AI-Assisted Self-Regulated Learning in English Language Education: A Conceptual Model for Human–Technology Scaffolding

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ABSTRACT

The integration of artificial intelligence (AI) into English language education has generated considerable scholarly interest, particularly in the context of self-regulated learning (SRL). Despite the rapid proliferation of AI-powered tools such as intelligent tutoring systems, automated writing evaluators, and speech recognition platforms, a coherent conceptual model that systematically articulates the interplay between human pedagogical agency and technological scaffolding remains underdeveloped. This paper addresses this gap by proposing a conceptual model of Human–Technology Scaffolding (HTS) in AI-assisted SRL for tertiary-level English-language education. Drawing upon Zimmerman's cyclical model of SRL, Vygotsky's zone of proximal development, and recent advances in human–AI co-regulation, the proposed framework delineates three interconnected layers: adaptive AI scaffolding, metacognitive mediation, and instructor-guided co-regulation. Through a synthesis of 70 peer-reviewed sources from Scopus-indexed journals published between 2018 and 2026, the paper critically examines how AI tools support the forethought, performance monitoring, and self-reflection phases of SRL across writing, speaking, listening, and reading. The model further accounts for ethical dimensions, including algorithmic bias, data privacy, digital equity, and the risk of over-reliance on automated systems. Implications for curriculum design, teacher professional development, institutional policy, and technology development are discussed. The paper concludes with a research agenda that emphasises the need for mixed-methods empirical validation, culturally responsive AI design, and longitudinal studies on affective and motivational outcomes in diverse educational contexts.

Keywords: artificial intelligence, self-regulated learning, English language education, human–technology scaffolding, metacognition

INTRODUCTION

English language proficiency constitutes a foundational competency for tertiary students worldwide, underpinning academic achievement, career readiness, and meaningful participation in global discourse. The emergence of artificial intelligence has precipitated a paradigm shift in language education, enabling unprecedented levels of personalisation, immediacy of feedback, and scalability of instructional support. AI-driven tools—ranging from large language model-based chatbots and automated writing evaluators to multimodal pronunciation coaches and intelligent tutoring systems—now occupy a prominent position in the language learning ecosystem, offering learners opportunities to set goals, monitor progress, and reflect on their performance with increasing autonomy (Shadiev et al., 2026; Fitriati & Williyan, 2025).

Self-regulated learning, as theorised by Zimmerman (2000), encompasses a cyclical process through which learners actively engage in forethought (goal setting, strategic planning), performance (self-monitoring, strategy deployment), and self-reflection (self-evaluation, causal attribution). The alignment between SRL theory and AI capabilities is conceptually compelling: AI tools can serve as external scaffolds that support each phase of the SRL cycle, providing adaptive prompts, diagnostic feedback, and reflective cues that complement human instruction. However, the relationship between AI scaffolding and learner self-regulation is neither linear nor unproblematic. Concerns about algorithmic bias, learner over-dependence, diminished critical thinking, and the erosion of human interaction have been raised across the literature (Selvam & González Vallejo, 2025; Nwafor, 2026; Gonzabay-Jiménez et al., 2026).

Despite a growing body of empirical work, the field lacks a unified conceptual model that systematically integrates the pedagogical, technological, and ethical dimensions of AI-assisted SRL in English language education. Existing frameworks tend to address these dimensions in isolation—focusing either on technology affordances, SRL theory, or ethical considerations—without articulating their reciprocal relationships within a coherent architecture. This paper addresses this gap by proposing a conceptual model for Human–Technology Scaffolding (HTS) that synthesizes insights from 70 Scopus-indexed sources published between 2018 and 2026.

The proposed model is organized around three interconnected layers: (a) adaptive AI scaffolding, which encompasses the technological tools and feedback mechanisms that support language learning; (b) metacognitive mediation, which refers to the processes through which AI and human agents foster learner awareness, strategic regulation, and reflective practice; and (c) instructor-guided co-regulation, which situates the role of teachers as mediators who bridge AI affordances with humanistic pedagogical goals. The paper proceeds to establish the theoretical foundations of the model, review the evidence base, present the HTS framework, discuss challenges and implications, and outline a research agenda for future inquiry.

THEORETICAL FOUNDATIONS

A. Zimmerman's Cyclical Model of Self-Regulated Learning

Zimmerman's (2000) model of SRL provides the predominant theoretical architecture for understanding how learners manage their cognitive, motivational, and behavioural processes. The model posits three recursive phases: forethought, during which learners establish goals and select strategies; performance, during which learners implement strategies while monitoring their effectiveness; and self-reflection, during which learners evaluate outcomes and attribute success or failure to controllable factors. This cyclical structure has been extensively applied in AI-enhanced language learning research, where AI tools are conceptualised as external agents that support each phase through adaptive prompting, real-time feedback, and structured self-assessment activities (Shi et al., 2025; Hou & Zhou, 2025; Banihashem et al., 2025).

