B., Janius, N., & Kasdiah, M. A. H. B. (2024). Concept paper: Efficiency of Artificial Intelligence (AI) tools for STEM education in Malaysia. *International Journal of Science and Research Archive*, *12*(2), 553-559.
- Annuš, N. (2024). Education in the age of artificial intelligence. *TEM Journal*, *13*(1), 404-413.
- Ayanwale, M. A., Adelana, O. P., Molefi, R. R., Adeeko, O., & Ishola, A. M. (2024). Examining artificial intelligence literacy among pre-service teachers for future classrooms. *Computers and education open*, *6*, 100179.
- Baltezarević, R., & Baltezarević, I. (2024). Students' attitudes on the role of artificial intelligence (AI) in personalized learning. *International Journal of Cognitive Research in Science, Engineering and Education*, *12*(2), 387-397.
- Bender, S. M. (2024). Awareness of artificial intelligence as an essential digital literacy: ChatGPT and Gen-AI in the classroom. *Changing English*, *31*(2), 161-174.
- Bukar, U. A., Sayeed, M. S., Razak, S. F. A., Yogarayan, S., & Sneesl, R. (2024). Decision-making framework for the utilization of generative artificial intelligence in education: A case study of ChatGPT. *IEEE Access*, *12*, 95368-95389.
- Bulathwela, S., Pérez-Ortiz, M., Holloway, C., Cukurova, M., & Shawe-Taylor, J. (2024). Artificial intelligence alone will not democratise education: On educational inequality, techno-solutionism and inclusive tools. *Sustainability*, *16*(2), 781.
- Bulut, O., Beiting-Parrish, M., Casabianca, J. M., Slater, S. C., Jiao, H., Song, D., ... & Morilova, P. (2024). The rise of artificial intelligence in educational measurement: Opportunities and ethical challenges. *arXiv preprint arXiv:2406.18900*.
- Celik, I., Gedrimiene, E., Siklander, S., & Muukkonen, H. (2024). The affordances of artificial intelligence-based tools for supporting 21st-century skills: A systematic review of empirical research in higher education. *Australasian Journal of Educational Technology*, *40*(3), 19-38.
- Cheah, Y. H., Lu, J., & Kim, J. (2025). Integrating generative artificial intelligence in K-12 education: Examining teachers' preparedness, practices, and barriers. *Computers and Education: Artificial Intelligence*, *8*, 100363.
- Chen, H. (2024). The ethical challenges of educational artificial intelligence and coping measures: A discussion in the context of the 2024 World Digital Education Conference. *Science Insights Education Frontiers*, *20*(2), 3263-3281.
- Choi, J. I., Yang, E., & Goo, E. H. (2024). The effects of an ethics education program on artificial intelligence among middle school students: Analysis of perception and attitude changes. *Applied Sciences*, *14*(4), 1588.
- Cordero, J., Torres-Zambrano, J., & Cordero-Castillo, A. (2024). Integration of generative artificial intelligence in higher education: Best practices. *Education Sciences*, *15*(1), 32.
- Cukurova, M. (2025). The interplay of learning, analytics and artificial intelligence in education: A vision for hybrid intelligence. *British Journal of Educational Technology*, *56*(2), 469-488.
- Dai, K., & Liu, Q. (2024). Leveraging artificial intelligence (AI) in English as a foreign language (EFL) classes: Challenges and opportunities in the spotlight. *Computers in Human Behavior*, *159*, 108354.
- Davis, C., Bush, T., & Wood, S. (2024). Artificial intelligence in education: Enhancing learning experiences through personalized adaptation. *International Journal of Cyber and IT Service Management*, *4*(1), 26-32.
- Díaz, B., & Nussbaum, M. (2024). Artificial intelligence for teaching and learning in schools: The need for pedagogical intelligence. *Computers & Education*, *217*, 105071.
- Dieterle, E., Dede, C., & Walker, M. (2024). The cyclical ethical effects of using artificial intelligence in education. *AI & society*, *39*(2), 633-643.
- Edwards-Fapohunda, M. O., & Adediji, M. A. (2024). Sustainable development of distance learning in continuing adult education: The impact of artificial intelligence. *IRE Journals*, *8*(1), 113-114.
- Erduran, S., & Levrini, O. (2024). The impact of artificial intelligence on scientific practices: an emergent area of research for science education. *International Journal of Science Education*, *46*(18), 1982-1989.
