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Synergizing Growth Mindset and Generative AI in K-12 Classrooms

A Framework for Fostering Resilient Learners in an Era of Uncertainty

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ABSTRACT

The rapid proliferation of generative artificial intelligence (GenAI) in educational settings presents both unprecedented opportunities and significant challenges for K-12 educators. This conceptual article examines the intersection of growth mindset pedagogy and GenAI integration in classroom learning environments. Drawing upon self-determination theory (SDT) and control-value theory (CVT), this paper proposes an integrated framework positioning teacher support as the critical mechanism through which students develop adaptive beliefs about intelligence while learning to collaborate with AI tools. The article synthesizes recent empirical evidence from 49 studies examining GenAI's impact on student learning, K-12 systematic reviews, and research on psychological needs satisfaction in technology-mediated contexts. Findings are organized into three thematic areas: (1) the dual nature of GenAI as both scaffold and potential crutch for learner development; (2) teacher strategies for cultivating growth-oriented AI literacy; and (3) classroom structures that support autonomy, competence, and relatedness in AI-integrated lessons. The proposed Growth Mindset-AI Synergy Framework offers practical guidance for educators seeking to harness AI's potential while preserving the essential human elements of teaching—empathy, mentorship, and belief in student potential. The article concludes that the deliberate cultivation of growth mindsets, supported by strategic teacher intervention, enables students to view AI not as a shortcut to accomplish a task, but as a cognitive partner in their ongoing intellectual development.

Keywords
AI Literacy
Classroom Engagement
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Growth Mindset
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Introduction

The emergence of generative artificial intelligence (GenAI) tools such as ChatGPT, DeepSeek, and Gemini has fundamentally altered the educational landscape, provoking both excitement about personalized learning possibilities and anxiety about academic integrity, critical thinking erosion, and the potential displacement of teacher roles. Within K-12 classrooms, where foundational cognitive habits and academic identities are formed, the integration of these tools raises particularly consequential questions about how students develop beliefs regarding their own capacity to learn and grow. Recent reviews have highlighted that AI technologies possess transformative potential for personalized instruction and adaptive learning, yet they simultaneously introduce ethical, pedagogical, and developmental challenges that require careful educational governance [1],[2].

At the heart of this educational transformation lies a psychological construct with decades of empirical support: the growth mindset. Stanford psychologists' foundational research established that students who believe intelligence and abilities can be developed through effort, strategy use, and feedback demonstrate greater resilience, higher academic achievement, and more sustained engagement with challenging tasks [3]. Yet the proliferation of AI tools that can instantly generate essays, solve mathematical problems, and provide seemingly authoritative answers threatens to undermine the very processes through which growth mindsets are cultivated. When students can bypass struggle and circumvent the effortful practice that builds neural connections, they risk adopting what [3] terms a "false growth mindset"—espousing belief in development while avoiding the productive struggle that genuine growth requires. Ryan and Deci [4] emphasized that authentic motivation develops when learners experience autonomy, competence, and meaningful engagement, all of which may be weakened if AI systems replace rather than support active learning processes.

Simultaneously, a growing body of research suggests that thoughtfully designed AI tools, when integrated with pedagogical intentionality, may support growth mindset development by providing personalized feedback, scaffolding challenging tasks, and normalizing mistakes as

learning opportunities. The critical variable appears to be not whether AI is used, but how teachers structure its use and frame its role within the broader learning ecosystem. As Chen and Shim's [5] recent research demonstrates, teacher support in GenAI-integrated classrooms operates through a serial mediation process: teacher support predicts growth mindset, which facilitates needs satisfaction, which ultimately relates to sustained engagement. Chiu [6] similarly found that AI-supported learning interactions can enhance student engagement and participation when instructional environments encourage reflection and active dialogue rather than passive consumption of AI-generated responses.

