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Integrating CALL and AIALL for an interactive pedagogical model of language learning

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Abstract
Given the great potential of integrating Computer-Assisted Language Learning (CALL) and Artificial Intelligence-Assisted Language Learning (AIALL) to enhance language learning outcomes, there is a growing interest in exploring their combined effects. In this vein, the present study aimed to develop and test an interactive pedagogical model of language learning (IPMLL) by integrating CALL and AIALL elements in a combined module. To further investigate the effects of this model, a comprehensive evaluation was conducted, considering various aspects such as learner motivation, personalized learning experiences, and feedback effectiveness. The results indicate that (1) the integration of CALL and AIALL in the IPMLL positively influenced learner motivation, leading to greater involvement and active participation in language learning activities; (2) the personal learning interactions facilitated by the IPMLL, including adaptive instruction and intelligent feedback, contributed to improved language proficiency and learner satisfaction. Theoretically, this integration aligns with established pedagogical theories and frameworks, such as cognitive theories of multimedia learning, emphasizing the significance of interactive and technology-enhanced learning environments. Pedagogically, the IPMLL offers practical implications for teachers, highlighting the benefits of incorporating CALL and AIALL elements in language teaching methodologies. This study contributes to the growing body of research on technology-enhanced language learning and provides insights for future developments in this field.

Keywords Interactive pedagogical model of language learning · IPMLL · Computer-assisted language learning · CALL · Artificial intelligence-assisted language learning · AIALL

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1 Introduction

The domains of Computer-Assisted Language Learning (CALL) and Artificial Intelligence-Assisted Language Learning (AIALL) have garnered significant attention in the domain of language education (An et al., 2023; Bin-Hady et al., 2023). CALL, which entails the utilization of computer technology to facilitate language learning, and AIALL, which integrates artificial intelligence (AI) tools and techniques to augment language learning outcomes, have demonstrated numerous advantages for language learners, including heightened motivation, personalized learning experiences, and enhanced feedback (Chamboko-Mpotaringa & Manditereza, 2023; Ji et al., 2023; Weng & Chiu, 2023).

Traditionally, CALL has been primarily focused on providing learners with a broad spectrum of multimedia resources, interactive exercises, and online language learning platforms (Chen & Yuan, 2023; Dao et al., 2024). These tools have demonstrated their effectiveness in promoting learner autonomy and offering valuable opportunities for practice and feedback beyond the confines of the classroom (Liu & Gablasova, 2023; Jeon et al., 2023; Xiao et al., 2023). On the other hand, AIALL has become as a promising approach that harnesses the power of AI advancements, such as natural language processing (NLP) and machine learning, to deliver smart tutoring programs, adaptive learning environments, and automated assessment tools (Alqahtani et al., 2023; Kamalov et al., 2023). These AI-based tools hold great potential in providing personalized instruction, adaptive feedback, and intelligent analysis of learner performance (Lin et al., 2023a, b; Yesilyurt, 2023). The integration of CALL and AIALL is supported by various theoretical frameworks, establishing a robust foundation for combining these two approaches and with an ultimate aim of enhanced language learning outcomes (Barrot, 2024; Valledor et al., 2023). CALL theories place significant emphasis on leveraging technology to improve language learning outcomes. The multimedia learning cognitive theory (Karakaya & Bozkurt, 2022; Li & Lan, 2022), for instance, posits that incorporating interactive multimedia elements in language learning can enhance learners' comprehension and retention of information (Bahari, 2022; Teng, 2023). Through the integration of CALL, which provides access to multimedia resources and interactive activities, learners can actively engage with diverse modalities of input and practice, thereby fostering deeper learning and advancing their language proficiency (Bahari et al., 2023; Hu, 2023; Pu & Chang, 2023). This integration facilitates the creation of dynamic and interactive language environments for learning that promote participation and meaningful experiences (Liu et al., 2023).

AI-assisted language learning theories underscore the significance of AI in supporting language learning processes (Zhai, 2023; Zou et al., 2023a). AI-powered adaptive learning systems have the capability to personalize instruction based on learners' individual needs, preferences, and performance (Essa et al., 2023; Rad et al., 2023; Sayed et al., 2023; Wang et al., 2023). This personalized approach aligns with the constructivist theory of learning (Gibson et al., 2023; Jin et al., 2024), which emphasizes learners' active construction of knowledge through meaningful interactions with the learning environment (Huang et al., 2023a, b; Liang et al., 2023; Xia et al., 2022). By integrating CALL with AIALL, learners can benefit from personalized

feedback, adaptive content recommendations, and targeted interventions that address their specific language learning challenges (Bahari et al., 2021; Hockly, 2023; Paladines & Ramirez, 2020). This integrated approach enhances learner autonomy, motivation, and engagement, ultimately leading to more effective language acquisition (Amaral & Meurers, 2011; Bahari, 2019, 2021). Furthermore, Vygotsky's (1978) sociocultural theory underscores the utmost significance of social interaction and collaboration in the language learning process. The integration of CALL and AIALL presents abundant opportunities for learners to engage in interactions, peer collaboration, and receive feedback (Alam, 2021; Chabot et al., 2020). AIALL offers simulated communication scenarios, virtual language exchanges, and intelligent chatbots that facilitate learners' participation in authentic communicative tasks (Huang, 2022; Jin, 2023; Tai, 2024). These interactions foster social interaction and collaborative learning experiences, aligning with the sociocultural theory that emphasizes on the significance of social interaction in language learning (Tai & Chen, 2023). Through practicing their language skills in realistic contexts, receiving immediate feedback, and engaging in meaningful conversations, learners can enhance their communicative competence.

This research seeks to examine the effect of the integration of CALL and AIALL in the context of foreign language learning; known as the interactive pedagogical model of language learning (IPMLL) versus CALL or AIALL alone approach to develop foreign language learning proficiency. By exploring the underlying theories of both CALL and AIALL, this study aims to contribute valuable insights into how this combination – IPMLL approach can enhance language proficiency and learner satisfaction. The outcomes of this investigation will offer practical guidance to educators, researchers, and designers in the development of effective language learning environments that capitalize on the strengths of CALL and AIALL, ultimately optimizing language learning outcomes. The IPMLL incorporates various components that support efficient language acquisition and improve language learning experiences. One key component of the IPMLL is the use of interactive language learning platforms of CALL, which offer an intuitive user interface and a variety of interactive exercises (Cheng et al., 2020; Yang et al., 2022; Zhang et al., 2022). These platforms allow learners to practice language skills in an engaging and interactive manner. Another component is the integration of adaptive learning algorithms of AIALL, which analyze learner data to personalize the learning experience (Iyer et al., 2023). These algorithms adapt the exercises' content and degree of difficulty according to individual needs, ensuring tailored instruction (Mehta et al., 2023). The IPMLL also incorporates NLP features of AIALL, such as speech recognition, automated feedback, and conversation simulations (Huang et al., 2023a, b; Tafazoli et al., 2019). These features enhance learners' speaking and listening skills by providing opportunities for practice and improvement (Tai, 2022; Zou et al., 2023a). Intelligent tutoring systems (ITS) of AIALL are integrated into the IPMLL, offering personalized guidance and feedback to learners. These systems identify areas of weakness, suggest relevant resources, and provide corrective feedback, supporting individualized learning and skill development. This study introduces the IPMLL, a novel framework that integrates CALL and AIALL to create adaptive, personalized, and interactive learning environments. The IPMLL addresses a critical gap in the literature by com-

bining the strengths of these two approaches and grounding them in cognitive and sociocultural theories.

Drawing on the nonlinearity and dynamicity of language learning motivation (Bahari, 2019), the IPMLL includes a variety of CALL tools and components such as gamification components (e.g. points, badges, and leaderboards), to cater to the dynamic nature learning motivate make the language learning process more engaging. Content integration of CALL is another crucial component, where various types of multimedia content, including text, audio, video, and interactive exercises, are integrated to develop different language skills and maintain learner engagement (Kasneci et al., 2023). Furthermore, learner progress tracking functionalities of CALL are incorporated into the IPMLL, allowing educators to monitor learners' progress, identify areas for improvement, and adapt teaching strategies accordingly. The combined module of CALL and AIALL in the IPMLL creates interactive language exercises that provide personalized feedback, incorporate speech recognition for pronunciation practice, offer automated writing correction and feedback, and facilitate virtual conversations and role-plays with AI-guided feedback. This integrated approach offers immersive and tailored language learning experiences. By leveraging these pedagogical principles and incorporating the main components of CALL and AIALL, the IPMLL enhances language learning experiences and promotes effective language acquisition.

