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RESEARCH PAPER

Artificial Intelligence as a Pedagogical Scaffold in K–12 Language and Literacy Education

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ABSTRACT

The artificial intelligence (AI) in language and literacy teaching at K-12 has expanded the opportunities of individualization in language learning. This systematic review, using the theory of sociocultural learning developed by Vygotsky and the Zone of Proximal Development (ZPD) in its explanations, describes the support of scaffolding learning provided by AI-powered education technologies in K12- language classroom settings. Drawing on the outcomes of empirical data gathered during the period of 2020-25, this review aims to synthesize the prior studies to understand how adaptive technologies, including ChatGPT, Grammarly, and Duolingo, can influence the needs of learners by providing real-time feedback, natural language processing, and content adaptation. The results confirm AI systems as similar to MKO dynamic mediators that fill in gaps in the capacity of learners to negotiate the ZPD. The implications of this research based on the AI-based tools is that the tooling should encourage equal, and non-discriminatory, language learning. It also requires cooperative consultation between educators, AI developers and policymakers in order to influence the moral integration within school curricula. Building on prior empirical work, this review is one of several contributors to current debate regarding the extent to which intelligent technology can be a pedagogic agent that supports individualized and scaffolded language learning at scale.

Keywords: AI in K–12 Education, Scaffolding, Adaptive Learning, Individualized Instruction, Systematic Review, Zone Of Proximal Development (ZPD)

Introduction

Artificial intelligence (AI) is being introduced to the K-12 education on a large scale, and it provides novel opportunities to student-centered teaching and redefine conventional pedagogical models.In language and literacy education in particular, AI tools such as intelligent tutoring systems, generative models (e.g., ChatGPT), and adaptive learning systems are employed to provide personalized instruction (Amiri et al., 2025; Singh, 2024). These innovations meet the global demand for scalable, personalized learning products that can meet diverse learner needs in both high-resource and low-resource classrooms (Almuhanna, 2024; Yaseen et al., 2025).

Importance of Language and Literacy as Foundational Skills

Language and literacy skills form the basis of academic success, intellectual development, and lifetime learning. Foundational literacy in reading, writing, listening, and speaking not only improves performance across the curriculum but also fosters critical thinking, identity, and social engagement (Ali et al., 2025; Hamid, 2025). The imperative to close learning gaps in these foundations, especially in early grades and in multilingual settings, has propelled interest in using AI tools for enhancing engagement and comprehension (Tolibovna, 2024; Alrawashdeh, 2023).

Overview of Scaffolding and ZPD

Vygotsky's theory of the Zone of Proximal Development (ZPD) is a compelling context in which to talk about how learning is made easier with assistance. The ZPD is the mental space where students can accomplish tasks under assistance but not on their own just yet. Scaffolding, as hypothesized by this theory, refers to temporary support by teachers, peers, or aids to promote students' transition to higher stages of learning (Ghimire & Neupane, 2024; Zapata, 2025). Current AI systems, through real-time feedback, adaptive difficulty, and dialogic exchange, can serve as digital scaffolds by responding dynamically to a learner's level of development at the time (Du, 2025; Liu & Wang, 2024).

The Growing Role of AI-Driven Personalization in Learning

Recent technological breakthroughs in AI—natural language processing (NLP), machine learning, and generative models—have enabled real-time adaptation of teaching materials to individual learner needs. Such technologies enable adaptive learning pathways through modifying linguistic sophistication, pace of learning, and feedback based on continuous learner input (Mavidi, 2025; Bahari et al., 2025). For example, applications like Duolingo and ChatGPT have been shown to enhance learner motivation and self-regulation through their capacity to simulate interactive human-like feedback (Shalihah, 2025; Torres & Statti, 2025). When paired with scaffolding concepts and ZPD theory, these systems can provide developmentally suitable challenge that accelerates literacy and language fluency acquisition.

Besides the promising futures in the application of AI in K–12 language instruction, several major gaps are present. Above all, there is not sufficient transparency regarding how existing AI tools directly align with proven educational theories such as scaffolding and ZPD. In addition, the uneven deployment of these tools among learning environments raises concerns regarding their effectiveness, equity, and long-term instructional value (Gautam, 2024; Sidorkin, 2025; Hamid et al., 2025). There is also very little synthesized empirical research on how teachers and students perceive AI tools and how their affordances vary in low-resource and high-resource contexts.

