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The evolution of CALL (Computer-Assisted Language Learning) to AI-driven SLA: A Literature-Based Synthesis

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ABSTRACT

This literature-based synthesis examines the historical and conceptual shift from Computer-Assisted Language Learning (CALL) to Artificial Intelligence-mediated approaches in Second Language Acquisition (SLA). The study aims to trace the evolution of CALL, analyze how AI transforms language learning processes, and identify the pedagogical and ethical implications of AI enhanced instruction. A structured review of scholarly work from applied linguistics, educational technology, and artificial intelligence was conducted using peer reviewed sources from 1996 to 2024, alongside foundational texts that shaped CALL and SLA theory. The synthesis integrates empirical, theoretical, and technological research, employing thematic and chronological analysis to connect CALL developments with emerging AI practices. Findings reveal that CALL laid essential pedagogical foundations centered on interaction, autonomy, and communicative authenticity, but struggled with adaptivity, contextual feedback, and cultural mediation. AI expands these foundations by enabling personalized learning pathways, intelligent tutoring, automated feedback, and data informed instructional design. However, the analysis also identifies challenges related to algorithmic bias, data privacy, teacher autonomy, learner identity, and risks of dehumanized instruction. The study concludes that AI represents not a replacement of CALL but an expansion of its principles into more adaptive and data driven environments. Future research must address ethical governance, teacher training, and equitable access to ensure that AI supports humanistic, context sensitive, and socially grounded language education.

INTRODUCTION

The integration of digital technologies into language education has progressed through several transformative stages, beginning with the early adoption of Computer-Assisted Language Learning (CALL) and extending to the rapid rise of Artificial Intelligence in Second Language Acquisition (AI-driven SLA). CALL has long been recognized as a central area of applied linguistics research, representing shifts in pedagogical thought, technological affordances, and learner needs. Early CALL approaches, rooted in behaviorist epistemology and drill-based practice, emerged in the 1960s and 1970s through systems such as PLATO, which provided structured computer mediated exercises for language learners (Chapelle, 2001; Levy, 1997). As language learning theories evolved, so did CALL, moving toward communicative and integrative models that emphasized interaction, meaning making, and learner engagement (Warschauer, 1996, 1998; Garrett, 1991, 2009). With the rise of sociocultural and constructivist perspectives, CALL began to support collaborative tasks, authentic communication, and learner agency (Kern, 2006; Blake, 2013; Lamy & Hampel, 2007). Throughout these developments, CALL research has frequently highlighted both the potential and the limitations of computer mediated environments in addressing learner differences, facilitating adaptive feedback, and providing context rich interactional opportunities (Hubbard, 2009; Stockwell, 2007; Bodnar *et al.*, 2017).

In recent years, a profound technological and conceptual shift has occurred with the growth of Artificial Intelligence, which has generated new forms of automation, personalization, and interaction in SLA. AI driven language learning is supported by advances in natural language processing, intelligent tutoring systems, machine learning, and conversational agents (Heift & Schulze, 2015; Zawacki Richter *et al.*, 2019; Fischer *et al.*, 2020). Unlike traditional CALL, which often relied on rule-based systems, AI enabled tools can analyze learner data, adapt content in real time, and simulate meaningful communicative exchanges. Studies have shown that adaptive learning environments can increase learner engagement, support individual pacing, and provide nuanced feedback aligned with learner performance (Holmes *et al.*, 2022; Wong & Wang, 2021). AI powered systems such as chatbots, automated writing evaluators, and intelligent tutoring systems are now being integrated into mainstream educational practice, offering new possibilities for learner autonomy and context sensitive learning (Li, 2022; Godwin Jones, 2021; Popenici & Kerr, 2017).

Despite these innovations, the field continues to grapple with important pedagogical, theoretical, and ethical questions. Contemporary SLA theory emphasizes interaction, meaningful input, output production, and sociocultural mediation (Krashen, 1982; Long, 1996; Swain, 2000; Vygotsky, 1978). Researchers therefore debate whether AI systems can authentically support such processes or if they risk reducing language learning

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to data driven optimization (Reinders, 2016; Zhao, 2023). Scholars also highlight concerns about algorithmic transparency, data privacy, bias, and the potential displacement of teacher roles in automated environments (Robert *et al.*, 2020; Holmes *et al.*, 2022; Popenici & Kerr, 2017). These tensions reflect a broader need to evaluate how technological innovation aligns with pedagogical principles and learner wellbeing.

