Literature Review | Organized by Topic

Project: AI in K-12 Edtech, adapting to student learning styles/emotional needs without replacing critical thinking (R1); building teacher trust and genuine classroom support (R2)

Topic 1: AI Literacy
Topic 2: Teacher Adoption, Trust & Professional Development
Topic 3: Student Voice, Participatory Design & Policy
Topic 4: Personalization & Adaptive Learning Outcomes
Topic 5: Learner Variability & Developmental/Emotional Psychology
Topic 6: Metacognition, Self-Regulation & Curiosity

Topic 1: AI Literacy
Definitions, Frameworks & Pedagogical Approaches
Top 5 takeaways:

- AI literacy is defined across four competencies: know/understand, use/apply, evaluate/create, and ethics, and is best taught through **constructionism**, where students learn by manipulating, questioning, designing with, and failing with AI rather than just using it as a tool (Paper 1).
- Three dominant pedagogical methods for teaching AI in K-12: project/problem-based learning, collaborative learning, and experiential learning (Paper 1).
- **Bloom's Taxonomy** (Remember, Understand, Apply, Analyze, Evaluate, Create) is repeatedly used as the backbone for structuring AI-related learning objectives and personalization frameworks (Papers 2, 11).
- Teachers should guide students to critically analyze and optimize their own prompts rather than accept AI outputs at face value; poor/vague prompting degrades learning value (Paper 2).
- Effective LLM-based personalization should be grounded in established theory (Bloom's, ZPD, UDL) rather than being purely algorithmic, content complexity should scale to student readiness, not just interest (Paper 11).

Individual notes:

Paper 1: Constructionism in K-12 AI Literacy Education (SAGE):

- AI literacy = ability to critically evaluate AI, communicate/collaborate with AI, and use AI as a tool; four aspects: know/understand, use/apply, evaluate/create, ethics.

- Constructionist learning: cognitive, contextual, and material dimensions; difficulty understanding a concept often comes from lack of simplifying materials, not concept complexity itself.

Paper 2: Generative AI in K-12 Education: A Systematic Review:

- Bloom's Taxonomy applied to AI: Remember, Understand, Apply, Analyze, Evaluate, Create.
- Students need help identifying/questioning false information; teachers should guide critical prompt analysis.
- LLMs enhance intrinsic motivation in English, math, physics; SRLbot encourages metacognitive reflection.
- Barrier: explaining GenAI's technology is the most frequently reported instructional challenge.
- Recommendation: language teachers focus on evaluating text authenticity; math teachers focus on verifying problem-solving logic.

Paper 11: Lim et al., Learning in Context (PAGE framework):

- Effective personalization should: build cognitive/affective learner profiles, use "contextual anchors," reduce cognitive load via analogies, preserve core content while personalizing examples, ground in Bloom's/ZPD/UDL.
- PAGE rewrites content using the student's academic background/interests (e.g., neural networks explained via video game mechanics or music).
- Personalization improved student trust/confidence that the system "understood them."

Topic 2: Teacher Adoption, Trust & Professional Development

Top 5 takeaways:

- Teacher adoption of AI is accelerating unevenly due to preparedness, policy uncertainty, and access inequality. Schools must teach students to evaluate AI outputs, recognize bias, and use AI responsibly (Paper 3).
- Teachers most benefit from PD that combines real-world problem-solving/case-based learning WITH direct instruction, pure hands-on or pure lecture alone is less effective (Paper 5).
- Addressing misconceptions and building basic (not overly technical) understanding of AI increases teacher self-efficacy and willingness to try teaching with it (Paper 5).

- Technology only benefits students when educators are actively involved with clear instructional intent, a well-designed adaptive tool is worthless if students skip the explanations (Paper 6).
- Human-in-the-loop design (AI drafts, teachers curate/customize) builds more trust and better outcomes than fully automated systems, teacher agency over instructional decisions matters more than automation efficiency (Paper 15; also Paper 14).

Individual notes:

Paper 3: K-12 Teachers' Adoption of GenAI (Extended TAM, China):

- AI success depends on equitable implementation, teacher involvement, protecting cognitive development.
- Serious concerns about cognitive dependency; schools must teach evaluation, bias recognition, limitations, responsible use.