Theoretical Framework

The review is based on socio-constructivist theories of learning, specifically, the Zone of Proximal Development (ZPD) by Vygotsky, and pedagogical theories of scaffolding (see Table 1).

The theories offer a perspective through which AI-based educational technologies can be criticized as a contributor to individualized learning in language and literacy education.

Vygotsky's Zone of Proximal Development (ZPD)

Vygotsky (1978) introduced the concept of the Zone of Proximal Development to determine the gap between what a learner can accomplish independently and what he can accomplish with the assistance of a more competent other. ZPD emphasizes the active process of learning, which involves collaborative work, systematic support, and prompt intervention. In AI-based contexts, the advanced systems are now playing this role of the more knowledgeable other by responding in real-time to the changing needs of students (Cai et al., 2025).

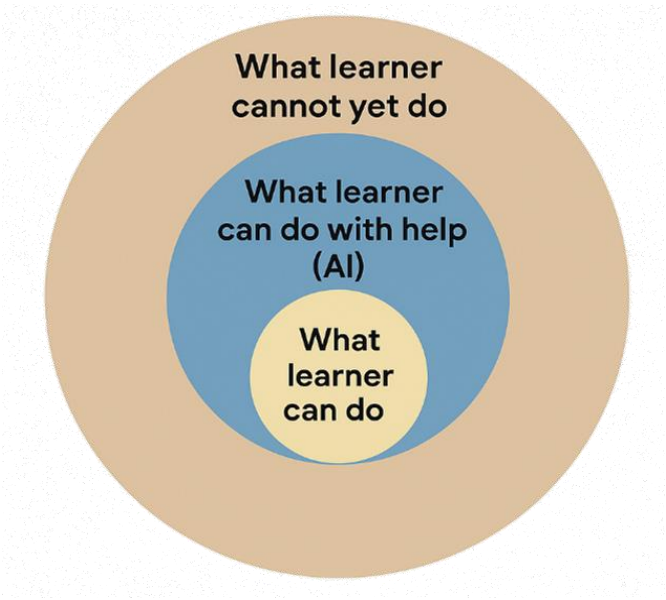

Figure 1. Zone of Proximal Development and AI Scaffolding

Definitions and Forms of Scaffolding

The concept of scaffolding has been used to refer to the learning strategies that help students to progress in the direction of more knowledge and more independence in the learning process. Among the most prevalent forms of scaffolding are:

- Procedural scaffolding, which supports learners to work with tools or procedures
- Strategic scaffolding, guiding the learners to the procedures of performing tasks
- Metacognitive scaffolding, supporting self-regulation and reflection
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Such forms of scaffolding are used within AI-based environments by technologies that adapt learning pathways dynamically, provide context-specific hints, and promote self-reflection (Amiri et al., 2025; Singh, 2024).

Table 1
Theoretical Constructs Linking AI, Scaffolding, ZPD, and Individualized Learning

Concept	Definition	Application in AI-driven Learning	Relevance to Language and Literacy Education
Zone of Proximal Development (ZPD)	The gap between what a learner can do independently and with support (Vygotsky)	Adaptive systems can calibrate challenge levels and provide tasks within learners' ZPD	Ensures students engage with tasks just beyond current skill level for growth
Scaffolding	Structured support to help learners achieve complex tasks	AI provides dynamic scaffolds like hints, feedback, and personalized pacing	Enhances comprehension and skill mastery in reading and writing
Individualized Learning	Tailoring instruction to each learner's needs, preferences, and pace	AI personalizes content, delivery style, and feedback using learner data	Addresses diverse learner profiles including ELLs and neurodiverse students
AI-driven Educational Technologies	Intelligent systems using algorithms for adaptive instruction	Includes ITS, NLP-based tutors, and generative AI tools	Facilitates scalable, data-informed support in literacy education

Definitions of Individualized/Personalized Learning

Personalized learning involves the tailoring of learning experiences to the individual needs, abilities, and interests of each student. This has a direct relationship with learner-centered pedagogy and is conventionally characterized by differentiated content, pace, and instructional strategies (Ali et al., 2025). Personalization within AI-enabled spaces is realized through continuous data-driven adaptation, responding in real-time, and learner modeling (Yaseen et al., 2025).