Furthermore, the shift from CALL to AI driven SLA is not only technological but conceptual. CALL scholarship has consistently underscored that effective language learning requires thoughtful, theory informed design rather than technological determinism (Chapelle, 2003; Levy & Stockwell, 2006; Bax, 2003). AI amplified approaches appear to resonate with post method perspectives that reject one size fits all techniques and instead emphasize flexibility, contextual sensitivity, and learner centeredness (Kumaravadivelu, 2006; Reinders & Hubbard, 2013). At the same time, sociocultural and identity-based research suggests that digital tools shape learner motivation, participation, and self-perception in complex ways (Norton, 2013; Ushioda, 2011). As AI systems mediate more learning experiences, these psychosocial dimensions become central to understanding their educational implications.

Given the rapid expansion of AI technologies, there is a need for comprehensive synthesis that traces the historical evolution from CALL to AI driven SLA and critically evaluates the theoretical and pedagogical implications. While several studies examine components of CALL or specific AI applications, fewer works integrate these strands to provide a holistic historical and conceptual account. A literature-based synthesis allows the mapping of developments across decades, connecting foundational CALL research with emerging AI focused scholarship. Such an approach can illuminate patterns, identify persistent gaps, and highlight tensions between technological innovation and pedagogical integrity.

The objective of this paper is therefore to provide a systematic synthesis of the evolution from CALL to AI driven SLA. It examines the historical trajectory of CALL, the technological and theoretical foundations of AI mediated language learning, and the sociocultural, psycholinguistic, and ethical considerations shaping contemporary SLA environments. Through this synthesis, the paper seeks to articulate how AI is reconceptualizing the nature of language learning and to outline future research directions that prioritize both innovation and sound pedagogy. As language education continues to digitize, it is essential to ensure that advances in AI complement, rather than replace, human interaction and teacher expertise.

Research Questions

This study is guided by the following research questions, which aim to explore the developmental trajectory and pedagogical implications of the shift from CALL to AI mediated SLA:

1. How has Computer Assisted Language Learning evolved over time in terms of technological development, theoretical foundations, and pedagogical orientation?
2. In what ways do contemporary Artificial Intelligence driven tools and environments transform the processes of second language learning, including interaction, personalization, and learner agency?
3. What pedagogical, theoretical, and ethical considerations emerge from the integration of AI into SLA, and how do these issues inform future directions for technology enhanced language education?

Research Objectives

To address the above questions, the study pursues the following research objectives:

1. To synthesize historical and contemporary scholarship in order to map the evolution of CALL and its underlying theoretical and pedagogical frameworks.
2. To examine the capabilities, mechanisms, and learning affordances of AI driven language learning tools, with attention to their impact on interaction, adaptivity, and learner experience.
3. To identify and critically evaluate the pedagogical, theoretical, and ethical issues associated with AI mediated SLA, and to propose directions for future research that balance technological innovation with pedagogical integrity.

MATERIALS AND METHODS

This study employs a literature-based synthesis to examine the evolution from CALL to AI mediated SLA. A literature-based synthesis analyzes existing scholarly works rather than collecting empirical data, and it is appropriate for topics that require historical interpretation, conceptual comparison, and analysis of pedagogical trends across decades. By drawing from published research in CALL, applied linguistics, educational technology, and artificial intelligence, this approach enables integrated examination of technological developments, theoretical shifts, and their implications for language education.

Relevant sources were identified through searches in Google Scholar, Scopus, Web of Science, ERIC, and journal repositories in applied linguistics and educational technology. The review focused on literature published from the mid-1990s to 2024, while also incorporating earlier foundational works as necessary to contextualize historical and theoretical development. Only peer reviewed journal articles, academic books, book chapters, and reputable conference publications directly related to CALL, AI based language learning, SLA theory, or technology enhanced pedagogy were included. Commercial reports lacking academic review or works unrelated to pedagogical perspectives were excluded.

The synthesis drew on theoretical writings on CALL and SLA, empirical studies evaluating digital tools, technological research describing AI applications in education, and critical scholarship addressing ethical and pedagogical issues. This range allowed for

multidisciplinary interpretation of how AI builds upon, extends, and challenges earlier CALL paradigms. The analysis combined chronological mapping of CALL and AI developments with thematic comparison of concepts such as adaptivity, autonomy, interaction, teacher mediation, and ethical concerns.