2 Literature review

2.1 Overview of language learning models

Language learning models, theories, and approaches are important in understanding the process of language acquisition (Ellis, 2010). These models provide a theoretical foundation for educators and researchers to comprehend how individuals learn and develop proficiency in a new language (Gass & Mackey, 2014). Among the most widely recognized language learning models are the communicative approach, cognitive theories, and sociocultural perspectives (Lantolf, 2011). These models offer valuable insights into the different aspects of language learning and highlight the factors that contribute to successful language acquisition (Lin et al., 2017; Yang et al., 2018). The communicative approach, for instance, emphasizes the importance of meaningful interaction in learning a language (Hung & Higgins, 2016; Gràcia et al., 2023). It suggests that learners acquire language skills through authentic communication and real-life situations, where they engage in purposeful conversations and exchange information. This approach recognizes the significance of context and encourages learners to use language in meaningful and communicative ways. Cognitive theories, as explored by Jiang and Zhang (2020) and Liang and Hwang (2023), emphasizing the mental processes involved in learning a language. These theories explore how learners acquire new vocabulary, grammar rules, and language structures through cognitive processes such as attention, memory, and problem-solving (Bahari et al., 2023). By investigating how learners organize and store language information in their minds, cognitive theories contribute to the development of lin-

guistic competence. On the other hand, sociocultural perspectives, as highlighted by Liu et al. (2022), emphasize the role of social interactions and cultural contexts in language development. According to this perspective, language is a social and cultural phenomenon as well as a cognitive process. (Yeh & Mitric, 2023). Language acquisition occurs through active participation in social activities, interaction with others, and immersion in the cultural practices of a specific community (Chen, 2016). This perspective acknowledges that language learning is influenced by social factors such as norms, values, and cultural expectations.

2.2 Computer-assisted language learning (CALL)

CALL is an instructional approach that harnesses the power of computer technology and digital resources to facilitate language learning. It encompasses a diverse range of tools and applications, including multimedia materials, online platforms, and language learning software (Lin et al., 2023a, b; Salih & Omar, 2021; Zhang & Zou, 2022). One of the main advantages of CALL is its ability to offer learners with self-paced learning opportunities (Chen et al., 2020a, b). Learners have access to language learning materials and activities at their own convenience, allowing them to progress through the content at a pace that suits their individual needs and preferences (Banumathi, 2023). This flexibility enables learners to take control of their learning process and tailor it to their specific goals and learning styles. Interactive exercises are another important aspect of CALL (Shin et al., 2023). These exercises engage learners actively in the language learning process by providing opportunities for practice and application of language skills. Through interactive exercises, learners can reinforce their understanding of vocabulary, grammar, pronunciation, and other language components in an engaging and interactive manner (Almusharraf & Bailey, 2023). This hands-on approach helps learners develop their language skills more efficiently. CALL also offers access to a wide range of authentic materials, such as videos, podcasts, articles, and online resources. These authentic materials can help develop learners' listening and reading skills while gaining exposure to diverse linguistic and cultural knowledge (Yeh & Heng, 2022).

2.3 Artificial intelligence-assisted language learning (AIALL)

AIALL is a rapidly developing instructional approach that integrates AI technologies into language learning environments (Bozkurt et al., 2021; Jeon et al., 2023). AIALL leverages NLP, machine learning algorithms, and ITS to provide personalized instruction, adaptive feedback, and automated assessment (Bozkurt et al., 2021; Jeon et al., 2023). One of the key advantages of AIALL is its ability to provide personalized instruction (Kamruzzaman et al., 2023). AIALL systems can analyze learners' language proficiency levels, identify areas of strengths and weaknesses, and provide tailored learning experiences that meet learners' individual needs and preferences (Chang et al., 2023). This personalized approach enables learners to receive targeted instruction that is relevant to their specific language learning goals (Wang et al., 2022). AIALL systems provide real-time and adaptive feedback on learners' language use, pronunciation, grammar, and other language components (Zou et al.,

2020). The adaptive Being based on learners' performance and customized to their individual learning needs, the adaptive feedback helps learners identify areas for improvement and adjust their language learning strategies accordingly (Chen et al., 2022a, b). Another significant feature of AIALL is its ability to generate automated assessments, which can accurately measure learners' language proficiency (Zhao et al., 2023). Moreover, AIALL systems are able to inform instructional design and pedagogies approaches which adjust patterns of learner performance (Nong et al., 2021).

2.4 Conceptual framework of IPMLL – integrating CALL and AIALL

The IPMLL, which integrates CALL and AIALL in language learning combines the strengths of both approaches to create interactive and adaptive learning environments. Theoretical frameworks, such as the cognitive theory of multimedia learning and sociocultural theories of language development, provide a basis for integrating CALL and AIALL (Lantolf, 2011; Mayer, 2002; Mohammed & Watson, 2019; Paas & Sweller, 2012). The IPMLL allows learners to benefit from the interactive and engaging features of CALL, such as multimedia materials and interactive exercises, while also leverages the personalized instruction and adaptive feedback provided by AIALL (Wang & Xu, 2023). Blending CALL and AIALL provides a flexible and dynamic learning environment that caters to learners' individual needs and preferences (Li & Peng, 2021; Wu et al., 2023). By incorporating AIALL technologies into CALL environments, learners can engage in computer-mediated communication, interact with peers and native speakers, and access authentic materials that reflect real-life language use and cultural contexts. The IPMLL framework builds on the cognitive theory of multimedia learning, which emphasizes the role of interactive multimedia in enhancing comprehension and retention, and Vygotsky's sociocultural theory, which highlights the importance of social interaction in language development. By integrating CALL and AIALL, the IPMLL provides a theoretically grounded model for creating dynamic, learner-centered language learning environments.

The present study was guided by a conceptual framework aimed at exploring the effective integration of CALL and AIALL in language learning environments (Weng & Chiu, 2023). The IPMLL framework emphasizes instructional design, technology integration, and learner-centeredness as critical components (Bahari, 2021) (Fig. 1). Specifically, the instructional design is important in the framework, involving selecting appropriate technologies, designing language learning activities and tasks aligned with language learning objectives, and providing personalized feedback tailored to individual learner needs (Chang et al., 2023; Hasibuan et al., 2023). The instructional design drew from relevant pedagogical theories, such as cognitive load theory and social constructivism, to ensure a strong theoretical grounding (Murtaza et al., 2022). Apart from instructional design, another crucial aspect of the IPMLL was technology integration, which aimed to provide a seamless integration of CALL and AIALL into language learning environments. This encompassed ensuring the availability of the required technical infrastructure, delivering comprehensive training to both teachers and learners on the effective utilization of these technologies, and promptly addressing any technical challenges that emerged during the integration process (Alresheed et al., 2017).

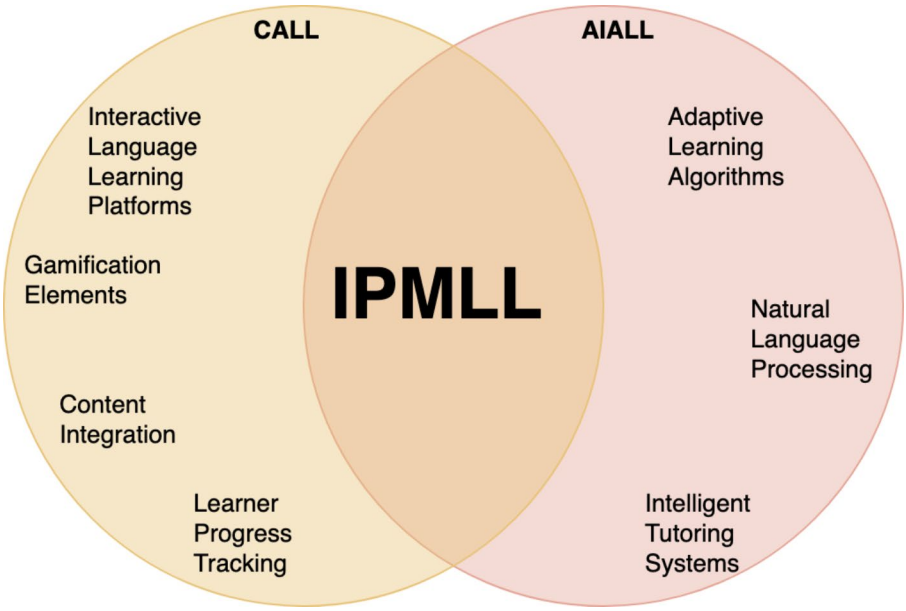

Fig. 1 IPMLL framework build on CALL and AIALL modules

Furthermore, the technology integration also took into account the ethical considerations associated with incorporating AIALL into language learning environments, including privacy concerns, data security and potential biases in algorithmic decision-making (Zou, Guan et al., 2023; Ntoutsi et al., 2020). The IPMLL framework incorporated the following components to enhance language learning outcomes. Interactive Language Learning Platforms were utilized to provide learners with interactive and engaging language learning experiences (Choi & Chung, 2021). Adaptive Learning Algorithms were used to garner learner data to personalize the learning experience and offer tailored feedback (Pradana et al., 2022). NLP facilitated learners' interaction with language learning technologies using natural language (Shardlow et al., 2022). ITS were employed to provide learners with individualised feedback and guidance (Erümit & Çetin, 2020). Gamification Elements were integrated to make language learning more engaging and motivating (Dermeval et al., 2019; Wang & Han, 2021). Content Integration ensured that language learning activities were aligned with language learning objectives (Crosthwaite et al., 2023). Learner Progress Tracking allowed learners to monitor their progress and receive feedback on their performance (Du et al., 2023).

The framework also placed a strong emphasis on learner-centeredness, recognizing the active and central role of learners in the language learning process. It aimed to meet the unique needs and preferences of learners by prioritizing personalized feedback, opportunities for reflection, and learner autonomy (see Table 1).