This article addresses a pressing gap in the literature: while substantial research examines either growth mindset interventions or AI integration in isolation, limited attention has been paid to their intersection, particularly within K-12 contexts where developmental trajectories are most malleable. Recent systematic reviews indicate that although GenAI tools can significantly improve students' academic performance and cognitive abilities, challenges, including over-reliance, misleading content generation, and educators' limited AI literacy, remain inadequately addressed [2], [7]. Furthermore, research specifically examining postgraduate international students reveals that AI both supports and complicates engagement, while potentially reinforcing isolation when institutional support mechanisms are absent. Long and Magerko [8] further argued that students require explicit AI literacy competencies, including the ability to critically evaluate AI outputs, understand algorithmic limitations, and make informed decisions regarding AI-assisted learning.

The central argument advanced here is that synergy between a growth mindset and the strategic utilization of AI within classroom settings offers remarkable potential for preparing a generation that is not only technologically proficient but also possesses the robust psychological foundation necessary to navigate a future characterized by profound uncertainty. This synergy does not occur automatically; it requires deliberate pedagogical design, informed teacher support, and classroom structures that preserve opportunities for productive struggle while leveraging AI's capabilities as a cognitive partner. Pea's theory of distributed intelligence [9] supports this argument by emphasizing that technological tools should augment human cognition and collaborative problem-solving rather than replace reflective thinking processes. Moreover, the World Economic Forum [10] identified adaptability, analytical thinking, creativity, and lifelong learning as critical competencies for future societies increasingly shaped by AI-driven transformation.

This conceptual article proceeds as follows: first, the theoretical framework integrating SDT and CVT is presented. Second, the methodology for synthesizing recent empirical evidence is described. Third, findings are organized into three thematic subsections, each accompanied by

a summary table synthesizing key evidence. Fourth, implications for practice and future research are discussed. Finally, a personal reflection on the educator's role in this transformed landscape is offered.

Material and Methods

A. Research Design

This study employs a conceptual synthesis methodology, integrating theoretical frameworks with recent empirical evidence to develop an actionable framework for educators. Conceptual synthesis is particularly appropriate when examining emerging phenomena where empirical research is rapidly evolving but has not yet coalesced into established paradigms. The approach enables the integration of findings from multiple disciplines to generate novel theoretical insights.

B. Literature Search Strategy

A systematic search of peer-reviewed literature published between 2021 and 2026 was conducted using the following databases: ERIC, PsycINFO, Scopus, Web of Science, and Google Scholar. Search terms included combinations of: "generative AI" or "GenAI" or "ChatGPT" or "AI chatbots" and "growth mindset" or "mindset" and "K-12 education" or "elementary education" or "secondary education" and "teacher support" or "classroom strategies." Additionally, backward citation searching of key articles and forward citation tracking were employed to identify relevant sources.

Table 1. Inclusion and Exclusion Criteria for Literature Selection

Criteria Type	Details
Inclusion Criteria	Peer-reviewed journal articles or conference proceedings
	Publication between 2021 and 2026
	Empirical studies (quantitative, qualitative, or mixed-methods) or theoretical papers with clear implications for K–12 practice
	Focus on GenAI in educational contexts or the growth mindset in technology-mediated learning
Exclusion Criteria	Non-English publications
	Opinion pieces without empirical or theoretical grounding
	Studies focused exclusively on higher education without K–12 relevance

C. Conceptual Framework: The Integrated SDT-CVT Model

The framework guiding this synthesis integrates self-determination theory (SDT) and control-value theory (CVT) to specify the mechanisms through which teacher support in AI-integrated classrooms relates to student engagement and mindset development. Following Chen and Shim's [5] recent specification, the framework delineates a directional motivational sequence. See Fig. 1 for the details.

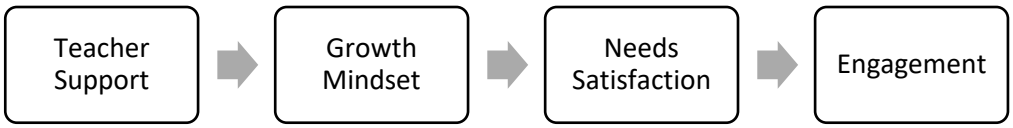


Fig. 1. Directional Motivational Sequence Framework

Within this model, perceived teacher support functions as the initiating contextual input, encompassing three dimensions aligned with SDT: competence support (clear explanations, structured guidance, process-oriented feedback), autonomy support (encouraging student choice and agency), and emotional support (expressions of care and psychological safety). Growth mindset is positioned as an intermediate cognitive mechanism that shapes how instructional support and AI-generated feedback are interpreted. Basic psychological needs satisfaction (autonomy, competence, relatedness) represents the proximal motivational state preceding engagement. GenAI is conceptualized as a contextual condition of instruction within which these motivational processes operate, rather than as an analytic predictor. This framing acknowledges that AI tools do not deterministically shape outcomes; rather, their effects are mediated by students' beliefs about learning and the quality of teacher support structuring their use.