Like other literature based approaches, this method is limited by reliance on published scholarship, which may overlook emerging commercial tools or undocumented classroom practices. It does not gather primary data and therefore cannot generalize learner outcomes beyond what is reported in the reviewed studies. Nevertheless, the method remains well suited to identifying historical patterns, conceptual shifts, and ongoing tensions that shape technology mediated language learning.

THE EVOLUTION OF CALL: HISTORICAL AND THEORETICAL FOUNDATIONS

The development of Computer Assisted Language Learning (CALL) reflects a long trajectory of pedagogical experimentation, theoretical refinement, and technological innovation within language education. Over six decades, CALL evolved from behaviorist drill and practice programs to communicative, integrative, and constructivist environments that use multimedia, networked communication, and learner centered principles. Scholars in applied linguistics and educational technology have identified distinct phases in this evolution, each shaped by learning theories and available technologies (Chapelle, 2001; Levy, 1997; Warschauer, 1996, 1998; Garrett, 1991, 2009). This section synthesizes the historical and theoretical foundations of CALL to clarify how earlier developments prepared the ground for AI mediated approaches in SLA.

Early CALL and Behaviorist Roots

Early CALL emerged in the 1960s and 1970s with structuralist linguistics and behaviorist learning theory. Systems such as PLATO provided repetitive drills, corrective feedback, and controlled practice designed to reinforce linguistic structures (Levy, 1997; Warschauer, 1996). These systems operationalized stimulus response learning and emphasized accuracy and habit formation (Chapelle, 2001). They prioritized discrete grammar instruction and memorization, with limited opportunities for interaction or creativity.

Despite technological constraints and linear programming, early CALL introduced influential ideas such as computer-based assessment, automated feedback, and individualized pacing (Hubbard, 2009; Davies *et al.*, 2013). Critiques later targeted its decontextualized practice and limited communicative value, as cognitive and humanistic theories emphasized meaningful input and processing (Kern, 2006). These concerns encouraged a move beyond behaviorist paradigms.

Communicative CALL

The rise of communicative language teaching (CLT) in the late 1970s and 1980s transformed CALL. SLA scholars emphasized meaningful communication, negotiation of meaning, and interactive feedback (Long, 1996; Krashen, 1982; Swain, 2000). Communicative CALL shifted toward tasks involving interpretation, expression, and problem solving (Warschauer, 1996, 1998; Garrett, 1991). Software included simulations, reconstruction activities, and contextualized tasks that promoted engagement with authentic texts.

Personal computers and early networking expanded communicative CALL through email interaction, online forums, and telecollaboration (Kern, 2006; Lamy & Hampel, 2007). These developments aligned CALL with interactionist perspectives and strengthened the pedagogical value of communication (Chapelle, 2003; Egbert & Hanson Smith, 1999). Limitations remained, particularly in adaptive feedback and realistic conversational exchange (Stockwell, 2007), paving the way for integrative and constructivist CALL.

Integrative and Constructivist CALL

The late 1990s and early 2000s marked a shift toward integrative and constructivist CALL, supported by multimedia, hypertext, and internet technologies. Integrative CALL used web platforms, virtual classrooms, and synchronous communication that enabled multimodal engagement with authentic contexts (Kern, 2006; Blake, 2013). Constructivist perspectives emphasized active meaning making through social interaction (Vygotsky, 1978). Studies highlighted tools such as video conferencing and discussion platforms that supported collaboration, negotiation, and intercultural communication (Lamy & Hampel, 2007; Levy & Stockwell, 2006; Garrett, 2009). These aligned with sociocultural theories that view learning as mediated by interaction, identity, and participation (Norton, 2013; Ushioda, 2011). The integrative phase also encouraged autonomy through self-paced exploration and digital portfolios (Benson, 2001), although challenges such as uneven participation and digital literacy persisted.

Strengths and Limitations of Traditional CALL

Traditional CALL produced strengths including autonomy, multimodal engagement, authentic communication, and flexible access. Studies show CALL enhances motivation and individualized learning (Chapelle, 2003; Blake, 2013; Stockwell, 2007). It supports collaboration and intercultural exchange (Lamy & Hampel, 2007; Kern, 2006).