Table 1 Components of the CALL, AIALL, and IPMLL

Components	Context	Critical Elements	Description
Interactive Language Learning Platforms	CALL	User-friendly interface and interactive exercises	Provides a platform for learners to practice language skills through a range of interactive exercises.
Adaptive Learning Algorithms	AIALL	Personalized learning experience	Analyzes learner data to personalize the learning experience by adapting the content and difficulty level of exercises based on individual needs.
NLP	AIALL	Speech recognition, automated feedback, and conversation simulations	Enhances learners' speaking and listening skills through features like speech recognition, automated feedback, and simulated conversations.
ITS	AIALL	Personalized guidance and feedback	Provides individualized guidance and feedback to learners by identifying areas of weakness, suggesting relevant resources, and offering corrective feedback.
Gamification Components	CALL	Points, badges, and leaderboards	Incorporates game-like components to motivate learners and make the language learning process more engaging and enjoyable.
Content Integration	CALL	Multimedia content integration	Integrates various types of multimedia content, such as text, audio, video, and interactive exercises, to develop different language skills and maintain learner engagement.
Learner Progress Tracking	CALL	Progress tracking	Tracks learners' progress to monitor performance, identify areas for improvement, and adapt teaching strategies accordingly.
Combined Module	CALL & AIALL	Interactive exercises with personalized feedback, speech recognition for pronunciation practice, automated writing correction and feedback, virtual conversations and role-plays with AI-guided feedback.	Combines the strengths of CALL and AIALL to create interactive language exercises that provide personalized feedback, incorporate speech recognition for pronunciation practice, offer automated writing correction and feedback, facilitate virtual conversations and role-plays with AI-guided feedback. This integrated approach offers immersive and tailored language learning experiences.

2.5 Research objectives and research questions

The integration of CALL and AIALL has attracted significant scholarly attention in recent years. Research studies have examined various facets of this integration, including the effectiveness of different instructional approaches, the impact on language learning outcomes, and the perceptions of teachers and learners (Wang, 2022). Several studies have demonstrated the positive effects of integrating CALL and AIALL on language learning outcomes (Bin-Hady et al., 2023; Chen et al., 2022a, b; Ebadi & Amini, 2022; Han, 2020). For instance, research has shown improvements in learners' language proficiency, vocabulary acquisition, and speaking skills (Gayed et al., 2022; Kim et al., 2019). Learners have also reported increased motivation and engagement when utilizing these technologies in their language learning activities (Bahari et al., 2023). However, despite these positive findings, there are still gaps in the existing literature that require attention. Specifically, more research is needed on

the practical implementation of integrating CALL and AIALL in diverse language learning contexts and the identification of best practices for effective integration (Dwivedi et al., 2023), which requires continued exploration and examination of the integration of CALL and AIALL.

The current study continued this line of research by developing a comprehensive language learning environment – IPMLL, which seamlessly integrated CALL and AIALL in order to provide that promotes engaging and personalized language learning experiences. The objectives of this study was: (1) to examine the practical implementation of the IPMLL and (2) to test the effectiveness of the IPMLL in terms of developing foreign language proficiency and learner satisfaction. The practical implementation of IPMLL includes creating interactive learning activities, personalized learning pathways, and intelligent assessment mechanisms. The significance of this research lies in its contribution to empirical evidence to support the implementation of IPMLL and to the ongoing discussions on innovative approaches to language learning in the digital age.

The research objectives were achieved by answering the following research questions:

RQ1: To what extent do EFL students, who incorporate the principles of the IPMLL, demonstrate significantly greater improvements in language proficiency compared to students in the comparison group?

RQ2: How do EFL students perceive the efficacy of CALL components (Interactive Language Learning Platforms, Gamification Components, Content Integration, and Learner Progress Tracking) and AIALL components (Adaptive Learning Algorithms, NLP, and ITS) in improving their language learning outcomes within the context of the IPMLL?

3 Research design

3.1 Participants

The sample for the study consisted of 144 undergraduate students (76 females and 68 males) enrolled in English as a Foreign Language (EFL) teaching programs at Azad University in Tehran, Iran. The university was selected as the research site due to its diverse student population and well-established language programs. The selection of participants was based on voluntary participation and availability during the designated study period. The age of participants ranged from 18 to 25 years, with a mean age of 21 years, representing young adult learners in a critical phase of academic and linguistic development. Participants were distributed across all four academic years of the undergraduate program, ensuring representation from first-year to final-year students.

English language proficiency was categorized as intermediate to advanced, based on standardized proficiency assessments aligned with the Common European Framework of Reference for Languages (CEFR) levels B2 to C1. The average duration of English language study among participants was six years, with a range of four to nine years. All participants reported prior experience with computer-based lan-

guage learning platforms and regular engagement with educational technology in academic activities. Technological proficiency was rated as moderate to high by 84% of participants, reflecting familiarity with tools relevant to the study. Socioeconomic backgrounds were diverse, with the majority (approximately 78%) identifying as middle-income, while the remainder represented lower- or upper-income households.

To enhance internal validity and ensure sample homogeneity, an exhaustive outlier analysis was conducted following the methodological guidelines outlined by Tabachnick and Fidell (2013). This analysis identified and excluded 18 data points that significantly deviated from the normative range, resulting in a final sample of 144 participants. Ethical standards were rigorously upheld throughout the research process. Informed consent was obtained from all participants to ensure voluntary involvement, and confidentiality measures were implemented to protect personal information and maintain anonymity. Participants were randomly assigned to one of four groups, each receiving a specific type of treatment based on the experimental condition:

Experimental Group 1 (CALL Group, $n = 34$).

- *Interactive Language Learning Platforms*: Participants used platforms like Rosetta Stone and Duolingo. These platforms provided structured interactive exercises in grammar, vocabulary, and listening comprehension. Each session included predefined learning objectives aligned with the Common European Framework of Reference for Languages (CEFR) to ensure consistency and measurable progress.
- *Gamification Components*: The intervention incorporated elements such as point systems, leaderboards, and achievement badges. These components were designed based on established motivational theories, such as Self-Determination Theory, to enhance intrinsic motivation by fulfilling the needs for competence, autonomy, and relatedness.
- *Content Integration*: Authentic materials, including news articles and videos, were selected based on relevance to the learners' cultural and linguistic context. The materials were evaluated for linguistic complexity using tools like the Lexile Framework to ensure they were appropriately challenging for the learners' proficiency levels.
- *Learner Progress Tracking*: A comprehensive tracking system was employed, capturing data on engagement, accuracy, and completion rates. This data was analyzed using statistical software to identify trends and provide individualized feedback, facilitating targeted interventions.

Experimental Group 2 ($n = 36$) received an educational intervention administered by their instructor, who relied on components of AIALL. Similar to Experimental Group 1, this group participated in 22 intervention sessions, each lasting 90 min. The intervention focused on utilizing Adaptive Learning Algorithms, such as those found in platforms like Babbel or Memrise. These algorithms dynamically adjusted the content and difficulty level of language learning materials based on individual learners' needs and performance. NLP techniques were employed to analyze learners' written or spoken language input, providing automated feedback and targeted error correction through platforms like Grammarly or Language Tool. Furthermore, ITS, such

as Carnegie Learning or Knewton, were utilized to provide personalized guidance and support to participants according to their strengths, weaknesses, and learning preferences.

- *Adaptive Learning Algorithms*: AI platforms employed machine learning models to personalize learning paths. Algorithms analyzed user performance data to adjust the difficulty and focus of exercises, aiming to maintain an optimal challenge level (Zone of Proximal Development).
- *NLP Tools*: Participants interacted with NLP-based systems that supported real-time conversation practice. These systems were evaluated for their accuracy in understanding and generating language, ensuring meaningful and contextually appropriate interactions.
- *ITS*: AI tutors provided scaffolded support, offering hints and explanations as needed. The effectiveness of these systems was assessed through pre- and post-intervention tests to measure gains in specific language skills.

Experimental Group 3 ($n=36$) received an educational intervention administered by their instructor, who integrated components of both CALL and AIALL. Like the previous groups, this group engaged in 22 intervention sessions, each lasting 90 min. The specific combination of CALL and AIALL components used in this group's intervention varied depending on the instructor's pedagogical approach and available resources. For example, participants may have utilized interactive language learning platforms from CALL while also benefiting from adaptive learning algorithms or ITS from AIALL.

- *Hybrid Learning Platforms*: The integration of CALL and AIALL components was structured to maximize synergies. Participants alternated between interactive exercises and AI-driven adaptive tasks, with the sequence and duration optimized based on cognitive load theory.
- *Dynamic Content Delivery*: AI algorithms selected content that matched learners' proficiency and learning objectives, supported by data analytics to ensure content diversity and relevance. Learners' engagement with the content was continuously monitored to adapt delivery strategies.
- *Collaborative Learning Features*: Technology-facilitated group activities were designed to promote peer interaction and collaborative problem-solving. The activities were grounded in social constructivist theories, emphasizing the role of social interaction in cognitive development.