- Ezeoguine, E. P., & Eteng-Uket, S. (2024). Artificial intelligence tools and higher education student's engagement. *Edukasiana: Jurnal Inovasi Pendidikan*, *3*(3), 300-312.
- Fadlelmula, F. K., & Qadhi, S. M. (2024). A systematic review of research on artificial intelligence in higher education: Practice, gaps, and future directions in the GCC. *Journal of University Teaching and Learning Practice*, *21*(6), 146-173.

- Famaye, T., Bailey, C. S., Adisa, I., & Irgens, G. A. (2024). " What Makes ChatGPT Dangerous Is Also What Makes It Special": High-School Student Perspectives on the Integration or Ban of Artificial Intelligence in Educational Contexts. *International Journal of Technology in Education*, *7*(2), 174-199.
- Farahani, M. S., & Ghasmi, G. (2024, July). Artificial intelligence in education: A comprehensive study. In *Forum for Education Studies* (Vol. 2, No. 3, pp. 1379-1379).
- Farooqi, M. T. K., Amanat, I., & Awan, S. M. (2024). Ethical considerations and challenges in the integration of artificial intelligence in education: A systematic review. *Journal of Excellence in Management Sciences*, *3*(4), 35-50.
- Filgueiras, F. (2024). Artificial intelligence and education governance. *Education, Citizenship and Social Justice*, *19*(3), 349-361.
- Fitrianto, I., Setyawan, C. E., & Saleh, M. (2024). Utilizing Artificial Intelligence for Personalized Arabic Language Learning Plans. *International Journal of Post Axial: Futuristic Teaching and Learning*, 30-40.
- Forero-Corba, W., & Bennasar, F. N. (2024). Techniques and applications of Machine Learning and Artificial Intelligence in education: a systematic review. *RIED-Revista Iberoamericana de Educación a Distancia*, *27*(1).
- Franco D'Souza, R., Mathew, M., Mishra, V., & Surapaneni, K. M. (2024). Twelve tips for addressing ethical concerns in the implementation of artificial intelligence in medical education. *Medical Education Online*, *29*(1), 2330250.
- Fullan, M., Azorín, C., Harris, A., & Jones, M. (2024). Artificial intelligence and school leadership: challenges, opportunities and implications. *School Leadership & Management*, *44*(4), 339-346.
- Fundi, M., Sanusi, I. T., Oyelere, S. S., & Ayere, M. (2024). Advancing AI education: Assessing Kenyan in-service teachers' preparedness for integrating artificial intelligence in competence-based curriculum. *Computers in Human Behavior Reports*, *14*, 100412.
- Galindo-Domínguez, H., Delgado, N., Campo, L., & Losada, D. (2024). Relationship between teachers' digital competence and attitudes towards artificial intelligence in education. *International Journal of Educational Research*, *126*, 102381.
- Galindo-Domínguez, H., Delgado, N., Losada, D., & Etxabe, J. M. (2024). An analysis of the use of artificial intelligence in education in Spain: The in-service teacher's perspective. *Journal of digital learning in teacher education*, *40*(1), 41-56.
- Gkintoni, E., Antonopoulou, H., Sortwell, A., & Halkiopoulos, C. (2025). Challenging cognitive load theory: The role of educational neuroscience and artificial intelligence in redefining learning efficacy. *Brain Sciences*, *15*(2), 203.
- Gökçearslan, S., Tosun, C., & Erdemir, Z. G. (2024). Benefits, challenges, and methods of artificial intelligence (AI) chatbots in education: A systematic literature review. *International Journal of Technology in Education*, *7*(1), 19-39.
- Grájeda, A., Burgos, J., Córdova, P., & Sanjinés, A. (2024). Assessing student-perceived impact of using artificial intelligence tools: Construction of a synthetic index of application in higher education. *Cogent Education*, *11*(1), 2287917.
- Guettala, M., Bourekkache, S., Kazar, O., & Harous, S. (2024). Generative artificial intelligence in education: Advancing adaptive and personalized learning. *Acta Informatica Pragensia*, *13*(3), 460-489.
- Guo, S., Zheng, Y., & Zhai, X. (2024). Artificial intelligence in education research during 2013–2023: A review based on bibliometric analysis. *Education and information technologies*, *29*(13), 16387-16409.
- 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.
- Iqbal, M., Khan, N. U., & Imran, M. (2024). The role of artificial intelligence (AI) in transforming educational practices: Opportunities, challenges, and implications. Qlantic Journal of Social Sciences, 5(2), 348-359.