D. Analytical Approach

Identified studies were analyzed using thematic synthesis, involving:

- line-by-line coding of findings related to growth mindset, AI integration, and teacher support;
- Organization of codes into descriptive themes;
- Development of analytical themes that extend beyond the content of original studies to generate new interpretive constructs.

Themes were refined through iterative discussion and checked against the theoretical framework to ensure coherence.

E. Quality Considerations

To enhance trustworthiness, multiple strategies were employed: triangulation across diverse study contexts (K-12, higher education, international settings); attention to disconfirming evidence; and maintenance of an audit trail documenting analytical decisions. The inclusion of recent systematic reviews provides a meta-level synthesis of primary research, strengthening the evidentiary base. In addition, findings were continuously compared across studies to identify recurring themes, contextual variations, and emerging patterns related to educational transformation.

Results and Discussion

Findings are organized into three thematic subsections, each addressing a distinct dimension of the growth mindset-AI integration nexus. Within each subsection, a table synthesizes key evidence from recent studies, followed by an interpretive discussion linking findings to the theoretical framework.

A. The Dual Nature of GenAI: Scaffolding or Crutch for Learner Development?

The first thematic area concerns the paradoxical nature of GenAI tools in educational contexts, simultaneously capable of supporting and undermining authentic learning. Recent evidence reveals that GenAI's impact on student development is not inherent to the technology but emerges from the conditions of its use and the beliefs learners bring to their interactions with it.

Table 2. Synthesis of Evidence on GenAI's Dual Effects on Learner Development

Context	Key Findings Related to Growth Mindset	Ref. No.
Systematic review of 49 higher education studies	GenAI enhances learning through personalized support and immediate feedback; however, concerns persist regarding over-reliance, reduced critical thinking, and academic integrity. Guided pedagogical integration is essential.	[7]
Systematic review of 45 K-12 studies (2020-2024)	GenAI tools significantly improve academic performance and cognitive abilities while enhancing motivation and personalized learning. Challenges include misleading content generation, technology comprehension difficulties, student dependence, and privacy concerns.	[11]
Qualitative interviews with 27 postgraduate international students in UK	GenAI enhances autonomy, competence, and emotional resilience while bridging linguistic and cultural barriers. However, over-reliance and ethical uncertainties underscore the need for institutional support. "Double-edged tool" metaphor captures paradoxical effects.	[12]
Conceptual framework development	AFCL framework transforms AI from an assessment threat to a catalyst for critical thinking and metacognition by shifting focus from products to documented critique processes. Critique literacy emerges as an essential competency.	[13]
Practitioner analysis of AI tutors and growth mindset	Thoughtfully designed AI tools can foster growth mindsets by emphasizing progress, effort, and learning strategies. Implementation requires customization and adherence to personalization principles. Normalizing "mistakes as data" represents a key design feature	[14]

The evidence synthesized in Table 2 reveals a consistent pattern across educational levels and international contexts: GenAI's effects on learner development are fundamentally ambivalent. The systematic review by Badger et al. [7], synthesizing 49 empirical studies, demonstrates that while GenAI chatbots can enhance learning through personalized support and immediate feedback, concerns regarding over-reliance and diminished critical thinking are empirically grounded rather than merely speculative. This finding aligns with Adekoya et al. [12]

qualitative research, in which participants explicitly characterized GenAI as a "double-edged tool"—simultaneously enabling self-directed learning while creating dependency risks that threaten autonomous functioning. Kasneci et al. [1] similarly noted that while large language models can improve accessibility and individualized instruction, they also pose risks related to reduced cognitive effort, misinformation, and weakened learner autonomy when used without pedagogical safeguards.