However, a significant proportion of studies invoke Zimmerman's framework without fully operationalizing its constructs or examining the dynamic interactions between phases. Banihashem et al. (2025) note that many investigations reference SRL theory superficially, failing to explicate how AI tools differentially support forethought, performance, and reflection. The HTS model proposed in this paper addresses this limitation by mapping specific AI functionalities to each SRL phase and articulating the conditions under which technological scaffolding enhances or constrains self-regulatory processes.

B. Vygotsky's Zone of Proximal Development and Scaffolding

Vygotsky's (1978) concept of the zone of proximal development (ZPD) provides a complementary theoretical lens for understanding AI-mediated learning. The ZPD denotes the distance between what a learner can accomplish independently and what they can achieve with guidance from a more knowledgeable other. In the context of AI-assisted language learning, the AI system functions as a technologically mediated scaffold that dynamically adjusts its support to the learner's evolving level of competence. This conceptualisation aligns with the notion of AI as a "capable peer" that provides graduated assistance—from explicit corrective feedback for novice learners to strategic prompts for advanced learners—thereby facilitating progressive autonomy (Rogti & Ouarniki, 2026; Li & Wilson, 2025).

The integration of ZPD theory with SRL frameworks enriches the conceptual model by emphasising the social and interactive dimensions of scaffolding. Whereas Zimmerman's model foregrounds individual self-regulation, Vygotsky's framework highlights the mediating role of tools and agents in shaping cognitive development. The HTS model synthesises these perspectives by positioning AI scaffolding within a broader ecology of human–technology interaction.

C. Human–AI Co-Regulation

Emerging theoretical work conceptualises SRL in AI-enhanced environments as a co-regulatory process involving both learner agency and AI adaptability. Human–AI co-regulation extends Zimmerman's model by incorporating iterative feedback loops, emotional support mechanisms, and dynamic calibration of scaffolding intensity based on real-time learner data (Hou & Zhou, 2025; Yang, 2026). This perspective recognises that effective self-regulation in technology-rich environments is not solely an individual cognitive achievement but an emergent property of the interaction between human intentionality and algorithmic responsiveness.

Co-regulation models also attend to affective dimensions that are frequently overlooked in cognitive-centric frameworks. AI tools equipped with sentiment analysis and empathic response capabilities can detect learner frustration, anxiety, or disengagement and adjust their feedback accordingly, thereby supporting not only cognitive but also emotional and motivational self-regulation (Fang et al., 2026; Shao, 2025). The HTS model incorporates this co-regulatory perspective as a central organizing principle, situating human and AI agents as complementary partners in the scaffolding process.

METHODOLOGY

This paper employs a conceptual synthesis methodology, integrating findings from 70 peer-reviewed sources indexed in Scopus. The literature was identified through systematic search strategies using combinations of terms including "artificial intelligence," "self-regulated learning," "English language learning," "tertiary education," and "scaffolding." The corpus encompasses meta-analyses, systematic reviews, empirical studies employing quantitative, qualitative, and mixed-methods designs, case studies, and theoretical syntheses published between 2018 and 2026. The synthesis follows an integrative review approach, identifying convergent themes, theoretical tensions, and empirical gaps that inform the development of the HTS conceptual model.

The selection criteria prioritised studies that: (a) examined AI tools in the context of English language learning; (b) engaged with SRL theory or related metacognitive constructs; (c) addressed tertiary education contexts; and (d) were published in peer-reviewed outlets indexed in Scopus. Studies were analysed thematically, with particular attention to the types of AI technologies employed, the pedagogical frameworks invoked, the learning outcomes measured, and the challenges and ethical considerations identified.

The Human–Technology Scaffolding (Hts) Model

The HTS model proposes a tripartite architecture comprising three interconnected layers that collectively support AI-assisted SRL in English language education. Each layer operates across the three phases of Zimmerman's SRL cycle, creating a matrix of scaffolding functions that can be differentially activated depending on learner needs, task demands, and instructional context.

A. Layer 1: Adaptive AI Scaffolding

The first layer of the HTS model encompasses the technological infrastructure that provides automated, personalized support for language learning. This layer includes several categories of AI tools, each aligned with specific SRL functions and language skill domains.