- Ivanashko, O., Kozak, A., Knysh, T., & Honchar, K. (2024). The role of artificial intelligence in shaping the future of education: opportunities and challenges. *Futurity Education*, *4*(1), 126-146.
- Jafari, F., & Keykha, A. (2024). Identifying the opportunities and challenges of artificial intelligence in higher education: a qualitative study. *Journal of Applied Research in Higher Education*, *16*(4), 1228-1245.
- Jatileni, C. N., Sanusi, I. T., Olaleye, S. A., Ayanwale, M. A., Agbo, F. J., & Oyelere, P. B. (2024). Artificial intelligence in compulsory level of education: Perspectives from Namibian in-service teachers. *Education and information technologies*, *29*(10), 12569-12596.
- Joel Augustus, D., Asiegbu Victor, I., & Obinna, E. (2025). Leveraging artificial intelligence (AI) for educational development in Nigeria: Examining the challenges and opportunities. *Journal of Social Science*, *2*(2).
- Karakose, T., & Tülübas, T. (2024). School Leadership and Management in the Age of Artificial Intelligence (AI): Recent Developments and Future Prospects. *Educational Process: International Journal*, *13*(1), 7-14.
- Karataş, F., Eriçok, B., & Tanrikulu, L. (2025). Reshaping curriculum adaptation in the age of artificial intelligence: Mapping teachers' AI-driven curriculum adaptation patterns. *British Educational Research Journal*, *51*(1), 154-180.
- Katsamakas, E., Pavlov, O. V., & Saklad, R. (2024). Artificial intelligence and the transformation of higher education institutions: A systems approach. *Sustainability*, *16*(14), 6118.
- Kazanidis, I., & Pellas, N. (2024). Harnessing generative artificial intelligence for digital literacy innovation: A comparative study between early childhood education and computer science undergraduates. *AI*, *5*(3), 1427-1445.
- Khreisat, M. N., Khilani, D., Rusho, M. A., Karkkulainen, E. A., Tabuena, A. C., & Uberas, A. D. (2024). Ethical implications of AI integration in educational decision making: Systematic review. *Educational Administration: Theory and Practice*, *30*(5), 8521-8527.
- 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*, 1562-1573.
- Kong, S. C., Korte, S. M., Burton, S., Keskitalo, P., Turunen, T., Smith, D., ... & Beaton, M. C. (2025). Artificial Intelligence (AI) literacy–an argument for AI literacy in education. *Innovations in education and teaching international*, *62*(2), 477-483.
- Kumar, S., Rao, P., Singhania, S., Verma, S., & Kheterpal, M. (2024). Will artificial intelligence drive the advancements in higher education? A tri-phased exploration. *Technological Forecasting and Social Change*, *201*, 123258.
- Lan, Y. (2024). Through tensions to identity-based motivations: Exploring teacher professional identity in Artificial Intelligence-enhanced teacher training. *Teaching and Teacher Education*, *151*, 104736.
- Lee, Y. J., Davis, R. O., & Ryu, J. (2024). Korean in-service teachers' perceptions of implementing artificial intelligence (AI) education for teaching in schools and their AI teacher training programs. *International Journal of Information and Education Technology*, *14*(2), 214-219.

- Leong, W. Y., Leong, Y. Z., & San Leong, W. (2024, October). Artificial Intelligence in education. In *IET International Conference on Engineering Technologies and Applications (ICETA 2024)* (Vol. 2024, pp. 183-184). IET.
- Lérias, E., Guerra, C., & Ferreira, P. (2024). Literacy in artificial intelligence as a challenge for teaching in higher education: A case study at portalegre polytechnic university. *Information*, *15*(4), 205.
- Li, M. (2025). Integrating artificial intelligence in primary mathematics education: Investigating internal and external influences on teacher adoption. *International Journal of Science and Mathematics Education*, *23*(5), 1283-1308.
- Lim, E. M. (2024). Metaphor analysis on pre-service early childhood teachers' conception of AI (Artificial Intelligence) education for young children. *Thinking Skills and Creativity*, *51*, 101455.
- Lin, H., & Chen, Q. (2024). Artificial intelligence (AI)-integrated educational applications and college students' creativity and academic emotions: students and teachers' perceptions and attitudes. *BMC psychology*, *12*(1), 487.