From the perspective of the integrated SDT-CVT framework, these findings suggest that GenAI's impact on growth mindset operates through its influence on learners' appraisals of control and competence. When students use AI to overcome genuine challenges while maintaining cognitive ownership of the learning process, the tool scaffolds competence development and reinforces beliefs in the malleability of ability. However, when AI use bypasses struggle entirely, the tool undermines the very experiences of effortful mastery that build growth-oriented beliefs. Ryan and Deci [4] emphasized that experiences of autonomy and competence are essential for sustaining intrinsic motivation, while Pekrun's control-value theory [15] further explains that students' perceptions of control strongly shape emotional engagement and persistence in learning activities.

The K-12-specific systematic review by Zhang et al. [11] adds important developmental considerations. Their analysis of 45 studies reveals that younger learners may be particularly susceptible to both the benefits and risks of GenAI. The capacity for personalized learning and enhanced motivation represents significant potential for elementary and secondary education, where engagement and foundational skill development are paramount. Yet the documented challenges (difficulty understanding how AI works, susceptibility to misleading content, and rapid development of technological dependence) suggest that K-12 contexts require particularly thoughtful pedagogical scaffolding. Long and Magerko [8] reinforced this concern by arguing that AI literacy should include the ability to critically interpret AI outputs, recognize algorithmic bias, and understand the limitations of automated systems. Hwang and Chang [2] similarly concluded that successful AI integration in schools depends heavily on teacher guidance, ethical awareness, and developmentally appropriate instructional design.

The AI-First Critique Learning (AFCL) framework offers a promising pedagogical response to these dualities [13]. By shifting assessment focus from final products to documented critique processes, AFCL positions AI not as an answer-generator but as a stimulus for metacognitive reflection. Students must articulate not merely what AI produced, but why they accepted, rejected, or modified its suggestions, a process directly aligned with growth mindset principles emphasizing strategy use and learning from feedback. Pea's concept of distributed intelligence [9]

supports this perspective by suggesting that technological tools should function as cognitive partners that extend human reasoning rather than replace reflective thinking processes.

The practitioner-oriented analysis from Getting Smart web [14] reinforces these findings while offering concrete design principles for growth-oriented AI tools. The emphasis on normalizing "mistakes as data" represents a direct operationalization of growth mindset principles within AI interaction design. When AI tutors respond to errors with process-oriented feedback rather than simply providing correct answers, they model the belief that errors represent learning opportunities rather than indicators of fixed inability. Wang and Xue [16], through a meta-analysis of generative AI in education, similarly found that AI-supported learning environments produce stronger outcomes when feedback encourages active reflection, iterative improvement, and learner agency. Furthermore, Zhai et al. [17] warned that without structured opportunities for critique and reflection, long-term AI use may negatively influence students' critical thinking development, particularly among younger learners who are still forming foundational cognitive habits.

B. Teacher Strategies for Cultivating Growth-Oriented AI Literacy

The second thematic area addresses the specific pedagogical strategies through which teachers can cultivate growth mindsets while developing students' capacity to use AI tools critically and productively. Recent research has begun to specify the dimensions of teacher support that prove particularly consequential in AI-integrated classrooms.

Table 3. AI and Critical Thinking Development

Context	Key Findings Related to Growth Mindset	Ref. No.
Survey of 366 Chinese university EFL learners in GenAI-integrated classrooms	Teacher support predicts engagement through serial mediation: teacher support, growth mindset, needs satisfaction, and engagement. Competence support operates through both direct and sequential pathways; emotional and autonomy support show direct associations with engagement and indirect effects via needs satisfaction.	[5]
Survey of 364 university students learning English with the ERNIE Bot chatbot	Needs satisfaction partially mediates the relationship between teacher support and behavioral, cognitive, and agentic engagement; it fully mediates the relationship with emotional engagement. Chatbots may emotionally engage students more effectively than teachers, suggesting that teachers should leverage AI's affective affordances.	[18]
Elementary school lesson plan development using GenAI in the Korean context	The eight-principal prompt design framework enhances teacher productivity and lesson coherence. GAI-supported design embeds achievement standards, restructures lessons into evidence-centered cycles, and strengthens process assessment with rubrics and e-portfolios. Fosters learner agency through guided questioning and transparent verification routines.	[19]
Practitioner guidance on educator-AI partnership	AI excels as a teaching assistant handling routine tasks, enabling educators to focus on mentoring and meaningful conversations. Teachers provide irreplaceable human elements: empathy, inspiration, judgment,	[20]

