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DIGITAL SCAFFOLDING AND SELF-REGULATED LEARNING IN ENGLISH LANGUAGE TEACHING: A SYSTEMATIC REVIEW

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ABSTRACT

Digital scaffolding has emerged as a potential pedagogical support in technology-enhanced language learning. However, empirical evidence on how different forms of digital scaffolding contribute to self-regulated learning (SRL) remains fragmented across English Language Teaching (ELT) contexts. This systematic literature review synthesizes empirical studies examining types of digital scaffolding and their contributions to learners' SRL. Studies published between 2016 and 2026 were identified through searches of major academic databases following the PRISMA framework. After screening and eligibility assessment, 34 qualitative, quantitative, and mixed-methods studies were included. The findings reveal five categories of digital scaffolding: instructional, metacognitive, cognitive, affective, and AI-adaptive scaffolding. These categories provide complementary regulatory support by facilitating strategy development, planning, monitoring, reflection, motivational regulation, and learner autonomy. The review's main contribution is the conceptualization of the Digital Scaffolding Regulatory Continuum (DSRC), which explains how digital scaffolding may facilitate learners' progression from external regulation toward autonomous SRL through co-regulation, internalization, and fading. Practically, lecturers and instructional designers should integrate complementary scaffolding approaches and gradually adjust support according to learners' regulatory development rather than treating digital technologies merely as instructional tools. Future research should investigate the longitudinal development of SRL and examine how AI-powered adaptive scaffolding supports its cognitive, metacognitive, motivational, and affective dimensions across diverse language-learning contexts.

Keywords: AI-supported, Digital Scaffolding, Dynamic Regulatory Continuum, Language Learning Environment, Self-Regulated Learning

INTRODUCTION

In recent decades, English as a Foreign Language (EFL) education has undergone a profound transformation driven by rapid technological advancement and the increasing demand for learners to become autonomous, strategic, and lifelong language users. Within this evolving context, self-regulated learning (SRL) has emerged as a central objective of EFL instruction, requiring learners to take responsibility for their learning processes, regulate

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learning strategies, and engage critically with language resources beyond the classroom (Hamid & Abbas, 2025). However, SRL does not develop automatically through exposure to digital technologies; it requires carefully designed pedagogical support that enables learners to gradually progress from external dependence toward independent regulation (Chen, 2021).

Nevertheless, many students continue to experience difficulties such as planning, monitoring and evaluating their learning. They still rely heavily on their lecturers' guidance. They often struggle to keep their learning motivation, cannot select appropriate learning strategies, and cannot effectively use digital technologies to support learning. However, technological advancement alone does not automatically make learners more independent. These cases indicate that digital technology is insufficient to support students independent learning, but also requires pedagogical support that gradually transfers learning responsibility. One of the most promising strategies is digital scaffolding.

The concept of scaffolding originates from sociocultural theory, particularly Vygotsky's notion of the Zone of Proximal Development (ZPD) which emphasizes the role of mediated support in enabling learners to perform beyond their current independent capabilities. . (Chen, 2021;Salem, 2016). Scaffolding serves not as a permanent support but as a transitory mechanism that facilitates the internalization of knowledge and skills. Scaffolding indicates the social assistance offered to a student while completing a learning task, addressing a difficulty, or achieving a goal that was once unattainable (Al Mamun & Lawrie, 2024; Valencia-Vallejo et al., 2019). Scaffolding is a pedagogical process that directs students from dependence on external assistance towards independent capabilities. Based on sociocultural theory (Vygotsky, 1978 cited in Nguyen, 2022), learning occurs through interaction and structured support such as directions, stimulating questions, or the use of digital media. This assistance allows students to complete tasks beyond their initial capacity, which is then gradually transformed into more independent cognitive abilities.

Previous studies conceptualize SRL as a multidimensional construct comprising cognitive, metacognitive, motivational, and behavioral regulation that is necessary for the development of students' employability and capacity for lifelong learning (Graaf et al., 2023;Pintrich, 2004 cited in Kim ,2021; Rasheed et al., 2021; Valencia-Vallejo et al., 2019). Recent empirical studies demonstrate that digital scaffolding has evolved from teacher-mediated support into AI-powered adaptive learning systems (Al Mamun & Lawrie, 2024;Azevedo et al.,2022;Hamid & Abbas,2025;Kim, 2021;Yawiloeng,2021). In this perspective, self-regulated learning (SRL) is facilitated by ongoing interactions between learners and instructional materials, with scaffolds serving as mediators that encourage learners to organize learning activities, assess comprehension, and evaluate the efficacy of strategies.