- Linderoth, C., Hultén, M., & Stenliden, L. (2024). Competing visions of artificial intelligence in education—A heuristic analysis on sociotechnical imaginaries and problematizations in policy guidelines. *Policy Futures in Education*, *22*(8), 1662-1678.
- Liu, R., Zenke, C., Liu, C., Holmes, A., Thornton, P., & Malan, D. J. (2024, March). Teaching CS50 with AI: leveraging generative artificial intelligence in computer science education. In *Proceedings of the 55th ACM technical symposium on computer science education V. 1* (pp. 750-756).
- Lye, C. Y., & Lim, L. (2024). Generative artificial intelligence in tertiary education: Assessment redesign principles and considerations. *Education Sciences*, *14*(6), 569.
- Ma, D., Akram, H., & Chen, I. H. (2024). Artificial intelligence in higher education: A cross-cultural examination of students' behavioral intentions and attitudes. *International Review of Research in Open and Distributed Learning*, *25*(3), 134-157.
- Ma, S., & Lei, L. (2024). The factors influencing teacher education students' willingness to adopt artificial intelligence technology for information-based teaching. *Asia Pacific Journal of Education*, *44*(1), 94-111.
- Mah, D. K., & Groß, N. (2024). Artificial intelligence in higher education: exploring faculty use, self-efficacy, distinct profiles, and professional development needs. *International Journal of Educational Technology in Higher Education*, *21*(1), 58.
- Mahmoud, C. F., & Sørensen, J. T. (2024). Artificial intelligence in personalized learning with a focus on current developments and future prospects. *Research and Advances in Education*, *3*(8), 25-31.
- Mao, J., Chen, B., & Liu, J. C. (2024). Generative artificial intelligence in education and its implications for assessment. *TechTrends*, *68*(1), 58-66.
- Marengo, A., Pagano, A., Pange, J., & Soomro, K. A. (2024). The educational value of artificial intelligence in higher education: A 10-year systematic literature review. *Interactive Technology and Smart Education*, *21*(4), 625-644.
- Martin, F., Zhuang, M., & Schaefer, D. (2024). Systematic review of research on artificial intelligence in K-12 education (2017–2022). *Computers and Education: Artificial Intelligence*, *6*, 100195.
- Memarian, B., & Doleck, T. (2024). Human-in-the-loop in artificial intelligence in education: A review and entity-relationship (ER) analysis. Computers in Human Behavior: Artificial Humans, 2(1), 100053.
- Merchán Sánchez-Jara, J. F., González Gutiérrez, S., Cruz Rodríguez, J., & Syroyid Syroyid, B. (2024). Artificial intelligence-assisted music education: A critical synthesis of challenges and opportunities. *Education Sciences*, *14*(11), 1171.
- Mikeladze, T., Meijer, P. C., & Verhoeff, R. P. (2024). A comprehensive exploration of artificial intelligence competence frameworks for educators: A critical review. *European Journal of Education*, *59*(3), e12663.
- Mouta, A., Pinto-Llorente, A. M., & Torrecilla-Sánchez, E. M. (2024). Uncovering blind spots in education ethics: Insights from a systematic literature review on artificial intelligence in education. *International Journal of Artificial Intelligence in Education*, *34*(3), 1166-1205.
- Mouta, A., Torrecilla-Sánchez, E. M., & Pinto-Llorente, A. M. (2024). Design of a future scenarios toolkit for an ethical implementation of artificial intelligence in education. *Education and Information Technologies*, *29*(9), 10473-10498.
- Murdan, A. P., & Halkhoree, R. (2024, June). Integration of Artificial Intelligence for educational excellence and innovation in higher education institutions. In *2024 1st International Conference on Smart Energy Systems and Artificial Intelligence (SESAI)* (pp. 1-6). IEEE.
- Musolin, M. H., Ismail, M. H., Farhan, M., Rois, N., Ismail, A., Huda, M., & Rohim, M. A. (2024, February). Understanding of artificial intelligence for Islamic education support and service: insights from empirical literature review. In *International Congress on Information and Communication Technology* (pp. 27-43). Singapore: Springer Nature Singapore.
- Mustafa, M. Y., Tlili, A., Lampropoulos, G., Huang, R., Jandrić, P., Zhao, J., ... & Saqr, M. (2024). A systematic review of literature reviews on artificial intelligence in education (AIED): a roadmap to a future research agenda. *Smart Learning Environments*, *11*(1), 59.
- Naixin, Z., Wai Yie, L., Tong, Z., & Changqing, W. (2024). Artificial Intelligence in Engineering Education: A Review of Pedagogical Innovations. INTI JOURNAL, 2024(46), 1-10.