Context	Key Findings Related to Growth Mindset	Ref. No.
	and belief in student potential. Strategic partnership enhances both efficiency and human connection.	
The Thailand Smart Classroom initiative with 10 pilot schools	Infrastructure investment, paired with teacher capacity-building essential. Teachers attended demonstrations of AI tool integration and reflected on classroom applications. Initiative deliberately balances technology with teacher creativity, professional judgment, and leadership.	[21]

The evidence synthesized in Table 3 converges on a central insight: teacher support remains essential in AI-integrated classrooms, but its forms and functions may require recalibration. The serial mediation model provides the most comprehensive specification of mechanisms to date [5]. Their finding that competence support relates to engagement through multiple pathways underscores the importance of teachers' roles in helping students interpret and utilize AI-generated feedback. When teachers provide clear explanations, structured guidance, and process-oriented feedback that helps students evaluate AI suggestions critically, they strengthen both growth-oriented beliefs and the experience of competence that drives sustained engagement. This aligns with Ryan and Deci's self-determination theory [4], which emphasizes that competence support is foundational for maintaining intrinsic motivation and active participation in learning environments.

The differential pathways identified for autonomy and emotional support are equally instructive. Autonomy support shows direct associations with engagement, suggesting that preserving student agency represents a non-negotiable teacher function even as AI capabilities expand. Emotional support, including expressions of care and creation of psychologically safe classroom climates, may become more rather than less important as AI tools enter the learning environment. Students experiencing uncertainty about AI accuracy or appropriateness need teachers who normalize these concerns and provide reassurance. Pekrun's control-value theory [15] further explains that students' emotional experiences strongly influence engagement and achievement, particularly when learners face unfamiliar or cognitively demanding technologies such as generative AI.

Chatbots may emotionally engage students more effectively than teachers, offering a nuanced perspective on human-AI complementarity [18]. Rather than viewing AI as competing with teachers for students' emotional connection, this finding suggests a strategic division of labor: AI handles the low-stakes, practice-oriented interactions where performance pressure is minimized, while teachers focus on the higher-stakes mentoring relationships where genuine human connection proves irreplaceable. Chiu [6] similarly found that AI-supported conversational systems can increase learner participation and interaction, particularly when

students perceive the environment as supportive and non-threatening. However, Long and Magerko [8] cautioned that effective AI integration requires students to develop AI literacy competencies so that emotional engagement with chatbots does not lead to uncritical trust in AI-generated information.

The elementary school context examined by Choi and Kim [19] demonstrates that these principles apply from the earliest educational levels. Their eight-principal prompt design framework, developed through iterative refinement with teacher advisory panels, shows how GenAI can support lesson planning that embeds growth mindset principles. The emphasis on evidence-centered learning cycles, guided questioning, and transparent verification routines directly supports the development of learner agency. This approach aligns with UNESCO [21] emphasis on pairing technological infrastructure with teacher capacity-building, recognizing that tools without pedagogical intentionality cannot produce desired outcomes. Hwang and Chang [2] similarly argued that AI integration in education must prioritize pedagogical alignment and teacher preparedness to ensure that technological innovation enhances rather than diminishes meaningful learning processes.