Despite these promising findings, most studies examined scaffolding, digital learning, and self-regulated learning independently, but the literature lacks a comprehensive explanation of how digital scaffolding explicitly mediates self-regulated learning in English language learning environments. Therefore, the review aims to synthesize the pedagogical link between digital scaffolding, AI-assisted learning, learner autonomy, and self-regulated learning.

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The rapid development of adaptive AI technologies, including intelligent tutoring systems, learning analytics, and generative AI tools, has introduced new forms of digital scaffolding in English as a Foreign Language (EFL) education. However, how these forms of scaffolding function as regulatory support systems that facilitate learners' transition from externally guided learning to autonomous and self-regulated language learning remains insufficiently understood. In particular, further synthesis is needed to explain how different forms of digital scaffolding support learners' self-regulation across varying stages of the learning process.

To address this gap, this systematic review synthesizes empirical evidence on digital scaffolding and self-regulated learning in English Language Teaching (ELT). It also proposes the Digital Scaffolding Regulatory Continuum (DSRC) as a conceptual framework for explaining how digital scaffolding may support learners' progression from externally regulated learning toward greater autonomy and self-regulation. Accordingly, this review investigates the types of digital scaffolding most frequently used to foster self-regulated learning and examines how digital scaffolding supports learners' self-regulated learning processes in language learning.

English language teaching benefits conceptually and practically from this study. It theoretically improves understanding of sociocultural theory, connectivism, AI-assisted learning, and self-regulated learning in digital language learning environments. The study offers educators, curriculum designers, and researchers' practical advice on creating responsive digital learning environments that promote learner autonomy, metacognitive awareness, and sustained self-regulated learning in the modern EFL classroom.

METHODS

This study utilizes a systematic literature review (SLR) according to the framework set by Page et al. (2021) known as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The SLR approach was selected to ensure transparency, systematic, replicable procedure for identifying, screening, evaluating and synthesizing empirical studies. The review aimed to synthesize empirical evidence role of digital scaffolding in fostering self-regulated learning (SRL) in English Language Teaching (ELT) contexts. Furthermore, the review identifies forms of digital scaffolding in language learning and to explain how such scaffolds assist self-regulated learning in English language teaching (ELT).

A systematic search was conducted across five major academic databases namely Google Scholar, Frontiers, ERIC, SpringerLink, and SAGE Journals. The search was carried out between January and April 2026. ERIC was mainly used for education research, while SpringerLink and SAGE Journals include many studies on educational technology and language teaching. Frontiers contains recent open-acesss research and Google Scholar was used to maximise the retrieval peer-reviewed studies across multiple publishers.

The following search string was used ("digital scaffolding" OR "AI scaffolding" OR "adaptive scaffolding") AND ("self-regulated learning" OR "self-regulation") AND ("EFL" OR

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"ESL" OR "English language teaching"). The keywords were optimized through first exploratory searches to guarantee consistency with pertinent terms in educational technology and applied linguistics literature. Only papers published from 2016 to 2026 were included to reflect recent advancements in AI-enhanced and digital learning settings.

The article selection process followed the PRISMA 2020 procedure consisting of four stages: identification, screening, eligibility assessment, and inclusion. During the identification phase, 679 records were identified using the pre-defined search strategy in five academic databases. All records retrieved were exported, organised and prepared for further assessment. Titles and abstracts were subsequently examined to assess their pertinence to the subject of digital scaffolding and self-regulated learning in English Language Teaching environments.

Then, in the eligibility stage, full-text publications were screened againts pre-specified inclusion and exclusion criteria. Studies were included if they were peer-reviewed empirical journal articles published between 2016 to 2026 that used qualitative, quantitative, or mixed-methods designs to investigate digital, adaptive, or AI-supported scaffolding in EFL,ESL or ELT contexts and explicitly addressed self-regulated and were available in full text. Studies were eliminated if they were review papers, conceptual articles, editorial, conference abstract, book chapters, opinion papers and studied that did not take place in the context of language learning. Studies that fulfilled all the selection criteria after the eligibility assessment were included in the final synthesis. The qualitative reviews includes a total of 34 articles. The quality of the included studies was assessed based on methodological rigor, clarity of research design, relevance to the review questions, and completeness of empirical reporting.