Overview of AI-Driven Educational Technologies

AI-driven education technologies that are relevant in this review include:

- ITSs: These are the Human-simulation adaptive systems that generate custom prompts and feedback (Ghimire & Neupane, 2024).
- NLP Tutors: These refer to the computer programs that process the language of students in order to ascertain the vocabulary, grammar, and fluency learning needs (Zapata, 2025).
- Adaptive Learning Platforms: These are adaptive systems that vary the content of instruction based on the performance and cognitive profile of the learners (Du, 2025).
- Generative AI Tools: These are similar to chatbots and writing assistants which encourage interaction and support students in real time (Mavidi, 2025; Bahari et al., 2025).

These technologies approach the simulation of the changing pedagogical models where the machines are not the passive means of the content delivery, but the active scaffolds which are modified according to the developmental learning areas.

Conceptual Framing

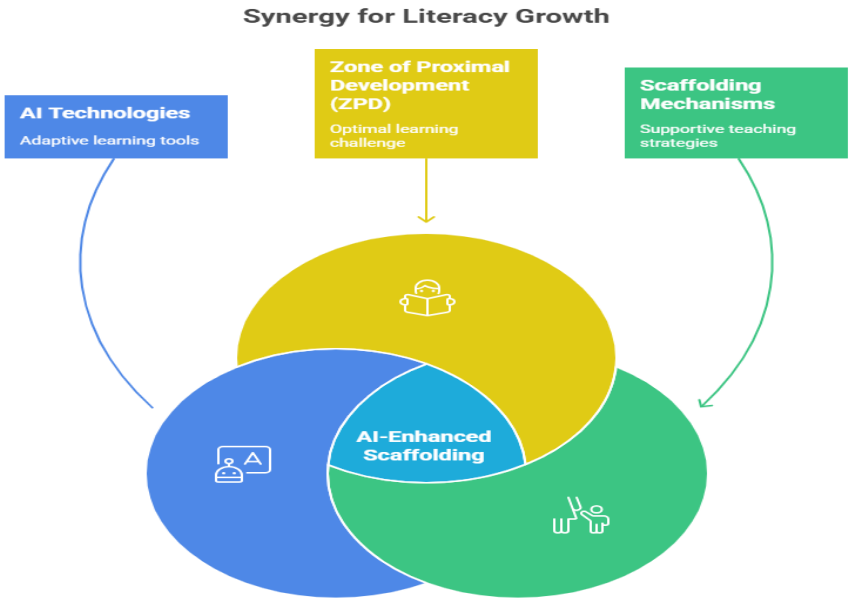

Figure 2. Conceptual Map

The above model (Figure 2) highlights:

- AI technologies are adaptive facilitators, continuously changing in response to learner data
- Scaffolding occurs within AI feedback loops, modeling and fading support as learning progresses
- ZPD is the cognitive zone targeted by AI-facilitated, personalized interventions

This model demonstrates the possibility of AI implementing socio-constructivist values and promoting one-on-one language learning instead of passive and homogenous learning. Literacy and language outcomes are what can be viewed as the product of better interaction within these areas (Liu & Wang, 2024; Almuhanna, 2024).

Material and Methods

This systematic review followed the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standards to be as transparent, reproducible, and methodologically rigorous as possible in the review process. The study aimed to synthesize existing evidence on the integration of AI-driven learning tools with scaffolding and Vygotsky's Zone of Proximal Development (ZPD) in K–12 language and literacy instruction (see Table 3).

Databases Searched

Systematic review of literature was conducted using five well-known academic databases between March 2025 and May 2025: Scopus, Web of Science, ERIC, IEEE Xplore, and Google Scholar. The databases were selected due to their widespread coverage in education, learning sciences, and computer-supported learning technologies (Du, 2025; Bahari et al., 2025).