The practitioner guidance in Xello [10] articulates a vision of an educator-AI partnership that preserves what is most essential about teaching while strategically leveraging AI's capabilities. The framing of AI as "teaching assistant" rather than teacher replacement directly addresses the job displacement fears that can undermine educators' willingness to engage with new technologies. When teachers understand AI as handling routine tasks (freeing time and energy for the mentoring, motivating, and meaningful conversations that drive genuine student growth), they are more likely to approach integration with openness rather than resistance. This perspective is reinforced by Kasneci et al. [1], who emphasized that large language models should augment rather than replace human educators, particularly in areas involving ethical judgment, emotional support, and adaptive pedagogy. Furthermore, the World Economic Forum [10] highlighted that future educational systems will increasingly require human-centered skills such as collaboration, creativity, empathy, and critical thinking, thereby reinforcing the continued centrality of teachers within AI-enhanced learning environments.

C. Classroom Structures Supporting Psychological Needs in AI-Integrated Learning

The third thematic area addresses the classroom-level structures and practices that support students' basic psychological needs (autonomy, competence, and relatedness) within AI-integrated learning environments. These structures operationalize the teacher strategies identified above within daily classroom routines. Synthesis of Evidence on Classroom Structures Supporting Psychological Needs

Table 4. Synthesis of Evidence on Classroom Structures Supporting Psychological Needs

Context	Key Findings Related to Growth Mindset	Ref. No.
Postgraduate international students in the UK	The Proposed Psychological Needs Framework demonstrates how AI intersects with SDT to shape engagement. AI facilitates: • Navigating autonomy and adaptation; • Augmented competence and "AI-halo effect"; • Fostering relatedness and emotional resilience	[12]
Chinese university EFL learners	Competence support is linked to engagement through needs satisfaction and growth mindset pathways. Emotional and autonomy support are essential for psychological safety and agency. Classroom structures must address all three needs simultaneously.	[5]
University students with ERNIE Bot	Needs satisfaction fully mediates the teacher support-emotional engagement relationship. Suggests classrooms should leverage AI's affective affordances while maintaining teacher roles for deeper engagement dimensions	[18]
AFCL framework development	Classroom-Locked Prompts ensure contextual specificity; Thinking Lenses scaffold analytical rigor; Standardized AI Interaction Environments generate verifiable reasoning traces. Structures shift focus from products to documented critique processes.	[13]
K-12 systematic review	Identifies need for targeted AI literacy training for educators. Most existing research focuses on short-term impacts; longitudinal studies are needed to evaluate long-term implications. Current evidence supports structured, guided integration.	[11]

The evidence in Table 4 reveals that supporting psychological needs in AI-integrated classrooms requires deliberate structural design, not merely teacher encouragement. Adekoya et al. [12], developed through qualitative research with postgraduate international students, identified three mechanisms through which AI interacts with SDT: navigating autonomy and adaptation, augmented competence, and fostering relatedness and emotional resilience. Each mechanism suggests corresponding classroom structures. Ryan and Deci [4] further emphasized that autonomy, competence, and relatedness constitute foundational psychological needs that must be systematically supported to sustain intrinsic motivation and learner well-being in technology-mediated environments.

For autonomy support, classroom structures must provide students with meaningful choices about when and how to use AI tools while preserving opportunities for AI-independent work [22]. The concept of "AI-free zones" emerges implicitly from this research, teaching students not merely to use AI but to critique its suggestions, verify its information, and recognize its limitations. Kasneci et al. [1] argued that large language models should be integrated into education with careful pedagogical safeguards to avoid overreliance and cognitive passivity. Similarly, Long and Magerko [8] highlighted that AI literacy involves critical competencies such as evaluating AI outputs, understanding algorithmic limitations, and making informed judgments about AI-generated information.

The AFCL framework provides the most detailed specification of classroom structures for psychological support [12]. Classroom-Locked Prompts ensure that AI interactions are contextually grounded in specific learning objectives, preventing generic use that bypasses genuine engagement with content. Thinking Lenses support competence development by making visible the cognitive processes expert learners employ when evaluating information. Standardized AI Interaction Environments generate verifiable reasoning traces, enabling teachers to assess process rather than merely product, and providing students with documentation of their own thinking development. Hwang and Chang [8] similarly emphasized that effective AI integration in education requires structured pedagogical frameworks that balance technological efficiency with active cognitive engagement. Pea [9] further explained that learning in technology-rich environments should be understood as distributed cognition, where tools support but do not replace human reasoning processes.