Lastly, the control group ($n=38$) received regular courses without receiving any additional educational intervention. These courses followed a standard curriculum and utilized commonly used tools and features. Participants in the control group engaged in activities such as online language exercises, interactive multimedia materials, and virtual language practice sessions. The focus was on developing language skills through structured lessons and practice opportunities provided by established platforms, such as Duolingo, Babbel, or Rosetta Stone. The control group's learning consisted of the regular sessions and duration as the other experimental groups, with

22 sessions lasting 90 min each. The purpose of the control group was to serve as a comparison to assess the effectiveness of the specific interventions implemented in the experimental groups.

- *Traditional Language Exercises*: The control group followed a standard curriculum with exercises focused on grammar, vocabulary, and comprehension skills. These exercises were aligned with institutional learning outcomes to ensure consistency across groups.
- *Interactive Multimedia*: Multimedia resources were used to support language learning, but lacked the interactive and adaptive elements present in the experimental groups. The selection of multimedia was based on pedagogical principles of multimodal learning.
- *Virtual Practice Sessions*: Regular practice sessions were conducted to reinforce language skills. These sessions followed a traditional format, with teacher-led instruction and individual practice, allowing for a direct comparison with the enhanced interventions.

3.2 Instruments and data analyses

3.2.1 Pretest and posttest of english proficiency

The study implemented a pretest-posttest design to evaluate participants' English language proficiency using the Oxford Placement Test (OPT), a globally recognized standardized assessment tool. The OPT was selected due to its robust psychometric properties, including high validity and reliability, as well as its alignment with the Common European Framework of Reference for Languages (CEFR). The CEFR provides an internationally accepted framework for assessing language proficiency levels ranging from A1 to C2. Adaptations were made to the pretest and posttest versions of the OPT to ensure equivalence in difficulty and content, thereby minimizing potential test-retest bias and enhancing methodological rigor. The assessment instrument comprehensively evaluated four core language skills: reading, writing, listening, and speaking. The reading section included comprehension passages followed by multiple-choice questions designed to assess understanding, vocabulary knowledge, and inferencing abilities. The writing section involved a structured essay task requiring participants to produce a short composition of 150–200 words on a specific topic. Written responses were evaluated using a rubric incorporating coherence, grammatical accuracy, lexical range, and task completion. The listening section involved audio recordings, such as conversations and announcements, followed by questions assessing comprehension of spoken English. The speaking section consisted of a structured oral interview, during which participants responded to prompts designed to measure fluency, accuracy, pronunciation, and interactive communication. Equal weight was assigned to each language skill, with a maximum score of 20 points per skill, resulting in a total possible score of 80.

The validity and reliability of the adapted OPT were rigorously evaluated to ensure the scientific soundness of the assessment. Expert reviews conducted by language assessment specialists confirmed the alignment of test items with CEFR standards

and ensured contextual appropriateness for the participants' academic environment. A pilot study involving 30 participants, excluded from the main study, was conducted to evaluate the equivalence of the pretest and posttest versions, confirm the clarity of instructions, and assess the suitability of scoring rubrics for the writing and speaking sections. Results from the pilot study demonstrated high internal consistency, with a Cronbach's alpha of 0.91, indicating excellent reliability. Inter-rater reliability for the writing and speaking sections achieved a high agreement rate of 92%, further validating the scoring process. The pretest was administered prior to the intervention to establish baseline proficiency levels, while the posttest was conducted following the intervention period to measure progress.

Statistical analyses were performed to examine differences in pretest and posttest scores in the pilot. Paired *t*-tests revealed statistically significant improvements in proficiency levels within the experimental groups, with p-values below 0.01. Effect sizes were calculated using Cohen's d, with values ranging from 0.6 to 0.8, indicating moderate to large effects of the intervention on language proficiency. The rigorous selection, adaptation, and validation of the OPT, combined with comprehensive statistical analyses, ensured a methodologically sound evaluation of the intervention's impact on English language proficiency.

3.2.2 Students' perceptions assessment questionnaire

To rigorously explore EFL students' perceptions of components in CALL and AIALL within the framework of Integrated Personalized Mobile Language Learning (IPMLL), a 12-item questionnaire was meticulously developed. This instrument employed a 6-point Likert scale, designed to capture nuanced levels of student satisfaction with components such as Interactive Language Learning Platforms, Gamification Components, Content Integration, and Learner Progress Tracking in CALL, as well as Adaptive Learning Algorithms, NLP, and ITS in AIALL.

The questionnaire was structured to measure perceptions across seven theoretically derived dimensions, reflecting the core functionalities of CALL and AIALL systems. Each dimension was operationalized through items designed to evaluate specific technological and pedagogical affordances within the IPMLL framework.

Adapted from a previously validated scale (Bahari, 2019), the questionnaire's foundation in established research (see Appendix A) ensured theoretical rigor. This adaptation involved an iterative process of expert reviews and pilot testing, which confirmed the instrument's content validity by aligning it with the specific context of the study. Expert feedback was used to refine items, ensuring clarity, relevance, and comprehensiveness.

Items were further adapted to align with the specific features of CALL and AIALL systems as conceptualized in the IPMLL framework. Guided by prior research on language learning technologies and pedagogical frameworks, each item was carefully worded to capture both functional and experiential aspects of the respective dimensions.

A panel of five experts in educational technology, second language acquisition, and psychometrics reviewed the initial set of items. The review focused on content validity (alignment with theoretical constructs), clarity and appropriateness of

item wording, and relevance of items to the EFL context. Feedback from the experts was incorporated iteratively to refine the questionnaire, ensuring it met the study's objectives.

The revised questionnaire was pilot-tested with a sample of 30 EFL students who shared similar demographic and linguistic characteristics to the target population. The pilot study aimed to assess the instrument's usability, clarity, and reliability. Minor adjustments were made to improve item comprehensibility and alignment with students' experiences.

To assess the reliability and validity of the questionnaire, Cronbach's alpha was calculated for each scale, yielding coefficients ranging from 0.66 to 0.78. While these values suggest a satisfactory level of internal consistency, further analyses were conducted to enhance the instrument's psychometric robustness. Exploratory factor analysis (EFA) was employed to examine the underlying factor structure of the questionnaire.

Principal axis factoring was used as the extraction method to account for potential non-normality in the data, and an Oblimin rotation was applied to allow for correlations between the theoretically related dimensions. The EFA revealed a seven-factor structure consistent with the theoretical dimensions. Factor loadings for all items exceeded 0.60, indicating strong item-factor relationships. The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.81, and Bartlett's test of sphericity was significant ($\chi^2 = 321.45$, $p < .001$), confirming the suitability of the data for factor analysis.

Additionally, confirmatory factor analysis (CFA) was conducted to validate the factor structure identified by EFA. The CFA model demonstrated good fit indices (CFI = 0.92, TLI = 0.90, RMSEA = 0.05), further confirming the construct validity of the questionnaire. These statistical analyses underscore the instrument's ability to reliably and validly measure students' perceptions across different components of CALL and AIALL. One-way ANOVAs and Turkey's HSD post-hoc analyses were used to answer the two research questions.

4 Results

4.1 Descriptive statistics

Table 2 presents the descriptive statistics of the pretest and posttest of the English proficiency among the four groups: Group 1 (CALL), Group 2 (AIALL), Group 3 (IPMLL), and Control Group.

4.2 Results of RQ1

The results of the ANOVAs of the Pretest and Posttest of English proficiency among the four groups are as follows. The ANOVA result for the Pretest of English proficiency was significant ($F(3, 140) = 4.896$, $p = .003$, $\eta^2 = 0.095$), indicating that four groups did not have the same level of English proficiency prior to the experiment. Tukey's HSD tests (see Table 3) was further conducted for pairwise comparison of Pretest English language proficiency. While there were no significant differences

Table 2 Descriptive statistics of the pretest and posttest of English proficiency among the four groups

		N	*M*	*SD*	95% Confidence Interval for Mean		Minimum	Max-imum
					Lower Bound	Upper Bound		
Pretest	CALL Group	34	29.85	3.276	28.71	31.00	25	35
	AIALL Group	36	30.31	4.465	28.79	31.82	24	38
	IPMLL Group	36	31.97	3.676	30.73	33.22	26	38
	Control Group	38	32.84	3.709	31.62	34.06	27	39
Posttest	CALL Group	34	47.35	4.512	45.78	48.93	41	55
	AIALL Group	36	50.67	5.138	48.93	52.41	41	68
	IPMLL Group	36	73.64	4.661	72.06	75.22	66	80
	Control Group	38	31.79	2.915	30.83	32.75	27	39

Table 3 The results of Tukey's HSD post-hoc tests on Pretest and Posttest of English proficiency