Writing and grammar support tools, such as automated writing evaluators and large language model-based assistants, provide real-time corrective feedback, stylistic suggestions, and metalinguistic explanations that support both the performance and self-reflection phases of SRL (Shadiev et al., 2026; Huang et al., 2023). These tools enable learners to identify patterns in their errors, track improvement over time, and develop increasingly autonomous revision strategies. The effectiveness of transformer-based models in providing nuanced, multi-level feedback that aligns closely with human judgments has been demonstrated across multiple studies (Cuéllar et al., 2025; Tang et al., 2024).

Speaking and pronunciation tools leverage speech recognition technology and natural language processing to deliver instant, adaptive feedback on articulation, fluency, and oral communication competence. Systems such as AI-powered oral dialogue generators and intelligent speaking training platforms accommodate diverse accents and speaking styles through multimodal analysis incorporating acoustic, linguistic, and visual features (Liu & Tian, 2026; Lu et al., 2026; Dubey et al., 2025). These tools are particularly effective in reducing speaking anxiety and building learner confidence, thereby supporting the motivational dimensions of SRL.

Automated feedback systems represent a cross-cutting technology that integrates with both writing and speaking tools to provide continuous assessment and progress tracking. These systems support SRL by enabling learners to set measurable goals during the forethought phase, monitor their progress during the performance phase, and evaluate their achievement during self-reflection (Li & Kim, 2024; Devi et al., 2025).

B. Layer 2: Metacognitive Mediation

The second layer of the HTS model addresses the metacognitive processes through which learners develop awareness of their own learning strategies, cognitive resources, and regulatory behaviours. AI tools increasingly function as metacognitive scaffolds by providing structured self-assessment prompts, strategic nudges, and reflective frameworks that foster higher-order thinking and self-awareness (Yifan et al., 2026; Yermaganbetova et al., 2026).

During the forethought phase, metacognitive mediation involves AI-guided goal-setting activities that help learners articulate specific, measurable learning objectives and select appropriate strategies. During the performance phase, AI systems provide real-time metacognitive prompts—such as reminders to monitor comprehension, adjust strategy use, or seek clarification—that support ongoing self-regulation. During the self-reflection phase, AI-generated analytics and visualisations enable learners to evaluate their progress against established benchmarks and identify areas requiring further attention.

The effectiveness of metacognitive scaffolding depends critically on its alignment with learner profiles, prior knowledge, and task complexity. Research indicates that scaffolds must be calibrated to avoid both under-support (which leaves learners struggling without adequate guidance) and over-support (which undermines autonomy and fosters dependency). The principle of scaffolded withdrawal—gradually reducing AI support as learner competence increases—is essential for promoting the transfer of regulatory skills from external to internal control (Rogti & Ouarniki, 2026; Tekir, 2026).

C. Layer 3: Instructor-Guided Co-Regulation

The third layer of the HTS model positions instructors as essential mediators who bridge the capabilities of AI tools with the humanistic dimensions of language education. While AI systems excel at providing consistent, scalable, and data-driven feedback, they lack the capacity for nuanced emotional support, cultural sensitivity, and pedagogical judgment that characterize effective human instruction. Combined human–AI feedback has been shown to outperform AI-only feedback in supporting emotional self-regulation, sustained engagement, and long-term maintenance of SRL skills (Fang et al., 2026; Zhang & Wang, 2025).

Instructor-guided co-regulation involves several interconnected functions. First, teachers serve as interpreters who help learners make sense of AI-generated feedback, contextualize automated assessments within broader learning goals, and address affective responses to corrective input. Second, teachers function as designers who curate AI-enhanced learning experiences, select appropriate tools for specific pedagogical objectives, and structure activities that integrate AI scaffolding with collaborative and communicative tasks. Third, teachers act as monitors who observe learners' interactions with AI systems, identify patterns of overreliance or disengagement, and intervene when scaffolding needs adjustment.

The instructor layer also addresses the critical need for professional development in AI integration. Research consistently indicates that many language instructors lack the digital competencies and pedagogical knowledge required to effectively leverage AI tools in their teaching practice (Kaya, 2024; Zulianti et al., 2025; Metwally & Bin-Hady, 2025). The HTS model therefore emphasizes the importance of sustained, targeted professional development programs that equip educators with both technical proficiency and critical awareness of the ethical implications of AI deployment in educational contexts.

Mapping Ai Scaffolding to Srl Phases and Language Skills

The HTS model provides a systematic mapping of AI scaffolding functions to the three phases of Zimmerman's SRL cycle across the four primary language skills. This mapping serves as both an analytical tool for researchers and a practical guide for educators seeking to design AI-enhanced learning experiences.