- Nedungadi, P., Tang, K. Y., & Raman, R. (2024). The transformative power of generative artificial intelligence for achieving the sustainable development goal of quality education. *Sustainability*, *16*(22), 9779.
- Ng, D. T. K., Chan, E. K. C., & Lo, C. K. (2025). Opportunities, challenges and school strategies for integrating generative AI in education. *Computers and Education: Artificial Intelligence*, 100373.
- Ng, D. T. K., Su, J., Leung, J. K. L., & Chu, S. K. W. (2024). Artificial intelligence (AI) literacy education in secondary schools: a review. *Interactive Learning Environments*, *32*(10), 6204-6224.
- Nguyen, A., Kremantzis, M., Essien, A., Petrounias, I., & Hosseini, S. (2024). Enhancing student engagement through artificial intelligence (AI): Understanding the basics, opportunities, and challenges. *Journal of University Teaching and Learning Practice*, *21*(6), 1-13.
- Nikolopoulou, K. (2024). Generative artificial intelligence in higher education: Exploring ways of harnessing pedagogical practices with the assistance of ChatGPT. *International Journal of Changes in Education*, *1*(2), 103-111.
- Obenza, B. N., Salvahan, A., Rios, A. N., Solo, A., Alburo, R. A., & Gabila, R. J. (2024). University students' perception and use of ChatGPT: Generative artificial intelligence (AI) in higher education. *International Journal of Human Computing Studies*, *5*(12), 5-18.

- Obidovna, D. Z. (2024). The pedagogical-psychological aspects of artificial intelligence technologies in integrative education. *International Journal Of Literature And Languages*, *4*(03), 13-19.
- Opesemowo, O. A. G., & Adekomaya, V. (2024). Harnessing artificial intelligence for advancing sustainable development goals in South Africa's higher education system: A qualitative study. *International Journal of Learning, Teaching and Educational Research*, *23*(3), 67-86.
- Opesemowo, O. A., & Ndlovu, M. (2024). Artificial intelligence in mathematics education: The good, the bad, and the ugly. *Journal of Pedagogical Research*, *8*(3), 333-346.
- Özer, M. (2024). Potential Benefits and Risks of Artificial Intelligence in Education. *Bartin University Journal of Faculty of Education*, *13*(2).
- Ozodakhon, K. (2024). The benefits and drawbacks of using artificial intelligence (ChatGPT) in education. *University Research Base*, 805-808.
- Pack, A., & Maloney, J. (2024). Using artificial intelligence in TESOL: Some ethical and pedagogical considerations. *Tesol Quarterly*, *58*(2), 1007-1018.
- Park, W., & Kwon, H. (2024). Implementing artificial intelligence education for middle school technology education in Republic of Korea. *International journal of technology and design education*, *34*(1), 109-135.
- Perkins, M., Furze, L., Roe, J., & MacVaugh, J. (2024). The Artificial Intelligence Assessment Scale (AIAS): A framework for ethical integration of generative AI in educational assessment. *Journal of University Teaching and Learning Practice*, *21*(6), 49-66.
- Rabiatu, M. M., & Shehu, S. A. (2024). Adopting artificial intelligence (AI) in education: challenges & possibilities. *Asian Journal of Advanced Research and Reports*, *18*(2), 106-111.
- Rahiman, H. U., & Kodikal, R. (2024). Revolutionizing education: Artificial intelligence empowered learning in higher education. *Cogent Education*, *11*(1), 2293431.
- Ramirez, E. A. B., & Esparrell, J. A. F. (2024). Artificial Intelligence (AI) in Education: Unlocking the Perfect Synergy for Learning. *Educational Process: International Journal*, *13*(1), 35-51.
- Rane, N. (2024). Enhancing the quality of teaching and learning through Gemini, ChatGPT, and similar generative Artificial Intelligence: Challenges, future prospects, and ethical considerations in education. *TESOL and Technology Studies*, *5*(1), 1-6.
- Robert, A., Potter, K., & Frank, L. (2024). The impact of artificial intelligence on students' learning experience. *Wiley Interdisciplinary Reviews: Computational Statistics*, *2*(01), 75-84.
- Roshanaei, M. (2024). Towards best practices for mitigating artificial intelligence implicit bias in shaping diversity, inclusion and equity in higher education. *Education and Information Technologies*, *29*(14), 18959-18984.