0			Mean Difference	*p*	95% Confidence Interval	
					Lower Bound	Upper Bound
Pretest of English Proficiency	CALL Group	AIALL Group	-0.453	0.960	-2.820	1.920
		IPMLL Group	-2.119	0.097	-4.490	0.250
		Control Group	-2.989*	0.006	-5.330	−0.650
	AIALL Group	CALL Group	0.453	0.960	-1.920	2.820
		IPMLL Group	-1.667	0.252	-4.000	0.670
		Control Group	-2.537*	0.025	-4.840	−0.230
	IPMLL Group	CALL Group	2.119	0.097	-0.250	4.490
		AIALL Group	1.667	0.252	−0.670	4.000
		Control Group	-0.870	0.760	-3.170	1.440
	Control Group	CALL Group	2.989*	0.006	0.650	5.330
		AIALL Group	2.537*	0.025	0.230	4.840
		IPMLL Group	0.870	0.760	-1.440	3.170
Posttest of English Proficiency	CALL Group	AIALL Group	-3.314*	0.010	-6.030	-0.600
		IPMLL Group	-26.286*	0.000	-29.00	-23.570
		Control Group	15.563*	0.000	12.880	18.240
	AIALL Group	CALL Group	3.314*	0.010	0.600	6.030
		IPMLL Group	-22.972*	0.000	-25.650	-20.300
		Control Group	18.877*	0.000	16.240	21.520
	IPMLL Group	CALL Group	26.286*	0.000	23.570	29.000
		AIALL Group	22.972*	0.000	20.300	25.650
		Control Group	41.849*	0.000	39.210	44.490
	Control Group	CALL Group	-15.563*	0.000	-18.240	-12.880
		AIALL Group	-18.877*	0.000	-21.520	-16.240
		IPMLL Group	-41.849*	0.000	-44.490	-39.210

Table 4 The results of Tukey's HSD post-hoc tests on perceptions of CALL and AIALL components

Dependent Variable			Mean Difference	*p*	95% Confidence Interval	
					Lower Bound	Upper Bound
Perceptions of CALL and AIALL Elements	CALL Group	AIALL Group	-0.100	0.730	-0.410	0.210
		IPMLL Group	-0.794*	0.000	-1.110	-0.480
	AIALL Group	CALL Group	0.100	0.730	-0.210	0.410
		IPMLL Group	-0.694*	0.000	-1.000	-0.390
	IPMLL Group	CALL Group	0.794*	0.000	0.480	1.110
		AIALL Group	0.694*	0.000	0.390	1.000

between CALL Group and AIALL Group, CALL Group and IPMLL Group, AIALL Group and IPMLL Group, and IPMLL and Control Group the scores of the Control Group differed significantly from CALL Group and AIALL Group. Specifically, Control Group had significantly higher scores than both CALL and AIALL Groups, with moderate effects.

In terms of the Posttest of English proficiency, the ANOVA result was significant with a large effect size ($F(3, 140) = 575.167$, $p < .001$, $\eta^2 = 0.925$), indicating substantial differences were found across the groups. The results of Tukey's HSD tests in Table 3 further showed that all the pairwise comparisons were significant. Specifically, we found that IPMLL Group had significantly higher Post English proficiency scores than the other three groups; whereas Control Group had significantly lower Post English proficiency scores than the other three groups. AIALL Group also had significant higher scores than CALL Group These suggest that the IPMLL had a much better effect in terms of developing English proficiency of EFL learners.

4.3 Results of RQ2

As the Control Group did not receive any treatment, the comparison of students' perceptions of the CALL and AIALL elements was only conducted among the rest of three experimental groups. The ANOVA result demonstrated a significant effect with a moderate effect size ($F(2, 103) = 21.943$, $p < .001$, $\eta^2 = 0.299$). The Tukey's HSD tests (Table 4) showed that while CALL and AIALL Groups did not differ in their perceptions, the two groups had significantly lower perception ratings than IPMLL Group.

4.4 Qualitative analysis

The qualitative analysis results indicated that the integration of interactive language learning platforms, gamification, content integration, learner progress tracking, adaptive learning algorithms, NLP, and ITS within the IPMLL framework significantly contributed to improved English language learning outcomes. Participants in the IPMLL group consistently emphasized the value of interactive platforms, particularly in fostering engagement and active participation. The inclusion of interactive exercises and real-time feedback was frequently highlighted as instrumental in promoting autonomy and providing dynamic opportunities for practice. These observations align with the superior posttest results achieved by the IPMLL group, demonstrat-

ing the effectiveness of interactive tools in creating highly engaging and immersive learning environments.

Gamification elements, such as points, badges, and leaderboards, were identified as critical components for maintaining motivation and encouraging consistent engagement. Participants reported that gamification features enhanced the enjoyment and perceived reward of the learning process, thereby fostering regular practice. The qualitative findings align with motivational theories, which emphasize the role of gamification in increasing intrinsic motivation. The integration of gamification within the IPMLL framework was strongly associated with improved proficiency, as reflected in posttest performance. In contrast, the absence of gamification in standalone CALL and AIALL tools was linked to lower engagement levels, as reported by participants in those groups.

Content integration emerged as a significant strength of the IPMLL framework, offering a cohesive and multimodal learning experience. The seamless combination of text, audio, video, and interactive exercises was frequently noted as reducing cognitive load and enhancing the ability to synthesize information across multiple modalities. Participants consistently linked this multimodal approach to meaningful learning experiences and higher proficiency outcomes. The findings underscore the importance of a unified and efficient learning environment in supporting comprehensive skill development across various language domains.

Learner progress tracking was identified as a vital feature, enabling participants to monitor individual strengths and weaknesses. Personalized feedback mechanisms were described as particularly valuable, as these facilitated targeted improvements and supported self-regulated learning. The combination of progress tracking with adaptive feedback systems provided actionable insights, which participants associated with measurable gains in language proficiency. The emphasis on individualized progress monitoring highlighted the importance of tailored feedback in fostering academic growth.

Adaptive learning algorithms were frequently noted for their ability to personalize the learning experience by adjusting content and difficulty levels according to individual needs. Participants reported that these algorithms effectively addressed specific challenges and maintained an optimal learning pace. The flexibility and customization afforded by adaptive technologies were consistently viewed as essential for sustaining engagement and focus. The qualitative findings confirmed the potential of adaptive learning systems to enhance efficiency and promote positive learning outcomes.

NLP tools were highlighted for their role in facilitating authentic language use. Features such as automated speech recognition, grammar correction, and conversational simulations were frequently cited as effective in improving speaking and writing skills. Participants emphasized the value of these tools in fostering meaningful interaction and providing immediate, context-specific feedback. The opportunity to engage in real-world communication scenarios was consistently linked to increased proficiency and confidence in language use.

ITS were recognized for providing personalized guidance and adaptive feedback. Participants reported that ITS effectively addressed individual learning gaps and offered tailored recommendations to enhance performance. The adaptive nature of

ITS was frequently mentioned as a key factor in maintaining motivation and focus, as it allowed learners to progress at an individualized pace while receiving continuous support. The integration of ITS within the IPMLL framework was identified as a critical component in promoting sustained engagement and facilitating targeted improvements in language proficiency.

The integration of CALL and AIALL within the IPMLL framework is not a simple combination of two models but a carefully designed system that leverages their strengths and addresses their respective limitations to achieve a synergistic effect. This integration enhances learning outcomes by creating a more comprehensive and adaptive approach to language education.

CALL systems excel in providing structured, multimodal, and interactive content but often lack adaptability to individual learner needs and real-time feedback (Cheng et al., 2020). Conversely, AIALL systems offer personalized learning through adaptive algorithms, intelligent tutoring, and NLP but are limited in their pedagogical structure and content resources (Yang et al., 2022). The IPMLL framework bridges these gaps by combining CALL's content-rich, pedagogically grounded environment with AIALL's adaptive and real-time capabilities. For instance, ITS embedded within CALL modules provide personalized feedback, while CALL components ensure that AIALL's adaptability is supported by rich, multimodal learning materials tailored to diverse learner needs.

The IPMLL framework achieves a synergistic effect, creating an integrated system that delivers outcomes superior to the sum of its parts. By combining the gamification features of CALL with the adaptive strategies of AIALL, it fosters enhanced learner engagement through an immersive and motivating environment dynamically aligned with individual interests and proficiency levels. This integration also supports improved learning outcomes, as AI-driven progress tracking and error analysis work in tandem with CALL's structured activities to enable targeted interventions, accelerate language acquisition, and address gaps in real-time. Authentic learning experiences are enriched when AIALL's NLP capabilities facilitate real-world communication tasks, supported by CALL's pedagogical design, ensuring learners develop practical, transferable language skills. Furthermore, this unified framework allows for scalability and accessibility, enabling AIALL's personalized learning to reach diverse learner populations while leveraging CALL's extensive content libraries and standardized instructional design.

Participant feedback highlights the framework's ability to engage learners by seamlessly blending CALL's interactive, gamified features with AIALL's personalized, real-time adaptability. Key aspects such as progress tracking, tailored interventions, and authentic learning tasks were identified as critical factors in improving language proficiency. These findings demonstrate that the IPMLL framework achieves outcomes that neither CALL nor AIALL could achieve independently, underscoring its innovative contribution to language education.

In conclusion, the IPMLL framework exemplifies a forward-thinking approach by integrating CALL and AIALL in a way that resolves their individual limitations and achieves a synergistic effect. This integration not only enhances engagement and learning outcomes but also positions the framework as a model for leveraging technology to meet the evolving demands of modern education.