Limitations include inadequate adaptive feedback, preprogrammed responses, unequal access, and superficial engagement when technology is prioritized over pedagogy (Hubbard, 2009; Bax, 2003). These limitations encouraged research into systems capable of analyzing learner input and adapting instruction in real time.

CALL's Contribution to Technology Mediated Language Learning

CALL contributed core ideas still present in AI mediated

learning, including interaction, feedback, autonomy, and digital communication (Chapelle, 2001, 2003; Levy & Stockwell, 2006). It established methodological traditions in evaluating tools and analyzing interaction (Garrett, 2009; Hubbard, 2009).

CALL shaped the goals of intelligent tutoring systems and adaptive platforms that extend personalization and communication (Heift & Schulze, 2015). The move from CALL to AI represents expansion rather than rupture, building on decades of pedagogical insight. CALL laid the groundwork for contemporary innovations that seek to improve adaptivity while maintaining the communicative and humanistic foundations of language learning.

EMERGENCE OF AI IN LANGUAGE EDUCATION

The integration of Artificial Intelligence into language education represents a major transformation following the development of CALL. AI has expanded possibilities for individualized learning, naturalistic communication, and data driven instructional design. Advances in machine learning, natural language processing, intelligent tutoring systems, and adaptive feedback now drive many digital language learning environments. Scholars in educational technology and applied linguistics examine how these tools reshape input, interaction, and learner autonomy (Heift & Schulze, 2015; Zawacki-Richter *et al.*, 2019; Fischer *et al.*, 2020). This section synthesizes major technological and conceptual developments distinguishing AI mediated learning from earlier CALL models.

Technological Developments Enabling AI in SLA

AI in language education is rooted in advances in computational linguistics, neural networks, and machine learning. Probabilistic models and deep learning architectures now support automated speech recognition, syntactic parsing, and semantic interpretation (Russell & Norvig, 2021; Jurafsky & Martin, 2023). In education, these developments enable systems that respond dynamically to learner input and monitor performance in real time (Fischer *et al.*, 2020; Holmes *et al.*, 2022). Cloud computing and big data infrastructures allow platforms to analyze large learner corpora, facilitating personalization at scale (Wong & Wang, 2021). Improvements in speech technologies have also expanded opportunities for oral practice and pronunciation support. Together, these innovations situate AI based SLA within broader algorithmically mediated learning environments.

Key AI Tools: NLP, Intelligent Tutoring Systems, and Chatbots

Natural Language Processing (NLP)

NLP supports automated writing evaluation, error detection, text simplification, and adaptive glossing. Deep learning models identify linguistic patterns and provide feedback based on learner performance (Fischer *et al.*, 2020). NLP tools are widely used for vocabulary learning and reading support (Godwin-Jones, 2021).

Intelligent Tutoring Systems (ITS)

ITS evaluate learner input, diagnose errors, and deliver tailored instruction using learner, domain, and pedagogical models (Heift & Schulze, 2015). These systems offer adaptive sequencing and immediate feedback aligned with cognitive skill development.

Chatbots and Conversational Agents

Conversational agents provide opportunities for simulated interaction and low stakes speaking practice. Recent neural models generate contextually relevant responses, supporting pragmatic development and negotiation of meaning (Popenici & Kerr, 2017; Fischer *et al.*, 2020). Mobile language learning increasingly integrates chatbots to offer ubiquitous conversational support (Godwin-Jones, 2021). Across these tools, AI's distinct contribution lies in its ability to analyze learner input, generate relevant output, and adapt responsively to individual needs.

Adaptive Learning Algorithms and Personalization

Adaptive learning is a central feature of AI mediated SLA. Machine learning models predict learner proficiency, knowledge gaps, and affective states, enabling dynamic adjustment of content and feedback (Holmes *et al.*, 2022). These systems rely on learner modeling to represent performance through probabilistic or neural mechanisms (Heift & Schulze, 2015). Adaptive analytics optimize task difficulty, sequence materials, and differentiate feedback in real time (Wong & Wang, 2021). This aligns with post method pedagogy emphasizing contextual sensitivity and learner centeredness (Reinders & Hubbard, 2013) and reflects SLA principles of input, scaffolding, and interaction (Krashen, 1982; Long, 1996; Swain, 2000). Emerging affective computing approaches also monitor motivation and engagement, adjusting strategies based on emotional responses.