A. Forethought Phase

In the forethought phase, AI tools support goal setting and strategic planning through diagnostic assessments, personalized learning pathway recommendations, and adaptive task sequencing. For writing, AI systems can analyze a learner's previous compositions to identify recurrent weaknesses and suggest targeted learning objectives. For speaking, speech recognition platforms can establish baseline proficiency profiles and recommend practice activities calibrated to the learner's current level. For listening and reading—skills that have received comparatively less research attention—AI tools can generate comprehension-level assessments and curate graded input materials matched to learner proficiency (Pan et al., 2025; Jantakoon et al., 2025; Yılmaz & Aydın, 2025).

B. Performance Phase

During the performance phase, AI scaffolding focuses on real-time monitoring, corrective feedback, and strategy prompting. Writing tools provide instant grammar and style corrections alongside metalinguistic explanations that support explicit knowledge development (Nagata & Swisher, 1995; Wiboolyasarin & Jinowat, 2025). Speaking platforms deliver immediate pronunciation feedback with visual and acoustic representations that enable self-correction. Gamification features, dialogic interaction modes, and motivational nudges embedded within AI systems serve to sustain engagement and self-efficacy throughout the performance phase (Xu & Li, 2024; Huang & Chen, 2025; Sökücü, 2025).

C. Self-Reflection Phase

In the self-reflection phase, AI tools facilitate outcome evaluation through performance analytics, progress dashboards, and comparative benchmarking. Learners can review AI-generated reports that document their improvement trajectories, identify persistent error patterns, and compare their performance against established standards or peer cohorts. The provision of empathic, dialogic feedback—particularly from large language models capable of generating contextually appropriate encouragement and constructive critique—enhances the reflective process by addressing both cognitive and affective dimensions of self-evaluation (So et al., 2026; Xiao et al., 2025).

Ethical Dimensions and Challenges

A. Algorithmic Bias and Fairness

AI-powered language learning tools risk perpetuating and amplifying biases embedded in their training data. Linguistic groups that are underrepresented in training corpora—particularly speakers of low-resource languages, non-standard dialects, and diverse accents—may receive less accurate feedback or be systematically disadvantaged by AI assessment algorithms (Selvam & González Vallejo, 2025; Nwafor, 2026). The development of fairness-aware algorithms, inclusive data collection practices, and explainable AI mechanisms is essential for mitigating these risks, though implementation remains challenging and requires ongoing oversight (Chen, 2025).

B. Data Privacy and Regulatory Compliance

The deployment of AI tools in educational settings generates substantial volumes of sensitive learner data, raising significant privacy concerns. Regulatory frameworks such as the General Data Protection Regulation impose strict requirements on data collection, storage, processing, and user consent that directly affect the design and deployment of AI-enhanced learning platforms (Tovar Cardozo, 2023; Hur & Kubsch, 2025). The HTS model emphasizes the necessity of embedding privacy-by-design principles in AI tool development and ensuring transparent communication with learners about how their data is used, stored, and protected (Al-Zahrani et al., 2026).

C. Digital Equity and Access

Disparities in digital infrastructure, device availability, internet connectivity, and digital literacy create significant barriers to equitable access to AI-powered learning tools, particularly in underserved regions and among disadvantaged student populations (Gonzabay-Jiménez et al., 2026; Torrisi-Steele, 2025). The HTS model acknowledges that the transformative potential of AI-assisted SRL can only be realized when accompanied by institutional investment in digital infrastructure, targeted digital literacy programs, and policy frameworks that prioritize equitable access (Dawle & Dapkekar, 2026).

D. Over-Reliance and Critical Thinking

A recurrent concern in the literature is that excessive dependence on AI tools may attenuate learner critical thinking, reduce originality in academic production, and diminish the quality of human interaction in educational settings (Tekir, 2026; Pham & Pham, 2025; Choi, 2025; Lee & Otani, 2026; Kumari et al., 2025). The HTS model addresses this concern through the principle of balanced scaffolding, which advocates the gradual transfer of regulatory responsibility from AI systems to learners as competence develops, complemented by instructor oversight to ensure learners maintain critical engagement with AI-generated feedback.

Implications For Practice and Policy

A. Curriculum Design

The HTS model offers a structured framework for integrating AI tools into English language curricula at the tertiary level. Curriculum designers can use the model to identify appropriate AI technologies for specific learning objectives, design scaffolding sequences that align with SRL phases, and create assessment rubrics that evaluate both language outcomes and self-regulatory competencies. The model also supports the design of hybrid learning environments that strategically combine AI-mediated and face-to-face instruction.