5 Discussion

This study provides empirical evidence demonstrating the efficacy of integration of CALL and AIALL within an interactive pedagogical framework for language acquisition. The results align with earlier studies that highlight the advantages of combining these two approaches in developing FL learners' language proficiency (Kasneci et al., 2023; Maican & Cocoradă, 2021). Our results showed that while IPMLL Group did not differ from the other three groups on their Pretest of English proficiency, they scored significantly higher on their Posttest of English proficiency than the other three groups. Moreover, IPMLL Groups also had better perceptions of the CALL and AIALL elements than CALL and AIALL Groups. The results of this study demonstrate the innovative potential of the IPMLL in transforming language learning through the integration of CALL and AIALL. By combining the multimedia-rich interactivity of CALL with the adaptive, personalized capabilities of AIALL, the IPMLL offers a unique framework that aligns with established pedagogical theories and addresses the limitations of traditional approaches. This study contributes to the growing body of research on technology-enhanced language learning by providing empirical evidence for the effectiveness of this integrated approach.

The integration of CALL offers learners a wide range of multimedia resources, interactive exercises, and online language learning platforms, promoting learner autonomy and providing opportunities for practice and feedback beyond the traditional classroom (Alobaid, 2020; Mynard, 2019). On the other hand, AIALL utilizes AI technologies, including NLP and machine learning, to deliver ITS, adaptive learning environments, and automated assessment tools (Mohamed et al., 2024). These AI-based tools provide personalized instruction, adaptive feedback, and intelligent analysis of learner performance (Alam, 2022; Chen et al., 2020a, b). The integration of CALL and AIALL within the proposed pedagogical model has yielded promising outcomes. Consistent with previous findings (Jin, 2023; Giannakos & Cukurova, 2023; Li et al., 2023) learners have reported increased motivation, personalized learning experiences, and enhanced feedback. The combination of multimedia resources, interactive exercises, and AI-powered tools has created an engaging and dynamic learning environment. Furthermore, the integration of CALL and AIALL aligns with theoretical frameworks that emphasize utilizing technology to improve language learning outcomes. The cognitive theory of multimedia learning suggests that incorporating interactive multimedia elements improves comprehension and information retention (Teng, 2023). This integration also supports learner-centered approaches that consider individual needs and preferences.

The seamless integration of components from CALL and AIALL aligns effectively with contemporary educational policies emphasizing the critical importance of incorporating technology into education (Wu et al., 2023). These policies highlight the transformative potential of technology in improving learning outcomes and fostering the development of essential digital literacy skills necessary for navigating a technology-driven society. The integration of CALL and AIALL within the proposed IPMLL framework directly supports these objectives by leveraging advanced technological tools to enhance language learning practices. This alignment ensures that

language learning methodologies remain relevant and responsive to the demands of modern educational systems (Rahimzadeh et al., 2023).

The qualitative analysis results further reinforce the compatibility of the IPMLL framework with these educational policies. Participants consistently emphasized the role of interactive platforms, gamification, and content integration in fostering learner engagement and promoting meaningful language acquisition. These findings align with established pedagogical principles that advocate for learner-centered, interactive, and multimodal approaches to education (Cheng et al., 2020; Yang et al., 2022; Zhang et al., 2022). The integration of adaptive learning algorithms, progress tracking, and ITS within the framework further supports individualized instruction, a key principle in modern educational theory, by addressing diverse learner needs and providing tailored feedback.

By incorporating these advanced technological components, the IPMLL framework not only adheres to educational policies but also positions language education as a leader in innovative pedagogical practices (Gartziarena & Altuna, 2023). The use of NLP tools and ITS, as highlighted in the qualitative findings, demonstrates the framework's potential to create authentic, real-world learning experiences, thereby equipping learners with practical communication skills. This approach aligns with pedagogical principles that emphasize the importance of contextualized learning and the development of transferable skills.

In summary, the integration of CALL and AIALL within the IPMLL framework exemplifies a forward-thinking approach to language education. By addressing the priorities outlined in educational policies and adhering to established pedagogical principles, the framework not only enhances language learning outcomes but also contributes to the broader goal of preparing learners for success in a digitally interconnected world. The qualitative results provide strong evidence of the framework's effectiveness in achieving these objectives, further validating its potential as a model for innovative and policy-aligned language education.

5.1 Implications

Theoretically, this study contributes to the existing literature on language learning models by providing empirical evidence for the effectiveness of integrating CALL and AIALL in language education. By developing an IPMLL that combines these two approaches, this study aligns with theoretical frameworks such as the cognitive theory of multimedia learning and the sociocultural theory of learning. The IPMLL offers a promising approach for language educators to leverage technology to enhance language learning outcomes. Pedagogically, the IPMLL developed in this study provides practical pedagogical approaches that can be utilized in the CALL environment. For instance, task-based language teaching can be enhanced by incorporating AIALL tools that offer individualized feedback and adaptive learning experiences based on learners' individual needs. Collaborative learning can be facilitated through online platforms and interactive exercises offered by CALL, allowing learners to engage in meaningful interactions with their peers. Furthermore, the IPMLL can support content-based instruction by providing learners with access to authentic multimedia resources and intelligent analysis of their performance.

5.2 Limitations

However, it is essential to recognize that this study has its limitations, as the sample size was relatively small and the study was restricted to a particular context, which may affect the applicability of the results in other situations. Additionally, the study focused on English as a Foreign Language students, so the results may not be applicable to other language learning contexts or proficiency levels. Future research should aim to replicate this study with larger and more diverse samples to validate the findings and further refine the IPMLL. Further investigation is also needed to explore the long-term effects of integrating CALL and AIALL on language learning outcomes. Additionally, it would be valuable to examine the perceptions and experiences of teachers in implementing these technologies in their classrooms and how they can best utilize the IPMLL. These steps will contribute to a deeper understanding of the potential benefits and challenges of integrating CALL and AIALL in language education and provide practical guidance for language educators to implement the IPMLL effectively.

6 Conclusions

In conclusion, the findings of this study yield empirical evidence supporting the effectiveness of integrating CALL and AIALL within an interactive pedagogical model for language acquisition. The results highlight the potential advantages of this integration in enhancing language proficiency, learner motivation, and engagement. Moreover, the integration of CALL and AIALL aligns with established theoretical frameworks, such as the cognitive theory of multimedia learning and the sociocultural theory of learning, which emphasize the significance of technology and social contexts in language acquisition. By incorporating interactive multimedia elements, personalized instruction, and adaptive feedback, this combined approach provides learners with a diverse array of resources and opportunities for practice beyond the confines of the traditional classroom environment. In conclusion, the integration of CALL and AIALL within an interactive pedagogical model exhibits promise in improving language learning outcomes. The findings of this study underscore the potential of the IPMLL to revolutionize language education by leveraging the strengths of CALL and AIALL. This integrated model not only enhances language proficiency and learner satisfaction but also aligns with global educational policies promoting the use of technology in education. Future research should explore the scalability and long-term impact of the IPMLL across diverse contexts and learner groups. Future research endeavors should further investigate this approach, considering different contexts and proficiency levels, to deepen our comprehension of its benefits and limitations.

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Data Availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate All procedures performed in this study involving adult human participants were in accordance with the ethical standards of the 1964 Helsinki declaration and its later amendments. Informed consent was obtained from all individual participants included in the study.

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References

Alam, A. (2021). Should robots replace teachers? Mobilisation of AI and learning analytics in education. In *2021 International Conference on Advances in Computing, Communication, and Control (ICAC3)* (pp. 1–12). IEEE. https://doi.org/10.1109/ICAC353642.2021.9697300

Alam, A. (2022). Employing adaptive learning and intelligent tutoring robots for virtual classrooms and smart campuses: reforming education in the age of artificial intelligence. In *Advanced Computing and Intelligent Technologies: Proceedings of ICACIT 2022* (pp. 395–406). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-19-2980-9_32

Almusharraf, A., & Bailey, D. (2023). Machine translation in language acquisition: A study on EFL students' perceptions and practices in Saudi Arabia and South Korea. *Journal of Computer Assisted Learning*. https://doi.org/10.1111/jcal.12857

Alobaid, A. (2020). Smart multimedia learning of ICT: Role and impact on language learners' writing fluency—YouTube Online English learning resources as an example. *Smart Learning Environments*, *7*(1), 24. https://doi.org/10.1186/s40561-020-00134-7

Alqahtani, T., Badreldin, H. A., Alrashed, M., Alshaya, A. I., Alghamdi, S. S., bin, Saleh, K., & Albekairy, A. M. (2023). The emergent role of artificial intelligence, natural learning processing, and large language models in higher education and research. *Research in Social and Administrative Pharmacy, 19*(8), 1236–1242. https://doi.org/10.1016/j.sapharm.2023.05.016

Alresheed, S., Raiker, A., & Carmichael, P. (2017). Integrating computer-assisted language learning in Saudi schools: A change model. Handbook on digital learning for K-12 schools, 369–380. https://doi.org/10.1007/978-3-319-33808-8_22

Amaral, L. A., & Meurers, D. (2011). On using intelligent computer-assisted language learning in real-life foreign language teaching and learning. *ReCALL*, *23*(1), 4–24. https://doi.org/10.1017/S0958344010000261

An, X., Chai, C. S., Li, Y., Zhou, Y., & Yang, B. (2023). Modeling students' perceptions of artificial intelligence assisted language learning. *Computer Assisted Language Learning*, 1–22. https://doi.org/10.1080/09588221.2023.2246519

Bahari, A. (2019). FonF practice model from theory to practice: CALL via focus on form approach and nonlinear dynamic motivation to develop listening and speaking proficiency. *Computers & Education*, *130*(3), 40–58. https://doi.org/10.1016/j.compedu.2018.11.009