- Ruiz-Rojas, L. I., Salvador-Ullauri, L., & Acosta-Vargas, P. (2024). Collaborative working and critical thinking: Adoption of generative artificial intelligence tools in higher education. *Sustainability*, *16*(13), 5367.
- Saatchi, S. G., Wahed, M. K. Y. A., Alqaraleh, M. K. S., Al-Shorman, H. M., Alanazi, T., Alka'awneh, S. M. N., ... & Alzyoud, M. (2025). The influence of compatibility on the acceptance of artificial intelligence in Kuwaiti universities. In *Intelligence-Driven Circular Economy: Regeneration Towards Sustainability and Social Responsibility–Volume 1* (pp. 103-117). Cham: Springer Nature Switzerland.
- Sağın, F. G., Özkaya, A. B., Tengiz, F., Geyik, Ö. G., & Geyik, C. (2024). Current evaluation and recommendations for the use of artificial intelligence tools in education. *Turkish Journal of Biochemistry*, *48*(6), 620-625.
- Salloum, S. A. (2024). AI perils in education: Exploring ethical concerns. *Artificial intelligence in education: The power and dangers of ChatGPT in the classroom*, 669-675.
- Salloum, S. A., Salloum, A., & Alfaisal, R. (2024). Objectives and Obstacles of Artificial Intelligence in Education. *Artificial Intelligence in Education: The Power and Dangers of ChatGPT in the Classroom*, 605-614.
- Samala, A. D., Rawas, S., Wang, T., Reed, J. M., Kim, J., Howard, N. J., & Ertz, M. (2025). Unveiling the landscape of generative artificial intelligence in education: a comprehensive taxonomy of applications, challenges, and future prospects. *Education and Information Technologies*, *30*(3), 3239-3278.
- Sămărescu, N., Bumbac, R., Zamfiroiu, A., & Iorgulescu, M. C. (2024). Artificial intelligence in education: Next-gen teacher perspectives. *Amfiteatru Economic*, *26*(65), 145-161.
- Sana, E., Fitriani, A., Soetarno, D., & Yusuf, M. (2024). Analysis of user perceptions on interactive learning platforms based on artificial intelligence. *Journal of Computer Science and Technology Application*, *1*(1), 26-32.
- Sanusi, I. T., Agbo, F. J., Dada, O. A., Yunusa, A. A., Aruleba, K. D., Obaido, G., ... & Oyelere, S. S. (2024). Stakeholders' insights on artificial intelligence education: Perspectives of teachers, students, and policymakers. *Computers and Education Open*, *7*, 100212.
- Sanusi, I. T., Ayanwale, M. A., & Chiu, T. K. (2024). Investigating the moderating effects of social good and confidence on teachers' intention to prepare school students for artificial intelligence education. *Education and information technologies*, *29*(1), 273-295.
- Sanusi, I. T., Ayanwale, M. A., & Tolorunleke, A. E. (2024). Investigating pre-service teachers' artificial intelligence perception from the perspective of planned behavior theory. *Computers and Education: Artificial Intelligence*, *6*, 100202.
- Sarwar, M. A., & Ms Saima, A. G. (2024). The role of artificial intelligence in shaping the future of education at higher secondary level. *Journal of Education and Social Studies*, *5*(1), 34-45.
- Sasikala, P., & Ravichandran, R. (2024). Journal of Digital Learning and Education. *Journal of Digital Learning and Education*, *4*(2), 145-155.
- Selwyn, N. (2024). On the limits of artificial intelligence (AI) in education. *Nordisk tidsskrift for pedagogikk og kritikk*, *10*(1), 3-14.
- Shailendra, S., Kadel, R., & Sharma, A. (2024). Framework for adoption of generative artificial intelligence (GenAI) in education. *IEEE Transactions on Education.*
- Shamsuddinova, S., Heryani, P., & Naval, M. A. (2024). Evolution to revolution: Critical exploration of educators' perceptions of the impact of Artificial Intelligence (AI) on the teaching and learning process in the GCC region. *International Journal of Educational Research*, *125*, 102326.
- Sharma, S., Singh, G., Sharma, C. S., & Kapoor, S. (2024). Artificial intelligence in Indian higher education institutions: a quantitative study on adoption and perceptions. *International Journal of System Assurance Engineering and Management*, 1-17.
- Singha, S., & Singha, R. (2024). The application of artificial intelligence in education: Opportunities and challenges. *Educational perspectives on digital technologies in modeling and management*, 282-292.