The importance of these structures is underscored by Zhang et al. [11] finding that most existing K-12 research examines short-term impacts, with limited understanding of long-term implications. This gap suggests that classroom structures must be designed not merely for immediate engagement but for sustained development of cognitive habits and learning dispositions. When students consistently practice critique literacy across multiple interactions with AI, they internalize habits of mind that persist beyond any single lesson or academic year. Supporting this concern, Zhai et al. [17] found that prolonged interaction with generative AI can influence students' critical thinking trajectories, making guided reflection and structured evaluation activities increasingly important in K-12 contexts.

Chen and Shim [5] found that all three dimensions of teacher support (competence, emotional, and autonomy) are positively associated with needs satisfaction, which reinforces the importance of comprehensive classroom design. Structures addressing only one need dimension are unlikely to produce optimal outcomes. For example, a classroom with robust competence support (clear explanations, structured guidance) but weak autonomy support (limited student choice, rigid procedures) may produce superficially engaged students who lack ownership of their learning. Similarly, classrooms emphasizing emotional support without corresponding competence support may leave students feeling cared for but unprepared to evaluate AI outputs critically. Pekrun's control-value theory [15] further suggests that students' emotional experiences in learning environments are strongly influenced by perceptions of control and task value, reinforcing the need for classroom designs that simultaneously support competence and autonomy.

The K-12 context introduces additional considerations regarding developmental appropriateness. Elementary students require more structured guidance in AI use than

secondary students, with correspondingly greater emphasis on teacher modeling of critique processes. Secondary students, with more developed metacognitive capacities, can engage in more independent AI interaction but still require scaffolding to ensure that independence does not become uncritical dependence. Chiu [6] demonstrated that AI-supported learning environments can increase engagement when accompanied by active teacher facilitation and reflective activities. Wang and Xue [19], through a meta-analysis of generative AI in education, also reported that positive learning outcomes are most consistent when AI tools are embedded within structured instructional designs rather than used as stand-alone technologies. These developmental considerations underscore the need for differentiated classroom structures aligned with students' evolving capacities and future workforce demands shaped by AI-driven transformation [10].

Conclusion

This conceptual article has examined the intersection of growth mindset and generative AI integration in K-12 classrooms, synthesizing recent empirical evidence within an integrated SDT-CVT framework. The analysis yields three primary conclusions with implications for research and practice. First, GenAI's impact on learner development is fundamentally shaped by the beliefs students hold about intelligence and learning, and by the quality of teacher support in structuring their AI interactions. The evidence consistently demonstrates that AI functions as a "double-edged tool" capable of either scaffolding authentic growth or enabling avoidance of productive struggle. The critical variable distinguishing these outcomes is not the technology itself but the pedagogical context within which it is embedded. Students with growth-oriented beliefs, supported by teachers who emphasize process over product and effort over easy answers, are positioned to use AI as a cognitive partner in their development. Students with fixed mindsets, or those in classrooms where AI use is unstructured and uncritical, face heightened risks of dependence and disengagement. Second, teacher support in AI-integrated classrooms operates through a serial mediation process: teacher support predicts growth mindset, which facilitates needs satisfaction, which ultimately relates to sustained engagement. This specification has important practical implications. It suggests that interventions targeting any single element of this sequence in isolation are unlikely to achieve optimal outcomes. Efforts to cultivate growth mindsets without corresponding attention to the classroom structures supporting autonomy, competence, and relatedness may produce superficial adoption of mindset language without genuine belief change. Similarly, investments in AI tools without corresponding teacher professional development in need-supportive practices risk wasting technological potential. Third, the synergy between growth mindset cultivation and strategic AI integration offers

remarkable potential for preparing students who are both technologically proficient and psychologically resilient. This synergy does not occur automatically but requires deliberate design of classroom structures, intentional teacher strategies, and sustained attention to students' evolving psychological needs. AFCL's critique-focused assessment, the eight-principal prompt design approach, the Psychological Needs Framework, and the serial mediation model specifying teacher support mechanisms. The frameworks and strategies synthesized here offer concrete guidance for educators seeking to realize this potential.

Conflict of Interest

The authors declare that there is no conflict of interest.

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