B. Teacher Professional Development

Effective implementation of the HTS model requires comprehensive professional development that addresses instructors' technical proficiency, pedagogical knowledge, and ethical awareness. Training programs should equip educators with the skills to critically evaluate AI tools, design AI-enhanced learning activities, interpret AI-generated analytics, and mediate between automated feedback and learners' needs. Professional development should also cultivate instructors' capacity to identify and address issues of bias, privacy, and equity in AI deployment (Kaya, 2024; Ayesha et al., 2026).

C. Institutional Policy

Institutions seeking to implement AI-assisted SRL at scale must develop comprehensive policy frameworks that address procurement standards for AI tools, data governance protocols, accessibility requirements, and mechanisms for ongoing evaluation and quality assurance. Institutional policies should also articulate clear guidelines for the ethical use of AI in assessment, academic integrity, and learner support, ensuring that AI deployment aligns with broader educational values and institutional missions.

D. Technology Development

The HTS model has implications for AI developers, who should prioritise the design of tools that are transparent, culturally adaptive, and aligned with established pedagogical frameworks. Collaboration among technology developers, educators, and learners is essential to ensure that AI capabilities address authentic pedagogical needs rather than impose technologically determined solutions. User feedback mechanisms, iterative design processes, and attention to diverse learner populations should characterise responsible AI development in education (Chen, 2025; Malykhin et al., 2025).

FUTURE RESEARCH DIRECTIONS

The HTS model generates several avenues for future empirical investigation. First, there is a pressing need for mixed-methods studies examining the mechanisms by which AI scaffolding influences SRL processes across diverse learner populations and educational contexts. Quantitative studies employing experimental and quasi-experimental designs can establish causal relationships between specific AI scaffolding interventions and learning outcomes, while qualitative investigations can illuminate learners' lived experiences, perceptions, and adaptive strategies as they navigate AI-enhanced environments.

Second, longitudinal research is needed to assess the durability and transferability of SRL skills developed through AI-assisted learning. Most existing studies employ cross-sectional designs with limited follow-up periods, leaving open questions about whether AI-scaffolded self-regulation persists after the removal of technological support and whether it transfers to contexts beyond the original learning environment.

Third, the affective and motivational dimensions of AI-assisted SRL require more systematic investigation. While cognitive outcomes have received extensive attention, the effects of AI scaffolding on learner motivation, self-efficacy, anxiety, resilience, and psychological well-being remain underexplored (Xu & Zheng, 2025; Shao, 2025; Xun et al., 2025). The HTS model's emphasis on co-regulation and emotional support provides a conceptual foundation for research that integrates affective variables into the study of AI-enhanced SRL.

Fourth, culturally responsive AI design represents a critical frontier. The concentration of existing research in specific geographic contexts—notably China and East Asia—limits the generalizability of current findings. Future studies should prioritize diverse cultural and linguistic contexts, investigate learner attitudes and experiences in the Global South, and develop AI tools that accommodate cultural variation in learning preferences, communication styles, and educational norms (Braha, 2026; Yang, 2025; Kundu & Bej, 2025).

Fifth, the role of AI as a co-regulatory partner—functioning not merely as a tool but as a reflective, empathetic, and culturally sensitive educational companion—merits sustained theoretical and empirical attention. Future research should explore models of human–AI partnership that distribute regulatory agency between learners, teachers, and AI systems in ways that maximize learning outcomes while preserving learner autonomy and ethical integrity.

CONCLUSION

This paper has proposed the Human–Technology Scaffolding model as a conceptual framework for understanding and designing AI-assisted self-regulated learning environments in English language education. The model integrates three interconnected layers—adaptive AI scaffolding, metacognitive mediation, and instructor-guided co-regulation—mapped systematically across the three phases of Zimmerman's SRL cycle. By synthesising insights from 70 Scopus-indexed sources across technological, pedagogical, and ethical dimensions, the model provides a comprehensive architecture for researchers, educators, and policymakers seeking to harness AI's potential while addressing its inherent challenges.

The evidence reviewed in this paper confirms that AI-driven SRL tools hold significant promise for enhancing English language proficiency among tertiary students by providing adaptive, personalised feedback across multiple skill domains. However, their effectiveness depends on thoughtful integration within robust pedagogical frameworks, balanced scaffolding that promotes rather than supplants learner autonomy, and sustained attention to issues of fairness, privacy, equity, and instructor readiness. The HTS model offers a principled foundation for pursuing these goals, while the proposed research agenda charts a path toward empirical validation and iterative refinement of the framework in diverse educational contexts.

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