- Sova, R., Tudor, C., Tartavulea, C. V., & Dieaconescu, R. I. (2024). Artificial intelligence tool adoption in higher education: A structural equation modeling approach to understanding impact factors among economics students. *Electronics*, *13*(18), 3632.
- Sperling, K., Stenberg, C. J., McGrath, C., Åkerfeldt, 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.
- Stolpe, K., & Hallström, J. (2024). Artificial intelligence literacy for technology education. *Computers and Education Open*, *6*, 100159.
- Storey, V. A., & Wagner, A. (2024). Integrating artificial intelligence (ai) into adult education: opportunities, challenges, and future directions. *International Journal of Adult Education and Technology (IJAET)*, *15*(1), 1-15.
- Storozhyk, M. (2024). Philosophy of future: Analytical overview of interaction between education, science, and artificial intelligence in the context of contemporary challenges. *Futurity Philosophy*, *3*(1), 23-47.
- Suryanarayana, K. S., Kandi, V. P., Pavani, G., Rao, A. S., Rout, S., & Krishna, T. S. R. (2024). Artificial intelligence enhanced digital learning for the sustainability of education management system. *The Journal of High Technology Management Research*, *35*(2), 100495.
- Tahir, M., Hassan, F. D., & Shagoo, M. R. (2024). Role of artificial intelligence in education: A conceptual review. *World Journal of Advanced Research and Reviews*, *22*(1), 1469-1475.
- Tan, X., Cheng, G., & Ling, M. H. (2024). Artificial intelligence in teaching and teacher professional development: A systematic review. *Computers and Education: Artificial Intelligence*, 100355.
- Tang, K. H. D. (2024). Implications of artificial intelligence for teaching and learning. *Acta Pedagogia Asiana*, *3*(2), 65-79.
- Tashtoush, M. A., Wardat, Y., Ali, R. A., & Saleh, S. (2024). Artificial intelligence in education: mathematics teachers' perspectives, practices and challenges. *Iraqi Journal for Computer Science and Mathematics*, *5*(1), 20.
- Tassoti, S. (2024). Assessment of students use of generative artificial intelligence: Prompting strategies and prompt engineering in chemistry education. *Journal of Chemical Education*, *101*(6), 2475-2482.
- Thorat, V., Rao, P., Joshi, N., Talreja, P., Shetty, A. R., & RAO, P. (2024). Role of artificial intelligence (AI) in patient education and communication in dentistry. *Cureus*, *16*(5).
- Topaz, M., Peltonen, L. M., Michalowski, M., Stiglic, G., Ronquillo, C., Pruinelli, L., ... & Fukahori, H. (2025). The ChatGPT effect: nursing education and generative artificial intelligence. *Journal of Nursing Education*, *64*(6), e40-e43.
- Tzirides, A. O. O., Zapata, G., Kastania, N. P., Saini, A. K., Castro, V., Ismael, S. A., ... & Kalantzis, M. (2024). Combining human and artificial intelligence for enhanced AI literacy in higher education. *Computers and Education Open*, *6*, 100184.
- Uygun, D. (2024). Teachers' perspectives on artificial intelligence in education. *Advances in Mobile Learning Educational Research*, *4*(1), 931-939.
- Vieriu, A. M., & Petrea, G. (2025). The impact of artificial intelligence (AI) on students' academic development. *Education Sciences*, *15*(3), 343.
- Vistorte, A. O. R., Deroncele-Acosta, A., Ayala, J. L. M., Barrasa, A., López-Granero, C., & Martí-González, M. (2024). Integrating artificial intelligence to assess emotions in learning environments: a systematic literature review. *Frontiers in psychology*, *15*, 1387089.
- Walter, Y. (2024). Embracing the future of Artificial Intelligence in the classroom: the relevance of AI literacy, prompt engineering, and critical thinking in modern education. *International Journal of Educational Technology in Higher Education*, *21*(1), 15.
- Wang, C., Wang, H., Li, Y., Dai, J., Gu, X., & Yu, T. (2025). Factors influencing university students' behavioral intention to use generative artificial intelligence: Integrating the theory of planned behavior and AI literacy. *International Journal of Human–Computer Interaction*, *41*(11), 6649-6671.
- Wang, J., & Li, J. (2024). Artificial intelligence empowering public health education: prospects and challenges. *Frontiers in public health*, *12*, 1389026.
- 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.