The collected data were analysed using a thematic synthesis approach. The analysis involved several stages. First, the reviewed studies were analyzed according to SRL dimensions including forethought (processes that precede the learning effort), execution control (processes that occur during learning), and self-reflection (activities that take place after learning). Second, the researchers' categorized studies based on types of digital scaffolding such as instructional scaffolding, metacognitive scaffolding, and AI-enhanced and adaptive scaffolding. Next, examining how digital scaffolding impact on self-regulated learning in ELT contexts. Finally, the synthesized findings were interpreted to construct a comprehensive understanding of the pedagogical role of digital scaffolding in contemporary language learning environments.

RESULTS

Types of Scaffolding Are Implemented in Digital Language Learning to Foster Self-Regulated Learning

The reviewed studies indicate that digital language learning environments employ several interrelated types of scaffolding to foster learners' self-regulated learning (SRL). Rather than relying on a single form of support, scaffolding is implemented through

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instructional, metacognitive, cognitive, affective and adaptive digital mechanisms that collectively guide learners' regulation of learning processes.

Instructional scaffolding is consistently reported as a foundational form of support that shifts learning toward a more student-centered orientation. It is originally contributed by Walqui (2006), cited in Yawiloeng (2021) namely, modelling, bridging, contextualizing, schema building, and developing metacognition. Nevertheless, the studies reviewed indicate that its importance extends beyond the facilitation of immediate task performance. Digital instructional scaffolding systematically restructures learning responsibility by gradually transferring control from instructors to learners. For example, Karimi et al., (2020) described that using graphic organizers to scaffold instruction greatly improved the students' listening comprehension. Similarly Gunupudi et al. (2024) found that inclusive student were able to independently build their skills and proficiency in using WhatsApp group as a digital scaffolding to regulate, guide and support them in learning about digital skill Instructional scaffolding is not just a speaking teaching technique, but a systematic mechanism for developing reflective, and autonomous learners (Basco et al., 2019). These studies emphasize the instructor's role as a metacognitive guide and highlight how digital tools can mediate this tutoring function.

Metacognitive scaffolding plays a central role in supporting core SRL processes particularly in the form of digital prompts. Several studies identified metacognitive prompts as mechanisms that explicitly guide learners through planning, monitoring, and reflection phases of learning. Digital prompts assist learners in setting learning goals and selecting initial strategies (planning), increasing awareness of comprehension and progress during task engagement (monitoring), and encouraging evaluation of strategy effectiveness after task completion (reflection) (Daumiller & Dresel, 2019; Hamid & Abbas, 2025). This is supported by Wu et al. (2017) that encourages monitoring and control procedures insofar as it encourages beginners to choose a learning objective and organize a sequence of tasks in accordance with that objective. In addition, ChatGPT's cognitive scaffolding improves language understanding and learning processes. Metacognitive scaffolding helps learners plan, monitor, and evaluate their learning through reflective prompts and leading questions. Through adaptive feedback and encouragement, affective scaffolding regulates emotions and enhances learners' motivation and confidence (Prasad & Swaroopa, 2025).These findings indicate that integration cognitive, metacognitive and affective make the otherwise implicit processes of self-regulation more visible and actionable for learners in digital language learning contexts.

Furthermore, AI-adaptive scaffolding based on Al Mamun & Lawrie (2024) represents an emerging form of support that dynamically responds to learners' needs. Studies focusing on AI-mediated environments reported the use of adaptive hints, feedback, and personalized pacing as scaffolding mechanisms that adjust in real time to learners' performance and engagement (Yaseen et al., 2025). Artificial intelligence-based interactive scaffolding (AIIS) is the method where learners engage with AI to facilitate learning through the implementation of activities with increasing aid from the AI then regulate their learning process to be independent (Sun & Wu, 2026).

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The findings demonstrate that digital scaffolding is a regulatory continuum rather than separate educational interventions. Metacognitive scaffolding increases regulatory awareness, affective scaffolding preserves motivation, and AI-adaptive scaffolding dynamically personalizes support. They aim to help students leave from external help to self-directed learning. As an instructional ecosystem grows, digital support mediates cognitive progress and learner autonomy in modern EFL situations, broadening scaffolding concept.