Paper 5: Teachers' PD Needs for AI Integration:

- Teachers want proficiency-building, peer networks, mentorship, shared guidebooks.
- Need to debunk "AI as threat" myths; explain decision-making basics to build trust.
- AI literacy gap is the primary barrier to integration (worst among elementary teachers).

Paper 6: Huebner & Burstein, Strategies for Effective Tech-Enabled Instruction:

- 5 categories of instructional benefit: personalization, curation/accessibility, engagement/motivation, communication/collaboration, learning analytics.
- Teachers' attitudes/beliefs/skills are key; cross-school/department collaboration needed; leaders should create safe space for teachers to share frustrations with tech.

Paper 14: AI as a Teaching Partner (Classroom Codesign):

- Teachers need pedagogical judgment + tool fluency: structuring goals, framing prompts, monitoring, modeling responsible use.
- Middle school teachers used shorter/structured workflows; high schoolers used sustained AI dialogue.
- The greatest value of AI grading was narrative feedback, not numeric scores.
- ~20% of teachers said customizing AI-generated lesson plans improved usefulness.

Paper 15: Shiksha Copilot (India, 757 schools):

- Human-in-the-loop: AI drafts → expert educators curate → teachers customize.

- Effectiveness depends on curricular alignment, contextual integration, and teacher trust.
- Preserving teacher agency (vs. full automation) likely builds more trust and better outcomes.

Topic 3: Student Voice, Participatory Design & Policy

Top 5 takeaways:

- Genuine personalization requires authentic student voice/agency, much "personalized learning" is actually designed by adults for students, not with them (Paper 10).
- Participatory design (PD) with high schoolers surfaced concrete tool guidelines: AI should give incremental hints instead of direct answers, and should let students verify sources themselves rather than blindly trust output (Paper 4).
- Students want transparency/control: proposed idea of AI quoting source text and asking students to think for themselves, preserving source verification while still using AI (Paper 4).
- Policy recommendations from student co-design: no GenAI as a legitimate cited source, limits on teacher AI use, private data deletion, student-led AI advisory committees (Paper 4).
- Equity must be designed in, low-internet-requirement tools and multilingual support are needed so personalization doesn't widen socioeconomic gaps (Paper 4).

Individual notes:

Paper 4: Participatory Design of GenAI with High School Students:

- Students want incremental hints, not direct answers; AI mistrust in information → let students verify via quoted source text.
- Policies: GenAI not a legitimate source, limits on teacher use, private data deletion.
- Design for equity: minimal internet requirement, multilingual support.
- Recommend transparent third-party AI certification program for edtech tools.

Paper 10: Personalized Learning Policy and Student Voice (statewide case study):

- Meaningful personalization requires authentic student voice/agency, not just algorithmic adaptation.
- Personalization is often designed by adults for students, not with them, schools may endorse it philosophically while keeping traditional teacher/system-directed structures.

Topic 4: Personalization & Adaptive Learning Outcomes

Top 5 takeaways:

- Students using personalized/adaptive learning technologies consistently outperform those receiving traditional instruction in reading literacy (Paper 7).
- Adaptive learning's success depends less on "having personalization" and more on HOW it's implemented, continuous learner modeling and ongoing instructional adaptation matter more than static profiles (Paper 8).
- AI-assisted personalized learning shows its strongest gains in knowledge development/content mastery (not just engagement/motivation), and effectiveness increases the longer the intervention runs, as AI gathers more learner data over time (Paper 9).
- Reading/adaptive systems that adjust challenge level to keep students in an optimal zone connect directly to Vygotsky's Zone of Proximal Development (Paper 7).
- The most successful implementations combine three things together: effective instructional design + teacher guidance + personalized technology, no single piece works alone (Paper 7, Paper 6).

Individual notes:

Paper 7: Personalized/Adaptive Learning Tech & Reading Literacy (global meta-analysis, 2024):

- Technologies examined: adapt difficulty, personalized feedback, activity recommendations, automatic pacing, strength/weakness identification.
- Connects to Vygotsky's ZPD, keeping students in optimal challenge zone.
- Best implementations combine instructional design + teacher guidance + tech.

Paper 8: Efficacy of AI-Enabled Adaptive Learning Systems 2010–2022 (meta-analysis):

- Effectiveness depends on continuous learner modeling + ongoing adaptation + sound instructional design, not just "presence" of personalization.
- Future ed-AI should dynamically respond to evolving needs rather than static models.