- Weidener, L., & Fischer, M. (2024). Artificial intelligence in medicine: cross-sectional study among medical students on application, education, and ethical aspects. *JMIR medical education*, *10*(1), e51247.
- Williamson, B. (2024). The social life of AI in education. *International Journal of Artificial Intelligence in Education*, *34*(1), 97-104.
- Wu, X. Y. (2024). Artificial Intelligence in L2 learning: A meta-analysis of contextual, instructional, and social-emotional moderators. *System*, *126*, 103498.
- Xia, Q., Weng, X., Ouyang, F., Lin, T. J., & Chiu, T. K. (2024). A scoping review on how generative artificial intelligence transforms assessment in higher education. *International Journal of Educational Technology in Higher Education*, *21*(1), 40.
- Yadav, S. (2024). Artificial Intelligence (AI) Integration in Higher Education: Navigating Opportunities and Ethical Frontiers in Education with Advanced Technologies. In *Impact of artificial intelligence on society* (pp. 43-59). Chapman and Hall/CRC.
- Yadav, U., & Shrawankar, U. (2025). Artificial intelligence across industries: A comprehensive review with a focus on education. *AI applications and strategies in teacher education*, 275-320.
- Yang, A. (2024). Challenges and opportunities for foreign language teachers in the era of artificial intelligence. *International Journal of Education and Humanities*, *4*(1), 39-50.
- Yang, W., Hu, X., Yeter, I. H., Su, J., Yang, Y., & Lee, J. C. K. (2024). Artificial intelligence education for young children: A case study of technology-enhanced embodied learning. *Journal of Computer Assisted Learning*, *40*(2), 465-477.
- Yang, Y., Chen, L., He, W., Sun, D., & Salas-Pilco, S. Z. (2024). Artificial intelligence for enhancing special education for K-12: A decade of trends, themes, and global insights (2013–2023). *International Journal of Artificial Intelligence in Education*, 1-49.
- Yılmaz, Ö. (2024). Personalised learning and artificial intelligence in science education: current state and future perspectives. *Educational Technology Quarterly*, *2024*(3), 255-274.
- Yim, I. H. Y. (2024). A critical review of teaching and learning artificial intelligence (AI) literacy: Developing an intelligence-based AI literacy framework for primary school education. *Computers and Education: Artificial Intelligence*, *7*, 100319.
- Yim, I. H. Y., & Su, J. (2025). Artificial intelligence (AI) learning tools in K-12 education: A scoping review. *Journal of Computers in Education*, *12*(1), 93-131.
- Yuan, L., & Liu, X. (2025). The effect of artificial intelligence tools on EFL learners' engagement, enjoyment, and motivation. *Computers in Human Behavior*, *162*, 108474.

- Yue, M., Jong, M. S. Y., & Ng, D. T. K. (2024). Understanding K–12 teachers' technological pedagogical content knowledge readiness and attitudes toward artificial intelligence education. *Education and information technologies*, *29*(15), 19505-19536.
- Zadorina, O., Hurskaya, V., Sobolyeva, S., Grekova, L., & Vasylyuk-Zaitseva, S. (2024). The role of artificial intelligence in creation of future education: Possibilities and challenges. *Futurity Education*, *4*(2), 163-185.
- Zarei, M., Mamaghani, H. E., Abbasi, A., & Hosseini, M. S. (2024). Application of artificial intelligence in medical education: A review of benefits, challenges, and solutions. *Medicina Clínica Práctica*, *7*(2), 100422.
- Zawacki-Richter, O., Bai, J. Y., Lee, K., Slagter van Tryon, P. J., & Prinsloo, P. (2024). New advances in artificial intelligence applications in higher education?. *International Journal of Educational Technology in Higher Education*, *21*(1), 32.
- Zhang, H., Perry, A., & Lee, I. (2025). Developing and validating the artificial intelligence literacy concept inventory: An instrument to assess artificial intelligence literacy among middle school students. *International Journal of Artificial Intelligence in Education*, *35*(1), 398-438.
- Zhou, X., Zhang, J., & Chan, C. (2024). Unveiling students' experiences and perceptions of artificial intelligence usage in higher education. *Journal of University Teaching and Learning Practice*, *21*(6), 126-145.
- Zohuri, B., & Mossavar-Rahmani, F. (2024). Revolutionizing education: The dynamic synergy of personalized learning and artificial intelligence. *International Journal of Advanced Engineering and Management Research*, *9*(1), 143-153.