AI vs. CALL: A Conceptual Shift

While AI builds on CALL foundations, it introduces a shift from tool-based support to model-based mediation. Traditional CALL supported instruction but lacked autonomous decision making. AI systems interpret learner behavior and tailor learning pathways, functioning as semi-autonomous instructional agents (Zawacki-Richter *et al.*, 2019; Fischer *et al.*, 2020). This creates new possibilities but raises concerns about data ethics, opacity, and overreliance on automated systems (Popenici & Kerr, 2017; Holmes *et al.*, 2022).

AI also challenges humanistic and sociocultural perspectives emphasizing identity, agency, and interaction within authentic communities (Norton, 2013; Ushioda, 2011). Although AI facilitates interaction and feedback, it cannot fully replicate relational communication. Scholars therefore call for critical balance, ensuring that AI supplements rather than replaces human mediation. Overall, AI represents both continuity with CALL and a reconceptualization of how language learning is supported

through intelligent, adaptive, and data informed systems.

THEORETICAL IMPLICATIONS FOR SLA

The emergence of AI in language education has generated significant theoretical implications for contemporary SLA. Unlike earlier computer-based environments, AI systems not only deliver content but make instructional decisions using learner data. These developments intersect with major SLA theories including post method pedagogy, sociocultural theory, interactionist approaches, psycholinguistics, and affective perspectives. This section examines how AI reshapes and challenges these frameworks.

AI and Post-Method Pedagogy

The integration of AI driven systems aligns closely with post method pedagogy. Kumaravadivelu (2006) describes post method teaching as context based, rejecting rigid prescriptions in favor of learner needs, teacher autonomy, and sociocultural relevance. AI appears to support this by offering adaptive pathways, individualized sequencing, and data informed scaffolding. These systems operationalize the principle of particularity through localized instruction (Reinders & Hubbard, 2013) and enhance practicality by converting analytics into pedagogical options (Holmes *et al.*, 2022). Conversational agents and tutoring systems also expand learner agency, in line with the principle of possibility (Godwin-Jones, 2021).

However, algorithmic decision making may undermine teacher autonomy if educators depend too heavily on automated adjustments. Popenici and Kerr (2017) warn that unchecked AI may shift authority from teachers to opaque systems. AI should therefore complement rather than replace post method pedagogy, allowing teachers to critically guide its use.

Sociocultural Perspectives: Identity, Interaction, Mediation

Sociocultural theory views language learning as socially mediated through interaction, identity, and participation (Vygotsky, 1978; Norton, 2013). AI tools can support mediated communication through chatbots and collaborative platforms, enabling negotiation of meaning and exposure to pragmatic language use (Kern, 2006; Blake, 2013). Such systems may lower anxiety and provide safe spaces for experimentation.

Yet identity formation and cultural participation rely on human relationships that AI cannot authentically reproduce. Studies show that learner identity is co constructed through empathy, reciprocity, and social affiliation (Lamy & Hampel, 2007; Ushioda, 2011). Excessive reliance on automated interaction risks limiting opportunities for authentic cultural engagement. AI thus highlights the need for balance between algorithmic support and socially grounded learning.

Psycholinguistic Dimensions: Processing, Input Enhancement

Psycholinguistic theories emphasize how learners process input, notice features, and produce output (Krashen, 1982; Swain, 2000; Long, 1996). AI systems provide new opportunities by offering real time enhancement and corrective feedback tailored to learner needs (Heift & Schulze, 2015). NLP based tools analyze output immediately and help learners notice and restructure linguistic forms. Chatbots can negotiate meaning and scaffold output, extending Long's interaction hypothesis.

However, automated feedback may remain overly prescriptive or ignore discourse level features (Hubbard, 2009). AI can also promote superficial efficiency if learners depend on correction without meaningful processing. Thus, AI can support psycholinguistic development, but effective design must preserve communicative purpose rather than mechanical accuracy.

Affective and Motivational Factors in AI-Enhanced Learning

Affective factors such as anxiety and motivation strongly influence SLA (Ushioda, 2011). AI tools can reduce stress through individualized feedback and low stakes conversational practice, benefiting hesitant or introverted learners (Wong & Wang, 2021). Personalization may increase willingness to communicate and persistence.