The Impact of Digital Scaffolding on Learners' Self-Regulated Learning Process in Language Learning

Many researchers have investigated scaffolding as a support in the learning process. Across the reviewed studies, digital scaffolding consistently emerged as a regulatory support system that influences not only learners' task performance but also the ways they plan, monitor, evaluate, and sustain their learning processes (Li et al., 2023). One of the most reliable patterns revealed in the literature is the impact of digital scaffolding in supporting learners' metacognitive regulation.

Several studies demonstrate that scaffolded digital environments increase learners' abilities to assess understanding, manage approaches, and evaluate learning progress during language learning activities. For example Ozaki & Ueda, (2020) found VSTF (Visual-Syntactic Text Formatting)-based text as digital scaffolding can benefit students' reading because they are able to monitor, control, and evaluate their comprehension. This result demonstrates that digital scaffolding externalizes many of the implicit cognitive processes, thereby allowing learners to engage more deliberately in self-monitoring and strategic regulating. Studies in blended and online learning contexts also suggests scaffolding enhances learners' awareness of learning challenges and promotes adaptive strategy use during task completion.

Scaffolding provides great importance in the movement of learners towards autonomy by assisting in planning and organizational procedures. In online Chinese as a Foreign Language (CFL) contexts, structured scaffolding materials such as learning schedules, explanatory notes, and task scripts were provided to guide learners through digital learning activities (Chen, 2021). These materials supported learners' planning by helping them organize their learning time by proficiency level and by monitoring progress through clarification of difficult vocabulary and listening content. It is in line with Hromalik & Koszalka (2018) that scaffolding can help learners become more self-regulated, which would benefit community college online learners. Similarly providing scaffolding for the learning process can serve as a metacognitive aid that helps learners to decide in a self-regulated manner (Yot-Domínguez & Marcelo, 2017).

Another important theme emerging from the synthesis that digital scaffolding promotes sustainable learning processes and not only short term academic success. Scaffolds are designed to support the SRL process produce more sustainable learning outcomes than simply improving test scores (Herold & Seufert, 2025). This means that the efficacy of scaffolding should be evaluated not only in terms of immediate performance scores, but also in terms of how well students can retain motivation, monitor their progress, and manage their tactics autonomously over time. Thus, scaffolding supports the emergence

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of enduring learning behaviours that extend beyond the limits of discrete instructional experiences.

The findings further reveal that real-time and adaptive digital scaffolding plays a particularly important role in dynamic online learning environments. Real-time personalized digital scaffolding is able to direct students' self-regulated learning processes, especially in monitoring and adjusting strategies (Lim et al., 2024). Similarly, digital scaffolding can stimulate monitoring, strategic control, and regulation of student motivation so that online learning outcomes such as Moodle discussion form and experiences can be improved sustainably (Fan et al., 2022; Rasheed et al., 2021; Samin, 2021). This indicates that digital scaffolding not only scaffolds learners' cognition, but also their social and motivational development by allowing them to endure and participate in online learning communities.

In sum, the effectiveness of digital scaffolding depends on pedagogical design and instructional mediation. Digital technologies provide structured support and adaptive feedback, but scaffolding works better when supervised by teachers or lecturers who stimulate reflection, assess learner progress, and gradually withdraw aid. Therefore, digital scaffolding should be seen as a pedagogically mediated structure that blends technical affordances with human guidance.

This study synthesizes instructional, metacognitive, and AI-adaptive scaffolding within Zimmerman's SRL framework, demonstrating how each component facilitates the phases of planning, performance, and self-reflection. The subsequent graphic depicts this relationship, emphasizing scaffolding as a dynamic structure that facilitates the progression toward self-regulated learning. The integration between type of scaffolding and self-regulated learning is shown figure 2 above.