Search Terms and Boolean Combinations

Search terms were developed to target research that bridged AI, language/literacy development, and pedagogical models like ZPD and scaffolding. The following Boolean phrases were utilized:

- "Artificial Intelligence" AND "language learning" AND "K-12"
- "AI tools" AND "literacy" AND "scaffolding"
- "Adaptive learning" AND "ZPD" AND "primary education"
- "AI-driven education" AND "individualized learning"
- "Intelligent tutoring" AND "Zone of Proximal Development" AND "language acquisition"

Search results were filtered by date (January 2020 to May 2025) and limited to full-text peer-reviewed journal articles and conference proceedings.

Inclusion Criteria

Studies were included to provide relevance and empirical validity if they met the following criteria:

- Published between the years 2015 to 2025
- Peer-reviewed English-language articles
- Empirical research studies (qualitative, quantitative, or mixed methods)
- Had a K–12 learner or educator target
- Discussed AI technologies in the context of scaffolding, ZPD, or personalized instruction

- Apparently linked to language and/or literacy acquisition

Examples of included studies meeting the above conditions are Ali et al. (2025) on interaction between AI-language tools and perceived enhancement, and Ghimire & Neupane (2024) on teacher perspectives of AI in language teaching.

Exclusion Criteria

Studies that were excluded if:

- Were purely theoretical, but devoid of empirical data (e.g., essays or opinion pieces)
- Placed focus on non-AI tools or unrelated technologies
- Did not include mention of individualized learning, scaffolding, or ZPD
- Were not performed in K–12 environments
- Were not published in full text

Screening Process

The literature search yielded 2,087 articles. Duplicates (n = 412) were excluded, and titles and abstracts were screened from 1,675 articles. After considering eligibility and relevance, 889 articles were evaluated in full-text, and 859 articles were rejected following the exclusion criteria. Eventually, 30 studies were included in this study (see Figure 3).