Bahari, A. (2021). Computer-mediated feedback for L2 learners: Challenges vs. affordances. *Journal of Computer Assisted Learning*, *37*(1), 24–38. https://doi.org/10.1111/jcal.12481

Bahari, A. (2022). Affordances and challenges of Technology-assisted Language Learning for Motivation: A systematic review. *Interactive Learning Environments*, *32*(1), 1–15. https://doi.org/10.1080/10494820.2021.2021246

Bahari, A., Zhang, X., & Ardasheva, Y. (2021). Establishing a computer-assisted interactive reading model. *Computers & Education*, *172*, 104261. https://doi.org/10.1016/j.compedu.2021.104261

Bahari, A., Wu, S., & Ayres, P. (2023). Improving computer-assisted Language Learning through the Lens of Cognitive load. *Educational Psychology Review*, *34*(2), 1–15. https://doi.org/10.1007/s10648-023-09764-y

Banumathi, J. (2023). Instruction process and learning issues in computer-assisted learning: A detailed review. *Computer-Assisted Learning for Engaging Varying Aptitudes: from Theory to Practice*, 36–54. https://doi.org/10.4018/9781668450581.ch004

Barrot, J. S. (2024). Trends in automated writing evaluation systems research for teaching, learning, and assessment: A bibliometric analysis. *Education and Information Technologies*, *29*, 7155–7189. https://doi.org/10.1007/s10639-023-12083-y

Bin-Hady, W. R. A., Al-Kadi, A., Hazaea, A., & Ali, J. K. M. (2023). Exploring the dimensions of ChatGPT in English language learning: A global perspective. *Library Hi Tech*. https://doi.org/10.1108/LHT-05-2023-0200

Bozkurt, A., Karadeniz, A., Baneres, D., Guerrero-Roldán, A. E., & Rodríguez, M. E. (2021). Artificial intelligence and reflections from educational landscape: A review of AI studies in half a century. *Sustainability*, *13*(2), 800. https://doi.org/10.3390/su13020800

Chabot, S., Drozdal, J., Peveler, M., Zhou, Y., Su, H., & Braasch, J. (2020). A collaborative, immersive language learning environment using augmented panoramic imagery. In *2020 6th International Conference of the Immersive Learning Research Network (iLRN)* (pp. 225–229). IEEE. https://doi.org/10.1109/ICAC353642.2021.9697300

Chamboko-Mpotaringa, M., & Mandidereza, B. (2023). Innovative Language Learning approaches: Immersive technologies and Gamification. In transforming the Language Teaching experience in the age of AI. *IGI Global*, 189–214. https://doi.org/10.4018/978-1-6684-9893-4.ch011

Chang, D. H., Lin, M. P. C., Hajian, S., & Wang, Q. Q. (2023). Educational Design principles of using AI Chatbot that supports self-regulated learning in education: Goal setting. *Feedback and Personalization Sustainability*, *15*(17), 12921. https://doi.org/10.3390/su151712921

Chen, J. C. (2016). The crossroads of English language learners, task-based instruction, and 3D multi-user virtual learning in Second Life. *Computers & Education*, *102*, 152–171. https://doi.org/10.1016/j.compedu.2016.08.004

Chen, C., & Yuan, Y. (2023). Effectiveness of virtual reality on Chinese as a second language vocabulary learning: Perceptions from international students. *Computer Assisted Language Learning*, 1–29. https://doi.org/10.1080/09588221.2023.2192770]

Chen, L., Chen, P., & Lin, Z. (2020a). Artificial intelligence in education: A review. *Ieee Access*, *8*, 75264–75278. https://doi.org/10.1109/ACCESS.2020.2988510

Chen, X., Zou, D., Cheng, G., & Xie, H. (2020b). Detecting latent topics and trends in educational technologies over four decades using structural topic modeling: A retrospective of all volumes of computers & Education. *Computers & Education*, *151*, 103855. https://doi.org/10.1016/j.compedu.2020.103855

Chen, X., Zou, D., Xie, H., Cheng, G., & Liu, C. (2022a). Two decades of Artificial Intelligence in Education: Contributors, collaborations, Research Topics, challenges, and future directions. *Educational Technology & Society*, *25*(1), 28–47. https://www.jstor.org/stable/48647028

Chen, J., Lai, P., Chan, A., Man, V., & Chan, C. H. (2022b). AI-assisted enhancement of student presentation skills: Challenges and opportunities. *Sustainability*, *15*(1), 196. https://doi.org/10.3390/su150101960196

Cheng, Y. W., Wang, Y., Yang, Y. F., Yang, Z. K., & Chen, N. S. (2020). Designing an authoring system of robots and IoT-based toys for EFL teaching and learning. *Computer Assisted Language Learning*, *34*(1–2), 6–34. https://doi.org/10.1080/09588221.2020.1799823

Choi, L., & Chung, S. (2021). Navigating online language teaching in uncertain times: Challenges and strategies of EFL educators in creating a sustainable technology-mediated language learning environment. *Sustainability*, *13*(14), 7664. https://doi.org/10.3390/su13147664

Crosthwaite, P., Luciana, & Wijaya, D. (2023). Exploring language teachers' lesson planning for corpus-based language teaching: A focus on developing TPACK for corpora and DDL. *Computer Assisted Language Learning*, *36*(7), 1392–1420. https://doi.org/10.1080/09588221.2021.1995001

Dao, P., Bui, T. L. D., Nguyen, D. T. T., & Nguyen, M. X. N. C. (2024). Synchronous online English language teaching for young learners: Insights from public primary school teachers in an EFL context. *Computer Assisted Language Learning*, *37*(8), 2359–2388. https://doi.org/10.1080/09588221.2023.2260429

Dermeval, D., Albuquerque, J., Bittencourt, I. I., Isotani, S., Silva, A. P., & Vassileva, J. (2019). GaTO: An ontological model to apply gamification in intelligent tutoring systems. *Frontiers in Artificial Intelligence*, *2*, 13. https://doi.org/10.3389/frai.2019.00013

Du, J., Hew, K. F., & Liu, L. (2023). What can online traces tell us about students' self-regulated learning? A systematic review of online trace data analysis. *Computers & Education*, *201*, 104828. https://doi.org/10.1016/j.compedu.2023.104828

Dwivedi, Y. K., Kshetri, N., Hughes, L., Slade, E. L., Jeyaraj, A., Kar, A. K., & Wright, R. (2023). So what if ChatGPT wrote it? Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy. *International Journal of Information Management*, *71*, 102642. https://doi.org/10.1016/j.ijinfomgt.2023.102642

Ebadi, S., & Amini, A. (2022). Examining the roles of social presence and human-likeness on Iranian EFL learners' motivation using artificial intelligence technology: A case of CSIEC chatbot. *Interactive Learning Environments*, *32*(2), 655–673. https://doi.org/10.1080/10494820.2022.2096638

Ellis, R. (2010). Second language acquisition, teacher education and language pedagogy. *Language Teaching*, *43*(2), 182–201. https://doi.org/10.1017/S0261444809990139

Erümit, A. K., & Çetin, İ. (2020). Design framework of adaptive intelligent tutoring systems. *Education and Information Technologies*, *25*(5), 4477–4500.

Essa, S. G., Celik, T., & Human-Hendricks, N. (2023). Personalised adaptive Learning technologies based on machine learning techniques to identify learning styles: A systematic literature review. *Ieee Access: Practical Innovations, Open Solutions*, *11*, 48392–48409. https://doi.org/10.1109/ACCESS.2023.3276439

Gartziarena, M., & Altuna, J. (2023). The influence of the L3 on In-Service teachers' beliefs about Language Teaching approaches and Multilingualism. *Journal of Language Identity & Education*, 1–13. https://doi.org/10.1080/15348458.2023.2198236

Gass, S. M., & Mackey, A. (2014). Input, interaction, and output in second language acquisition. *Theories in second language acquisition* (pp. 194–220). Routledge.