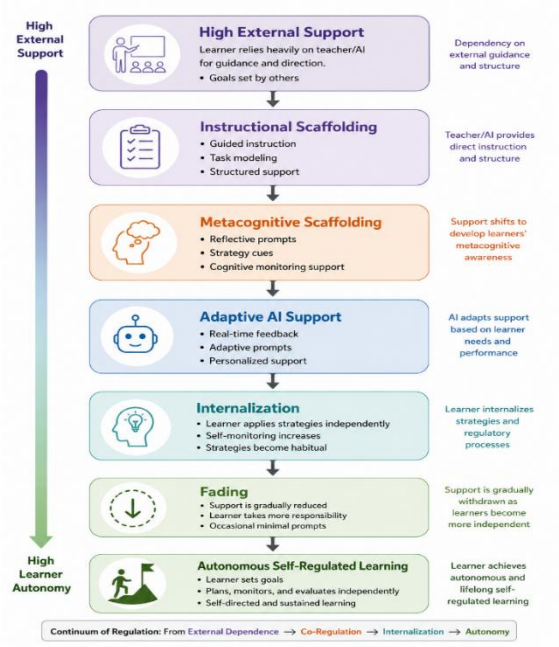


Figure 2. Digital scaffolding regulatory continuum

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The conceptual map illustrates the proposed Digital Scaffolding Regulatory Continuum (DSRC), which explains how learners gradually move from high external support to autonomous self-regulated learning. The continuum begins with instructional scaffolding, where teachers or AI provide guidance, modeling, and structured support. As learners gain experience, metacognitive scaffolding promotes planning, monitoring, and reflection, while adaptive AI delivers personalized feedback based on learners' needs. Through these stages, learners progressively internalize effective learning strategies. As their competence increases, external support is gradually reduced through fading, shifting responsibility for learning from teachers or AI to the learners themselves. This progression reflects a continuum of regulation from external dependence, through co-regulation and internalization, to autonomous self-regulation. Overall, the DSRC conceptualizes digital scaffolding as a dynamic process that progressively develops learners' capacity to regulate their own learning in AI-supported digital reading environments**.**

DISCUSSION

Synthesized articles indicate that scaffolding materials serve not only as instructional resources but also as critical supports that facilitate learners' self-regulated learning in digital language environments. Scaffolding structures are not only supplemental materials but also shape the capacity of the learners to organize, monitor and evaluate their learning activities inside technology-mediated environments (Al Mamun & Lawrie, 2024; Li et al. 2023). The results indicate that the educational value of digital scaffolding is not just in increasing task performance but also in developing learners' long-term regulatory competence.

At first, learners perceive scaffolding materials as procedural tools primarily designed to assist them in accomplishing academic tasks. Chen (2020); Li et al. (2023) indicate that learners increasingly use scaffolding to regulate learning rather than access content. Socioculturally, regulating skills arise through mediated participation before becoming internalised as independent regulation. Scaffolding helps learners develop cognitive and metacognitive strategies within their Zone of Proximal Development (Yawiloeng, 2021). This reinforces Vygotsky's sociocultural perspective that student develops through mediated interaction before becoming internally regulated.

Across the reviewed studies, digital scaffolding consistenly functions as an external regulatory mechanism that supports learners' cognitive and metacognitive process while gradually fostering independent self-regulation (Graaf et al., 2023;Herold & Seufert ,2025; Hromalik & Koszalka,2018). Reflection prompts, strategy guides and structured learning support encourage learners to monitor their progress, evaluate learning strategies, and engage more effectively with digital resources. Collectively, these findings suggest that the value of digital scaffolding extends beyond improving task performance to strengthening learners' long term self-regulated learning. Therefore, digital environment should integrate regulatory support that gradually transfer learning responsibility from lecturer to students, ultimately promoting learner autonomy (Yot-Domínguez & Marcelo, 2017)

The literature shows that adaptive AI-enhanced scaffolding allows real-time co-regulation between learners and digital systems. Azevedo et al. (2022); Azir & Sriyanto (2021); Hamid & Abbas (2025) found that adaptive scaffolds give immediate feedback,

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personalized pace, and context-sensitive coaching that adapts to learners' performance. AI-enhanced instructional supports adapt to learner interaction patterns. Thus, AI is a responsive co-regulatory partner that enhances learners' strategic awareness and metacognitive participation throughout learning tasks. Clive & Athyal (2026); Hou & Zhou (2025); Khan et al. (2025) suggest that AI-mediated scaffolding supports the cyclical processes of planning, monitoring, and self-reflection, enhancing learners' regulating capacity during digital language learning. Similarly, Jin et al. (2023) argue that the AI system provides real-time feedback that helps control learning so that it can improve students' self-regulated learning abilities.

The synthesized evidence indicates that self-regulated learning develops most effectively when instructional, metacognitive and adaptive scaffolding are integrated as complementary forms to support rather than implemented independently. Instructional scaffolding provides learners with initial guidance and learning strategies, metacognitive scaffolding promotes planning, monitoring and reflection, while adaptive AI-enhanced scaffolding delivers personalized support based on learners' evolving needs. This complementary process aligns with Zimmerman's cyclical model of self-regulated learning, demonstrating that digital scaffolding not only supports task completion but also strengthens learners' regulatory competence. These findings suggest that integrating multiple forms of scaffolding facilitates a gradual transition from externally guided learning to autonomous language learning, thus reinforcing learner autonomy in ELT contexts.