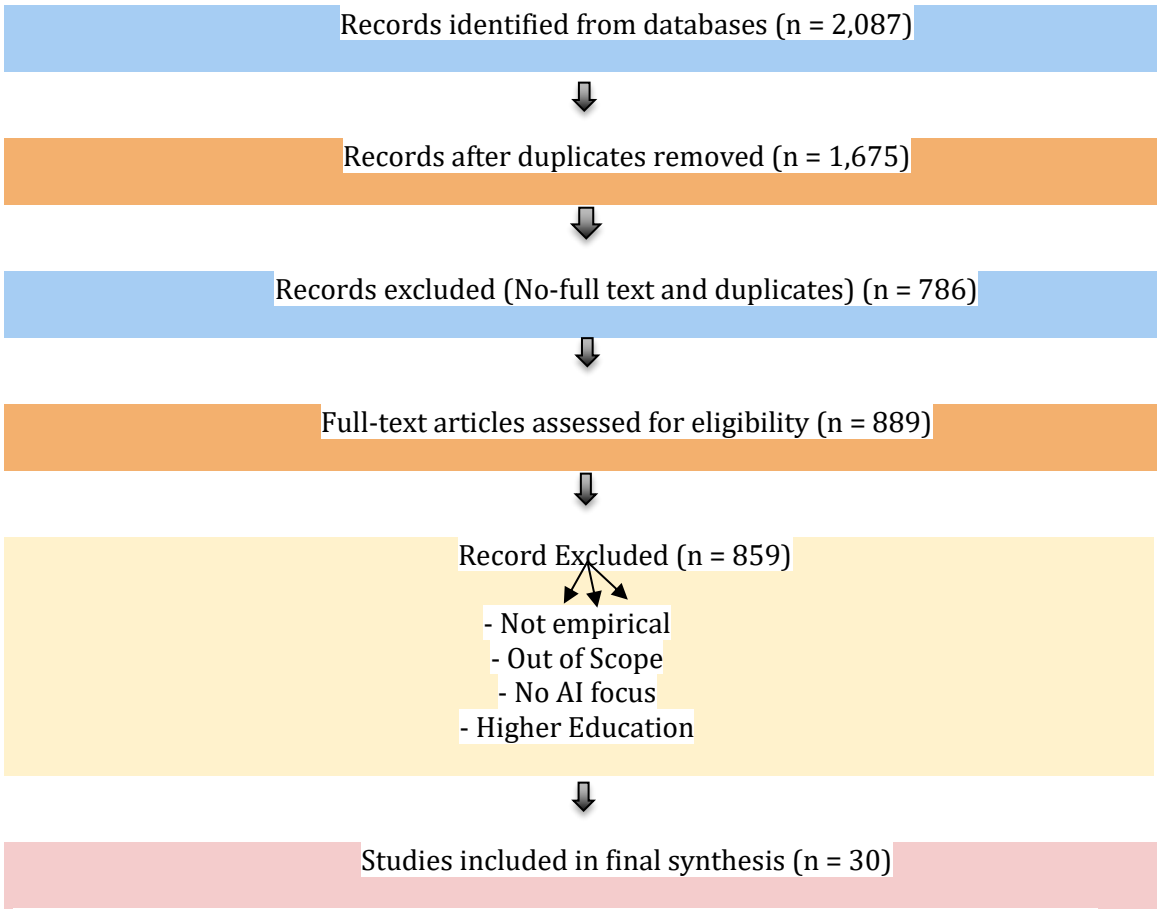

Figure 3. Screening Process - *Adapted from PRISMA 2020 guidelines (Page et al., 2021)*

Quality Assessment

Each of the studies included was critically appraised using the Mixed Methods Appraisal Tool (MMAT, 2018 version), which allows the critical appraisal of qualitative, quantitative, and mixed-methods studies. The criteria used were as follows: clear research

questions, appropriateness of methodology, appropriateness of the sampling approach, and validity of the data. All the studies scored ≥60% on the MMAT, denoting moderate to high methodological quality (e.g., Torres & Statti, 2025; Zapata, 2025).

Data Extraction and Coding Strategy

A standard template for data extraction was developed to promote consistency across studies. The data obtained were:

- Authors and publication year
- Study context (e.g., country, grade)
- AI tools used (e.g., adaptive systems, generation tools, chatbots)
- Specific alignment with scaffolding or ZPD principles
- Outcomes of students (e.g., engagement, retention, fluency, comprehension)
- Endorsers' perceptions (students/teachers)
- Ethical or equity-related outcomes

Coding was carried out thematically and aligned with five core themes: language acquisition effectiveness, adaptive learning strategies, student engagement, teacher perspectives, and equity or ethical considerations (Yaseen et al., 2025; Liu & Wang, 2024; Singh & Goyal, 2025).

Table 2
Methodological Process

Component	Description
Review Protocol	Systematic review conducted using PRISMA 2020 guidelines
Databases Searched	Google Scholar, ERIC, Scopus, Web of Science, IEEE Xplore
Search Terms	("Artificial Intelligence" OR "AI") AND ("Language Learning" OR "Literacy") AND ("ZPD" OR "Scaffolding")
Inclusion Criteria	Peer-reviewed, empirical studies (2021–2025), focused on K–12, AI, ZPD/scaffolding, and literacy
Exclusion Criteria	Non-empirical papers, studies without AI elements, irrelevant to literacy or individualized learning
Screening Process	Title/abstract review → full-text review
Quality Appraisal	Mixed Methods Appraisal Tool (MMAT) used to assess study rigor
Data Extraction	Author(s), year, AI method, learner context, findings, theme alignment

Results and Discussion

Table 3
Key Characteristics of Some Exemplary Studies

Author(s)	Year	Country	AI Tool/ Tech	Method	Participants	Literacy Focus	Key Outcomes
Du (2025)	2025	China	AI Chatbot (Conversational Agent)	Mixed Methods	105 EFL learners (college)	Reading, SRL	Improved self-regulated learning and retention
Zapata (2025)	2025	USA	GenAI tools for writing	Qualitative	ELLs (secondary level)	Multiliteracies	Enhanced learner creativity and engagement
Cai, Msafiri, & Kangwa (2025)	2025	Zambia/ Kenya	Adaptive AI tutor	Mixed Methods	Secondary school learners	Vocabulary, Grammar	Improved performance in scaffolding zones
Almuhanna (2024)	2024	Saudi Arabia	Customized AI resources	Survey	200 K-12 Teachers	Language curriculum design	Positive perception of AI's role in material personalization
Ghimire & Neupane (2024)	2024	Nepal	ITS-based language platform	Interviews	18 ELT instructors	All language domains	Strong alignment with ZPD, especially