Yet emotionally detached environments can weaken motivation if tasks feel impersonal or overly monitored. Learners may experience stress when evaluated by invisible analytics (Holmes *et al.*, 2022), echoing critiques of dehumanized CALL environments (Kern, 2006). Effective implementation requires combining AI mediated support with teacher interaction, peer collaboration, and human encouragement.

Overall, AI introduces new emotional dynamics without replacing affective dimensions of SLA. Its potential must be balanced with human mediated guidance to sustain motivation, identity, and meaningful communication.

PEDAGOGICAL IMPLICATIONS

The integration of Artificial Intelligence in second language learning offers notable pedagogical opportunities while presenting new challenges for teachers, learners, and institutions. AI reshapes instructional design, expands learner autonomy, and redefines teacher roles, while also raising concerns related to ethics, dehumanization, and unequal access. This section highlights the key implications of AI mediated SLA.

Learner Autonomy and Agency

AI technologies support learner autonomy through personalized pathways, individualized pacing, and adaptive feedback aligned with learner needs (Benson, 2001; Chapelle, 2003). Adaptive systems generate customized tasks and targeted scaffolding based on performance data (Heift & Schulze, 2015), promoting self-directed engagement beyond classroom boundaries through mobile tutors and conversational platforms (Godwin-Jones, 2021). These opportunities align with

post method pedagogy, which supports learner driven strategies (Kumaravadivelu, 2006).

However, autonomy in AI environments requires digital literacy and metacognitive awareness. Learners may treat AI as a corrective shortcut rather than a tool for strategic learning. Without teacher support, autonomy risks becoming passive dependence on automated solutions, emphasizing the need for critical digital awareness to navigate algorithmic feedback effectively.

Teacher Roles in AI-Enhanced Classrooms

AI changes teacher responsibilities from delivering content to designing, mediating, and ethically supervising learning. Teachers interpret system recommendations, contextualize feedback, and facilitate sociocultural interaction (Holmes *et al.*, 2022). AI can support teachers by diagnosing errors or predicting learner needs (Wong & Wang, 2021), but does not replace human expertise.

Scholars warn that reliance on automated systems may undermine teacher autonomy and reduce professional judgment (Popenici & Kerr, 2017; Bax, 2003). Since language learning is relational, teachers remain essential for empathy, interaction, and identity support (Kern, 2006; Norton, 2013). The teacher's role is therefore not diminished but redirected toward pedagogical and ethical mediation.

Instructional Design for AI-Based Learning

Instructional design for AI mediated SLA must incorporate communicative, sociocultural, and psycholinguistic principles rather than delegating learning to automation. AI should enhance interaction, noticing, and negotiation of meaning, consistent with interactionist theories (Long, 1996; Swain, 2000). Designers should embed tasks requiring collaboration and authentic discourse, which AI alone cannot replicate (Lamy & Hampel, 2007). Tools must serve as scaffolds, not substitutes for communicative pedagogy.

Instruction should also include reflection on AI ethics and algorithmic decision making so learners can interpret automated feedback critically. Developing AI literacy enables students to understand how systems operate and question technological authority.

Challenges: Over-Reliance, Dehumanization, Digital Divide

AI raises risks of over reliance, with learners becoming dependent on automated correction rather than internalizing linguistic patterns. This can discourage risk taking and weaken output-based learning (Swain, 2000). Teachers may also over delegate instructional responsibility to AI, diminishing the relational aspects of language learning (Popenici & Kerr, 2017).

Dehumanization can occur when instruction lacks empathy and emotional connection. Mechanistic environments may reduce motivation and personal investment, echoing critiques of earlier CALL (Kern, 2006). Ethical concerns about data harvesting further complicate trust in learning processes (Holmes *et al.*, 2022).

Finally, AI may widen the digital divide. Access to AI tools varies across socioeconomic and regional contexts, limiting participation in personalized learning experiences. Inequality in access, long recognized in CALL research, continues to impact learner outcomes (Davies *et al.*, 2013). Addressing disparities requires institutional investment, equitable infrastructure, and inclusive policy that supports fair distribution of AI opportunities.

ETHICAL AND CRITICAL CONSIDERATIONS

As AI becomes increasingly integrated into second language learning, ethical concerns emerge regarding the governance and social implications of intelligent systems. Issues related to algorithmic bias, data privacy, ethical data use, and sustainability affect how AI can be responsibly employed in education. These concerns highlight the need to balance technological innovation with equity, human rights, and pedagogical values.