It is similar with Prasad & Swaroopa, (2025) demonstrated that AI-powered tools such as ChatGPT extend the traditional concept of scaffolding by providing adaptive and responsive support throughout learners' writing process. Unlike traditional teacher-provided scaffolding, AI-mediated scaffolding dynamically adjust support according to learners responses and performance, allowing a shift from externally regulated learning to internally regulated processes, ultimately fostering learner autonomy and self-regulated learning (Hou & Zhou, 2025;Wang et al., 2025).

The transition process from guided learning to independent learning within a scaffolding framework takes place gradually and adaptively in which instructional support is progressively reduced as learners' self-regulation (Azevedo et al., 2022;Daumiller & Dresel, 2019:Kim, 2021;Li et al., 2023). Previously, learners receive structured guidance through modelling, prompts and strategic support, which gradually shifts towards activities and independent strategy use. In AI-mediated learning environment, this process becomes more adaptive because digital system can continuously adjust the level of support according to learners' performance and learning needs (Liu & Zhou, 2026).Collectively, these findings suggest that fading should be viewed not merely as the withdrawal of instructional support but as a regulatory process that facilitates the internalization of learning strategies and promotes learner autonomy in ELT contexts.

AI-mediated scaffolding provides adaptive feedback, reflective prompts, and context-sensitive assistance that support learners' planning, monitoring, and task performance (Yan et al., 2025;.Yang, 2026)These functions position AI as a co-regulatory partner that supports learners' strategic awareness and learning efficiency while gradually fostering independence through adaptive guidance. Overall, the findings conceptualize digital scaffolding in EFL as a

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dynamic regulatory continuum that facilitates learners' progression from external guidance to autonomous self-regulation. This perspective extends the role AI beyond that of an instructional tool, highlighting its potential to support the gradual development of learner autonomy in digital language learning environment.

Based on the synthesis of the reviewed studies, this review proposes the Digital Scaffolding Regulatory Continuum (DSRC), a conceptual model explaining how instructional, metacognitive, cognitive, affective, and AI-adaptive scaffolding collectively support learners' progression from external regulation to autonomous self-regulated learning. Unlike previous studies that examined these scaffolding approaches separately, the DSRC integrates them into a coherent developmental continuum that explains the gradual transfer of regulatory responsibility from lecturer or AI system to learners.

CONCLUSION

This systematic review concludes that digital scaffolding supports self-regulated learning (SRL) in language education by helping learners organize, monitor, reflect, employ strategies and enhance learner autonomy gradually. This review's key contribution is to conceptualize digital scaffolding not only as a set of teaching tools, but as a dynamic regulatory continuum. The synthesis research indicates that instructional scaffolding establishes a foundation for learning, metacognitive scaffolding enhances learners' regulation awareness, and adaptive AI-enhanced scaffolding tailors support to learners' changing requirements. These complementing supports together allow a progressive shift from external direction to autonomous self-regulation.

In theoretically, findings highlight internalization, fading and co-regulation as key mechanisms connecting digital scaffolding with self-regulated learning. Those also reveal that lecturers and instructional designers should not just add technological resources to instruction, but deliberately incorporate digital and AI-supported scaffolds in ELT practice. Digital learning environment should provide enough scaffolding in the early phases of learning, encourage metacognitive awareness by using prompts and reflection, and then adapt or remove scaffolding as learners gain more regulatory competence.

This review has certain limitations. The result of synthesis was based on studies with different research designs, technology, learning environments and measures of self-regulated learning, which limits direct comparison across studies and does not allow for conclusive conclusions regarding the relative usefulness of particular types of scaffolding, Moreover, the current research still offers limited understanding of the specific relationship between scaffolding designs and measured self-regulated learning results, and how the AI-mediated regulation interacts with learners' individual metacognitive and motivational traits. Future research should investigate the longitudinal development of self-regulated learning, compare different scaffolding configurations directly and examine how adaptive and AI-mediated scaffolds can support cognitive, metacognitive, motivational and effective dimension of self-regulation in different EFL contexts.

This review contributes to the literature by proposing the Digital Scaffolding Regulatory Continuum (DSRC), a conceptual framework that explains how digital scaffolding

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progressively supports learners' development from external regulation to autonomous self-regulated learning in AI-supported digital reading environments.

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