							in beginner-intermediate transitions
Amiri et al. (2025)	2025	Bangladesh	AI-powered vocabulary games	Experimental	65 middle school students	Vocabulary acquisition	Significant gains with scaffolding-based adaptive progression
Yaseen et al. (2025)	2025	Jordan	Adaptive feedback platform	Quantitative	500 K-12 students	Reading comprehension	Higher engagement and digital literacy moderated feedback effectiveness
Mavidi (2025)	2025	India	NLP-based fluency tutor	Case Study	15 High school EFL learners	Speaking fluency	Personalized AI support increased pronunciation and fluency
Bahari et al. (2025)	2025	Multinational	AI-Enhanced CALL System	Survey & Focus Group	120 students	Listening & reading	Positive response to interactive scaffolding and challenge calibration
Singh (2024)	2024	India	Personalized AI dashboard	Theoretical model	N/A	Personalized learning	Outlined mechanisms of AI adaptation in scaffolding across ZPD levels
Liu & Wang (2024)	2024	China	AI critical thinking tool	Intervention	80 university EFL learners	Literary analysis	Enhanced critical thinking and deeper engagement in ZPD-aligned instruction
Gautham (2024)	2024	USA	Adaptive learning platform	Experimental	ELL students in Grades 6–8	Reading & social learning	Increased collaboration and peer scaffolding observed through platform usage
Singh & Goyal (2025)	2025	India	GenAI integration conceptual	Conceptual	N/A	Multiliteracy, cognitive dev	Emphasized AI as scaffold across metacognitive zones
Torres & Statti (2025)	2025	USA	AI for creative writing tasks	Practical guide	Language educators	Creative writing	Proposed lesson plans with strategic AI feedback models
Mehranirad (2025)	2025	Iran	Teacher training + AI tools	Intervention	60 EFL teachers	Instructional design	AI-supported PD improved teachers' use of ZPD-aligned materials

The studies vary in geographical location, AI technologies, and design, but all have a prolonged interest in personalized language and literacy learning within the ZPD theoretical framework.

Thematic Synthesis

Theme 1: AI Applications Supporting Scaffolding

Most of the reviewed studies captured the use of AI to offer scaffolding in real time through features such as creation of hints, cycles of automated feedback, and pacing by adaptation. For instance, Amiri et al. (2025) demonstrated how an AI-based vocabulary game dynamically adjusted difficulty levels according to the performance of learners, capturing strategic scaffolding. Similarly, Liu and Wang (2024) demonstrated how AI applications supplemented metacognitive scaffolding by enabling critical thinking in conducting tasks of literary analysis.

Du (2025) recognized how conversational AI agents operated as procedural scaffolds to EFL learners by means of elaborative questioning and summarization strategies that assisted self-regulation. They simulate human tutoring by modulating their support via learner input, as advocated in Vygotsky's view of guided learning that takes place in the ZPD.

Theme 2: AI in ZPD-Sensitive Instruction

Several studies explicitly applied ZPD principles. Cai et al. (2025) used adaptive tutoring systems that estimated the ZPD of each learner and adjusted the progression of the content based on it. According to Ghimire and Neupane (2024), the teachers who employed AI indicated that AI helped in closing the gap of the ZPD, particularly in the transition of novice to intermediate levels.

Bahari et al. (2025) emphasized how AI systems used performance data on learners to adjust the challenges appropriately- so that the tasks were within the ZPD of each student. This type of progression monitoring enables the gradual withdrawal of support as the learners become more competent.

Theme 3: Outcomes on Language and Literacy Learning

The application of the artificial intelligence technology is linked to positive results in language and literacy learning. Yaseen et al. (2025) wrote about flexible platforms that were used to improve reading comprehension and engagement based on adaptive feedback. Mavidi (2025) found that AI-mediated and real-time correction led to improved accuracy and fluency in pronunciation, and that Zapata (2025) and Torres and Statti (2025) found that generative AI liquids enabled creativity in composing and promoted more dynamic multimodal literacy.