Algorithmic Bias and Fairness

AI systems rely on data driven models that may inherit linguistic and cultural biases present in training corpora. As a result, language technologies can reproduce discriminatory norms, misinterpret learner input, or privilege dominant English varieties while marginalizing multilingual voices. Popenici and Kerr (2017) caution that these systems embed assumptions that may influence educational decisions without transparency. In SLA, biases can affect pronunciation scoring, automated writing evaluation, and interactional feedback.

Scholars emphasize the need for fairness audits and ethical safeguards to prevent AI from reinforcing linguistic inequalities (Zawacki-Richter *et al.*, 2019; Holmes *et al.*, 2022). Because language learning requires cultural variation and pragmatic nuance, systems must be designed with inclusive datasets and culturally responsive parameters to protect equity.

Data Privacy in AI Systems

AI mediated environments collect extensive personal data including voice samples, keystrokes, emotional predictions, and behavioral analytics. Although these data support personalization, they also raise privacy risks. Holmes *et al.* (2022) note that learners often lack awareness of how their data are stored, processed, or sold to third parties. Companies can monetize learner information by refining proprietary systems or sharing metadata.

These practices raise questions about consent and ownership. Ethical implementation requires transparent data communication and compliance with privacy frameworks. Without such transparency, learners may become participants in educational surveillance systems that limit autonomy and undermine trust.

Ethical Use of Learner Data

Ethical risks extend beyond privacy to how institutions interpret and act on learner data. Predictive analytics may label or track students, shaping access to opportunities through automated judgments. Popenici and Kerr (2017) warn that profiling can reinforce inequality. In SLA, such analytics may influence placement, feedback, and instructional pathways.

To ensure responsible use, educators must mediate algorithmic outputs through human judgment. AI should serve as assistive support, not a mechanism that governs learner potential. Ethical guidelines should prioritize agency, informed consent, and critical interpretation of analytics.

Sustainability and Long-Term Impacts

AI introduces long term concerns related to infrastructure, teacher training, and equitable access. Without sustained investment, AI adoption can widen gaps between well resourced and under resourced institutions (Davies *et al.*, 2013). Sustainability also relates to pedagogy. Kern (2006) argues that technology enhanced learning must align with humanistic values rather than innovation for its own sake. Commercial pressures also influence AI development. Godwin-Jones (2021) notes that corporate interests may prioritize profit over pedagogy, risking commodification of learning. Ethical sustainability requires transparency, cultural inclusivity, and democratic access to AI tools.

Responsible AI in SLA depends on continuous ethical evaluation and equitable infrastructure. As language education adopts intelligent systems, it is critical to ensure that technology supports human development, learner dignity, and educational justice.

RESULTS AND DISCUSSION

The evolution from traditional CALL to AI-mediated SLA marks both continuity and transformation in technology-enhanced language learning. Earlier developments in CALL established foundational principles of learner-centered interaction, autonomy, and computer-supported communication, while contemporary AI expands these principles by introducing adaptive personalization, semi-autonomous feedback, and data-driven decision-making. This synthesis highlights conceptual convergences and divergences between CALL-era thinking and AI-era ideologies, emphasizing unresolved tensions that continue to shape the field.

CALL scholarship consistently emphasized that technology should serve pedagogical aims rather than dictate instructional practices (Chapelle, 2003; Levy & Stockwell, 2006). Researchers argued that communicative authenticity, learner agency, and sociocultural engagement constituted core requirements for meaningful language learning (Warschauer, 1996, 1998; Kern, 2006; Lamy & Hampel, 2007). Contemporary AI-driven approaches build on these values, offering tools that can adapt to learner levels, scaffold interaction, and deliver individualized support (Heift & Schulze, 2015; Fischer *et al.*, 2020). AI systems extend CALL's vision by providing granular insights into learner performance and facilitating semi-automated conversational practice through chatbots and intelligent tutors (Godwin-Jones, 2021).

However, the shift from tool-based CALL to model-based AI introduces a new ideology in which learning is increasingly shaped by computational inference rather than human instructional design. AI systems learn from large datasets, generate predictions, and operate autonomously to select learning content (Holmes *et al.*, 2022). This represents a conceptual shift from technology as a pedagogical resource to technology as an instructional agent. While this supports individualized learning, it also risks reducing pedagogy to algorithmic optimization. Popenici and Kerr (2017) caution that algorithmic decision-making may limit teacher agency and reframe educational values around efficiency and measurable outputs.