Paper 9: Effect of AI-Assisted Personalized Learning (31-paper meta-analysis):

- Strongest gains in knowledge development/content mastery over engagement/motivation.
- Longer interventions = more effective, as AI accumulates more learner info over time.

Topic 5: Learner Variability & Developmental/Emotional Psychology

Top 5 takeaways:

- Every child enters the classroom with unique experiences, strengths, and challenges, a one-size-fits-all model under-serves nearly all learners; education should focus on individuals, not statistical averages (Paper 12).
- Emotions directly shape attention, memory, motivation, understanding, and knowledge transfer, they are not separate from cognition (Paper 12).
- Rejects strict "nature vs. nurture": experiences actively shape brain development while biology shapes how experiences are processed, learning environments must support cognitive AND emotional development together (Paper 12).
- Self-Determination Theory (SDT): students are most motivated when three needs are met, autonomy (meaningful choice), competence (belief they can succeed), and relatedness (feeling connected to teachers/peers) (Key Terms doc).
- Real classroom variability is significant even within one class, teachers observed advanced students pushing AI far beyond assignments while struggling students engaged more once reassured they could start small; multilingual students found voice through AI conversation they didn't have in whole-class discussion (Paper 14).

Individual notes:

Paper 12: Pape, Learner Variability Is the Rule, Not the Exception:

- Every child has unique experiences/strengths/challenges shaping how they understand, collaborate, and solve problems.
- Emotions shape attention, memory, motivation, understanding, knowledge transfer.
- Rejects nature-vs-nurture dichotomy; experience shapes brain development, biology shapes processing.

Paper 14: AI as a Teaching Partner (Classroom Codesign):

- Considerable variability within/across classes: advanced learners push AI beyond assignment scope; struggling students engaged once told they could start with just one part.
- Multilingual learners who hesitated in whole-class talk found voice through AI conversation.

Key Terms doc: Executive Function & Motivation:

- Executive Function = brain's "air traffic control": focus attention, ignore distractions, working memory, planning, switching strategies, impulse control, self-monitoring.
- Self-Determination Theory (SDT): autonomy, competence, relatedness as the three psychological needs driving motivation.

Topic 6: Metacognition, Self-Regulation & Curiosity

Top 5 takeaways:

- Curiosity is a learnable, malleable cognitive skill (not a fixed trait) that improves through a repeatable 4-step process: Identify uncertainty → Guess → Seek information → Assess (Paper 13).
- Children guided through this 4-step process via conversational agents (rather than given direct answers) showed real gains in metacognitive awareness and their ability to generate their own learning questions (Paper 13).
- Students using AI tend to skip the self-reflection phase of the Zimmerman Self-Regulated Learning Model, which is arguably the most important phase, it's what lets students adapt their prompting/strategy based on past AI interactions (Key Terms doc).
- **Skipping self-reflection means students don't refine their "prompt engineering" over time, capping how much they can actually benefit from AI-aided learning (Key Terms doc).**
- **Metacognition is fundamentally about children learning to ask themselves reflective questions ("Do I understand this? Why did I make that mistake? What should I try next?") This is described as a current gap needing to be solved, tied closely to motivation (Key Terms doc).**

Individual notes:

Paper 13: Interactive Environments for Training Children's Curiosity (pilot study):

- 4-step process: Identify ("What don't I know?"), Guess ("What might the answer be?"), Seek ("What question should I ask?"), Assess (did new info resolve uncertainty?).
- Children interacted with conversational agents guiding each step while reading informational texts, rather than receiving direct answers.
- Significant improvements in metacognitive awareness and ability to generate curiosity-driven questions.

Key Terms doc: Self-Regulated Learning & Metacognition:

- Zimmerman SRL Model: students neglect the self-reflection phase, limiting metacognitive optimization and adaptive prompt engineering.
- Metacognition = "thinking about thinking": do I understand this? why the mistake? what strategy next?
- Framed explicitly as a gap that needs solving,tied to student motivation.

Possibly Tangential / Cross-Cutting

- **Overreliance & academic integrity concerns**: raised in Papers 2, 3, and 4 (teacher worries about dependency/creativity suppression; student desire to verify sources; policies against citing AI).
- **Equity/access** (low-bandwidth tools, multilingual support, socioeconomic gaps in personalization): appears in Papers 3, 4, and 10. Minor in volume so far, but likely worth flagging as a limitation/future-work

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