Theme 4: Learner Profiles and Equity Consequences

Equity-related themes emerged in studies of ELLs, students with fewer device-access opportunities, or students with varying learning differences. Almuhanna (2024) and Singh (2024) stated that teacher awareness and digital literacy had a significant influence on the effectiveness of AI tools in less-resourced environments. Yaseen et al. (2025) explained that digital literacy served as a mediating factor for personalized feedback and that not all students benefit equally from scaffolding supported by AI unless there is an intervention to address underlying digital skills.

Theme 5: Limitations in Current Approaches

Despite the potential of AI-aided scaffolding, there remain limitations. Many studies highlighted that AI software is typically culturally insensitive and context-less (Bahari et al., 2025). Also, Mehranirad (2025) mentioned that the teachers require extensive training in their profession for successful incorporation of AI in their classes. Moreover, data privacy and algorithmic bias in personalization concerns are not yet fully explored (Singh & Goyal, 2025). Finally, it was concluded that theoretical consistency with ZPD is substantial, but empirical evidence operationalizing gains in learning through ZPD-consistent scaffolding is limited in some domains and for certain ages by this time (Singh, 2024).

Hence, the findings of this systematic review imply that while many AI-powered education software features resemble scaffolding, misalignments between underlying theory and design intentions such as the Zone of Proximal Development (ZPD) persist. For example, ChatGPT and Duolingo provide real-time feedback, yet no system has been found to demonstrate adaptive challenge calibration within a learner's ZPD (Amiri et al., 2025; Lee & Bang, 2025). This suggests an important distinction: most tools automate support rather than providing developmentally responsive scaffolding.

In addition, although the literature generally invokes scaffolding, there is little research clarifying whether AI systems model or dynamically adjust ZPD for learners (Du, 2025; Torres & Statti, 2025). This is a critical theoretical omission: AI systems typically function outside of formative feedback loops that are required to steer learners' progress through their ZPD.

Conclusion

It was a systematic review that explored the intersection of the AI-based learning technologies, scaffolding theory, and Zone of Proximal Development (ZPD) developed by Vygotsky in the context of personalized language and literacy education. The results show that even though AI systems have already advanced in their ability to make teaching individual through adaptive feedback and tracking of performance, a considerable number of them cannot reflect the more subtle theoretical undertones of scaffolding or model ZPD dynamics.

It is important to note that AI systems with interactive hints, challenge calibration and metacognitive support are more aligned with the principles of scaffolding and show a higher probability of successful literacy results (Amiri et al., 2025; Ali et al., 2025; Tolibovna, 2024). The general presence of conceptual haze and lack of operational faith in relation to ZPD as presented in most AI tools implies that people are mostly working on automation as opposed to development.

In order to realize the potential of AI in teaching literacy, practitioners and designers need to work together in the design of theory-oriented, context-sensitive, tools that are not just concerned with the performance measurements but also the cognitive preparedness of the students. The deployment of AI in the context of educational psychology can turn technology into the passive instructor, namely, scaffolding and ZPD.

Finally, the findings make the case of a human-focused vision of educational AI, which does not ignore the indispensable role of teachers, adds sociocultural perspectives, and prioritizes equitable access and design. AI would become a disruptive changes agent to individualized learning, in this setup, especially in the early learning areas of language and literacy instruction.

Implications for Instructional Design

The instructional design implications are a few. Teachers and developers must design AI tools that transcend static adaptation to contextualized scaffolding, such as metacognitive cues and strategy recommendations based on students' evolving needs (Tolibovna, 2024; Cai et al., 2025). For example, procedural scaffolds can be effectively delivered via NLP-enabled tutors for sentence composition and grammar drills (Ali et al., 2025), whereas strategic scaffolds may be better suited for teacher-modeling.

Instructional designers could also find through the use of ZPD-sensitive algorithms that identify the range of the present proficiency of a learner and change the difficulty of tasks based on that range (Alrawashdeh 2023; Singh 2024). Dynamic calibration, as opposed to a consistent, one-size-fits-all automation is still what is needed to be faithful to the theoretical frame as suggested by Vygotsky.