Comparing CALL and AI reveals a distinct tension between technological sophistication and pedagogical integrity. CALL research emphasized the social and cultural nature of language learning (Kern, 2006; Norton, 2013; Ushioda, 2011). AI systems, by contrast, primarily operationalize cognitive and behavioral dimensions of learning through predictive modeling and automated feedback. Although chatbots simulate interaction, they cannot replicate the identity formation, empathy, negotiation of meaning, or intercultural awareness that arise from human communication. Sociocultural theories therefore underscore the need to maintain human mediation as a core dimension of language learning, even as AI expands the scope of instructional possibilities.

Another critical issue involves data ethics and learner autonomy. AI-driven SLA supports learner choice and self-direction, yet this autonomy is mediated through algorithmic pathways that may remain invisible to learners. Learners may appear independent while being subtly guided by automated recommendations. Benson (2001) and Kumaravadivelu (2006) highlight autonomy as an ethical and pedagogical right, not merely a functional skill. In AI-enabled contexts, true autonomy requires learners to understand how their data is used and how AI systems shape learning trajectories.

Unresolved issues in the literature include the question of how AI can support identity, motivation, and affect, which are central to SLA but difficult to model computationally. While AI tools can reduce anxiety and facilitate low-stakes practice (Wong & Wang, 2021), scholars warn that emotionally detached environments may undermine motivation and relational engagement (Kern, 2006). Research has yet to fully address how affective and relational dimensions can be integrated into AI-driven systems without compromising humanistic pedagogy.

A further concern involves equity and access. CALL scholars repeatedly documented disparities in technological availability and digital literacy (Davies *et al.*, 2013), and AI intensifies these inequalities due to higher infrastructural demands, subscription-based platforms, and the commercial monetization of language learning. As Godwin-Jones (2021) notes, commercial interests increasingly shape

technological development, raising questions about whose educational priorities are being served.

Toward a Balanced Framework

Synthesizing insights from CALL-era and AI-era research suggests the need for a balanced framework in which AI supports, but does not replace, humanistic and socially grounded pedagogy. Such a framework would include:

Adaptive Personalization with Human Mediation

AI provides real-time feedback and individualized pathways, while teachers interpret data and maintain sociocultural relevance.

Communicative Authenticity with Algorithmic Support

AI tools scaffold practice and noticing, but authentic human interaction remains central to identity formation and language socialization.

Critical Autonomy

Learners must be empowered not only to use AI tools but also to understand and critique the algorithmic structures that shape their learning.

Ethical Stewardship

Transparent data policies and culturally inclusive models ensure that AI serves educational equity rather than algorithmic bias or commercial interests.

Overall, AI does not replace the pedagogical foundations established by CALL. Instead, it amplifies and extends them, while introducing new ethical, relational, and epistemological questions. The future of SLA requires integrating technological innovation with a deep commitment to humanistic learning, ensuring that AI remains a supportive presence in language education rather than a dominant force that redefines learning on computational terms.

CONCLUSION

This literature-based synthesis traces the evolution of technology-mediated language learning from early CALL to contemporary AI-driven SLA. CALL established core principles such as learner autonomy, communicative engagement, and constructivist interaction that continue to shape digital language pedagogy. Building on these foundations, AI introduces intelligent adaptivity, data-driven feedback, and semi-autonomous systems that enable large-scale personalization. Whereas CALL functioned mainly as a pedagogical support within teacher-led frameworks, AI increasingly shapes instructional pathways through algorithmic decision-making. This shift reflects both continuity and disruption, raising new pedagogical, theoretical, and ethical considerations.

AI demonstrates strong potential for individualized learning, enhanced communicative practice via conversational agents, and real-time feedback and analytics (Heift & Schulze, 2015; Fischer *et al.*, 2020). However, it also introduces concerns related to algorithmic opacity, teacher agency, data privacy, and the risk of reducing language learning to measurable outputs (Popenici & Kerr, 2017; Holmes *et al.*, 2022). If humanistic dimensions are neglected, AI may undermine the sociocultural richness of SLA.

Future research should emphasize ethical frameworks, AI literacy, multimodal and identity-sensitive systems, and long-term impacts on motivation, equity, and teacher roles, ensuring AI supports ethical, inclusive, human-centered pedagogy.

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