Ethical and Equity Considerations

Ethical and equity issues about artificial intelligence arise in K-12 language instruction. First, algorithmic bias—specifically NLP model bias—can disenfranchise speakers of non-standard dialects or multilingual learners, increasing educational inequality (Zafar & Afzal, 2025; Kayyali, 2025). Second, language access inequalities can

persist as AI tutors are trained on predominantly English corpora, diminishing their usefulness for English Language Learners (ELLs) in multilingual classrooms (Yaseen et al., 2025).

Further, the over-reliance on AI automation may inadvertently displace essential teacher-mediated interactions. While AI offers efficiency and scalability, it is not a substitute for the relational and intuitive dimensions of human scaffolding (Ghimire & Neupane, 2024; Walter, 2024). As such, balanced models that blend machine intelligence and human mentorship are necessary (Hamid, 2025).

Limitations of Current Research

Despite accumulating evidence, the current research is confronted with several limitations. First, longitudinal studies tracking the long-term cognitive and linguistic impact of AI tools are lacking (Mehranirad, 2025). Most of the evaluations continue to be short-term and task-based, and they offer no hint of the manner in which AI scaffolding impacts deep comprehension or literacy development in the long term.

Second, operationalization of ZPD is either unclear or variable across studies. While some models mention ZPD conceptually, there are few that operationalize it into empirical models embedded in tool design or assessment (Sidorkin, 2025; Singh & Goyal, 2025). Additionally, there is an asymmetric reliance on proxy measures, i.e., test scores or user engagement, rather than substantive indicators of learning transfer or metacognitive development (Gautam, 2024).

Future Research Directions

The synthesis of current literature reveals major opportunities for research development at the intersection of artificial intelligence, scaffolding theory, and language and literacy education. Several significant directions emerge:

Design-Based Research Integrating AI and Developmental Psychology

Design-based research strategies that incorporate AI development together with developmental psychology and education theory expertise need to be adopted in future work. This would enable iterative development and testing of AI-driven interventions using ZPD-inspired and scaffolded learning approaches (Amiri et al., 2025; Torres & Statti, 2025). Collaborations between cognitive scientists, teachers, and AI developers can enable tools to be sensitive to learner cognition and development rather than simply engineering for the optimization of engagement metrics.

Hybrid Human-AI Scaffolding Models

Given the limitations of automation alone, there is a pressing need for models of AI-based scaffolds coupled with human-mediated instruction. Future research should explore hybrid learning environments in which AI provides procedural and strategic supports and teachers address emotional, motivational, and metacognitive scaffolding (Ali et al., 2025; Lee & Bang, 2025). Such hybrid models are particularly relevant to multilingual and multicultural classrooms, where sensitive human feedback remains crucial.

Development of ZPD-Aware AI Architectures

A second priority is the creation of ZPD-sensitive AI architectures—intelligent systems that can discern a learner's actual and potential level of development and modulate instruction accordingly. This would involve building into the AI decision-making process models of challenge calibration, performance history, and learner feedback (Cai et al., 2025;

Du, 2025). These architectures will need to be capable of adjusting dynamically over time, capturing a teacher's moment-to-moment judgment in zone-sensitive instruction.

Longitudinal and Cross-cultural Research.

The existing literature is limited by the presence of short-term methodology frameworks and absence of cultural diversity. Therefore, one of the main directions that I would focus future research on is longitudinal research to capture long-term cognitive and literacy outcomes of AI-based interventions with special attention to the deep-learning outcomes over short-term assessment scores (Mehranirad, 2025). Furthermore, cross-cultural research is required to explain the functioning of AI tools in the context of the heterogeneous lingual and cultural environments, and define the ways scaffolding mechanisms need to be changed to consider the contextual variations (Sidorkin, 2025; Walter, 2024).

Discrimination against Under-represented Groups of Learners.

The analysis of AI-enhanced scaffolding related to under-represented or marginalized populations of learners is an urgent research gap. Such groups include the students in low resource settings, neurodiverse students, and people with partial education attainment in formal schooling. Future research should explore the practice of using AI as a scalable scaffolding among these groups of individuals, thus promoting equality and inclusivity in the field of educational innovation (Yaseen et al., 2025; Zafar and Afzal, 2025).

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