Gayed, J. M., Carlon, M. K. J., Oriola, A. M., & Cross, J. S. (2022). Exploring an AI-based writing Assistant's impact on English language learners. *Computers and Education: Artificial Intelligence*, *3*, 100055. https://doi.org/10.1016/j.caeai.2022.100055

Giannakos, M., & Cukurova, M. (2023). The role of learning theory in multimodal learning analytics. *British Journal of Educational Technology*, *54*(5), 1246–1267. https://doi.org/10.1111/bjet.13320

Gibson, D., Kovanovic, V., Ifenthaler, D., Dexter, S., & Feng, S. (2023). Learning theories for artificial intelligence promoting learning processes. *British Journal of Educational Technology*, *54*(5), 1125–1146. https://doi.org/10.1111/bjet.13341

Gràcia, M., Alvarado, J. M., Vega, F., Jarque, M. J., Castillo, P., & Adam-Alcocer, A. L. (2023). A digital tool designed to support secondary education teachers' professional development and to develop students' oral language competence. *Computer Assisted Language Learning*, 1–27. https://doi.org/10.1080/09588221.2023.2197963

Han, Y. (2020). Connecting the past to the future of computer-assisted language learning: Theory, practice, and research. *Issues and Trends in Learning Technologies*, *8*(1). https://doi.org/10.2458/azu_itlt_v8i1_han

Hasibuan, R., Parta, B. M. W., Imro'athush Sholihah, I.,., H., Damayanto, A., & Farihatun, F. (2023). Transformation of Indonesian Language Learning with Artificial Intelligence Applications: The era of the Independent Curriculum for Learning in universities in Indonesia. *Indonesian Journal of Education (INJOE)*, *3*(2), 341–363. https://doi.org/10.54443/injoe.v3i2.71

Hockly, N. (2023). Artificial Intelligence in English Language Teaching: The Good, the bad and the Ugly. *RELC Journal*, *54*(2), 445–451. https://doi.org/10.1177/00336882231168504

Hu, C. C. (2023). Exploring the impact of CPS-Based Robot-assisted teaching in STEM Education: Enhancing knowledge, skills, and attitudes. *International Journal of Human–Computer Interaction*, *40*(22), 7193–7213. https://doi.org/10.1080/10447318.2023.2262278

Huang, W., Hew, K. F., & Fryer, L. K. (2022). Chatbots for language learning—are they really useful? A systematic review of chatbot-supported language learning. *Journal of Computer Assisted Learning*, *38*(1), 237–257. https://doi.org/10.1111/jcal.12610

Huang, H., Zheng, O., Wang, D., Yin, J., Wang, Z., Ding, S., & Shi, B. (2023a). ChatGPT for shaping the future of dentistry: The potential of multi-modal large language model. *International Journal of Oral Science*, *15*(1), 29. https://doi.org/10.1038/s41368023002 39-y

Huang, X., Zou, D., Cheng, G., Chen, X., & Xie, H. (2023b). Trends, research issues and applications of artificial intelligence in language education. *Educational Technology & Society*, *26*(1), 112–131.

Hung, Y. W., & Higgins, S. (2016). Learners' use of communication strategies in text-based and video-based synchronous computer-mediated communication environments: Opportunities for language learning. *Computer Assisted Language Learning*, *29*(5), 901–924. https://doi.org/10.1080/09588221.2015.1074589

Iyer, L. S., Chakraborty, T., Reddy, K. N., Jyothish, K., & Krishnaswami, M. (2023). AI-Assisted Models for Dyslexia and Dysgraphia: Revolutionizing Language Learning for Children. In *AI-Assisted Special Education for Students With Exceptional Needs* (pp. 186–207). IGI Global. https://doi.org/10.4018/979-8-3693-0378-8.ch008

Jeon, J., Lee, S., & Choe, H. (2023). Beyond ChatGPT: A conceptual framework and systematic review of speech-recognition chatbots for language learning. *Computers & Education*, *206*, 104898. https://doi.org/10.1016/j.compedu.2023.104898

Ji, H., Han, I., & Ko, Y. (2023). A systematic review of conversational AI in language education: Focusing on the collaboration with human teachers. *Journal of Research on Technology in Education*, *55*(1), 48–63. https://doi.org/10.1080/15391523.2022.2142873

Jiang, D., & Zhang, L. J. (2020). Collaborating with 'familiar'strangers in mobile-assisted environments: The effect of socializing activities on learning EFL writing. *Computers & Education*, *150*, 103841. https://doi.org/10.1016/j.compedu.2020.103841

Jin, S. (2023). Speaking proficiency and affective effects in EFL: Vlogging as a social media-integrated activity. *British Journal of Educational Technology*, *55*(2), 586–604. https://doi.org/10.1111/bjet.13381

Jin, X., Kim, E., & Kim, K. C. (2024). Transforming early Childhood Education: The Nuri Curriculum Reform in South Korea. *Journal of the Knowledge Economy*, *15*, 12337–12360. https://doi.org/10.1007/s13132-023-01586-1

Kamalov, F., Calonge, S., D., & Gurrib, I. (2023). New era of artificial intelligence in education: Towards a sustainable multifaceted revolution. *Sustainability*, *15*(16), 12451. https://doi.org/10.3390/su151612451

Kamruzzaman, M. M., Alanazi, S., Alruwaili, M., Alshammari, N., Elaiwat, S., Abu-Zanona, M., & Alanazi, A., B (2023). AI-and IoT-Assisted sustainable Education systems during Pandemics, such as COVID-19, for Smart cities. *Sustainability*, *15*(10), 8354. https://doi.org/10.3390/su15108354

Karakaya, K., & Bozkurt, A. (2022). Mobile-assisted language learning (MALL) research trends and patterns through bibliometric analysis: Empowering language learners through ubiquitous educational technologies. *System*, *110*, 102925. https://doi.org/10.1016/j.system.2022.102925

Kasneci, E., Seßler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., & Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences*, *103*, 102274. https://doi.org/10.1016/j.lindif.2023.102274

Kim, N. Y., Cha, Y., & Kim, H. S. (2019). Future English learning: Chatbots and artificial intelligence. *Multimedia-Assisted Language Learning*, *22*(3).

Lantolf, J. P. (2011). The sociocultural approach to second language acquisition: Sociocultural theory, second language acquisition, and artificial L2 development. *Alternative approaches to second language acquisition* (pp. 24–47). Routledge.

Li, P., & Lan, Y. J. (2022). Digital language learning (DLL): Insights from behavior, cognition, and the brain. *Bilingualism: Language and Cognition*, *25*(3), 361–378. https://doi.org/10.1017/S1366728921000353

Li, B., & Peng, M. (2021, November). The Evaluation of a Blended Teaching Mode Based on an AI Language Learning Platform. In *2021 2nd International Conference on Information Science and Education (ICISE-IE)* (pp. 1437–1440). IEEE. https://doi.org/10.1109/ICISE-IE53922.2021.00320

Li, Q., Luximon, Y., Zhang, J., & Song, Y. (2023). Measuring and classifying students' cognitive load in pen-based mobile learning using handwriting, touch gestural and eye-tracking data. *British Journal of Educational Technology*, *55*(2), 625–653. https://doi.org/10.1111/bjet.13394

Liang, J. C., & Hwang, G. J. (2023). A robot-based digital storytelling approach to enhancing EFL learners' multimodal storytelling ability and narrative engagement. *Computers & Education*, *201*, 104827. https://doi.org/10.1016/j.compedu.2023.104827

Liang, J. C., Hwang, G. J., Chen, M. R. A., & Darmawansah, D. (2023). Roles and research foci of artificial intelligence in language education: An integrated bibliographic analysis and systematic review approach. *Interactive Learning Environments*, *31*(7), 4270–4296. https://doi.org/10.1080/10494820.2021.1958348

Lin, C. H., Zhang, Y., & Zheng, B. (2017). The roles of learning strategies and motivation in online language learning: A structural equation modeling analysis. *Computers & Education*, *113*, 75–85. https://doi.org/10.1016/j.compedu.2017.05.014

Lin, V., Barrett, N. E., Liu, G. Z., Chen, N. S., & Jong, M. S. Y. (2023a). Supporting dyadic learning of English for tourism purposes with scenery-based virtual reality. *Computer Assisted Language Learning*, *36*(5–6), 906–942. https://doi.org/10.1080/09588221.2021.1954663

Lin, C. C., Huang, A. Y., & Lu, O. H. (2023b). Artificial intelligence in intelligent tutoring systems toward sustainable education: A systematic review. *Smart Learning Environments*, *10*(1), 41. https://doi.org/10.1186/s40561-023-00260-y

Liu, T., & Gablasova, D. (2023). Data-driven learning of collocations by Chinese learners of English: A longitudinal perspective. *Computer Assisted Language Learning*, 1–26. https://doi.org/10.1080/09588221.2023.2214605

Liu, C. C., Liao, M. G., Chang, C. H., & Lin, H. M. (2022). An analysis of children'interaction with an AI chatbot and its impact on their interest in reading. *Computers & Education*, *189*, 104576. https://doi.org/10.1016/j.compedu.2022.104576

Liu, S., Gao, S., & Ji, X. (2023). Beyond borders: Exploring the impact of augmented reality on intercultural competence and L2 learning motivation in EFL learners. *Frontiers in Psychology*, *14*, 1234905. https://doi.org/10.3389/fpsyg.2023.1234905

Maican, M. A., & Cocoradă, E. (2021). Online foreign language learning in higher education and its correlates during the COVID-19 pandemic. *Sustainability*, *13*(2), 781. https://doi.org/10.3390/su13020781

Mayer, R. E. (2002). Multimedia learning. In Psychology of learning and motivation (Vol. 41, pp. 85–139). Academic Press. https://doi.org/10.1016/S0079-7421(02)80005-6

Mehta, P., Chillarge, G. R., Sapkal, S. D., Shinde, G. R., & Kshirsagar, P. S. (2023). Inclusion of Children With Special Needs in the Educational System, Artificial Intelligence (AI). In AI-Assisted Special Education for Students With Exceptional Needs (pp. 156–185). IGI Global. https://doi.org/10.4018/979-8-3693-0378-8.ch007

Mohamed, A. M., Shaaban, T. S., Bakry, S. H., Guillén-Gámez, F. D., & Strzelecki, A. (2024). Empowering the Faculty of Education students: Applying AI's potential for motivating and enhancing learning. *Innovative Higher Education*. https://doi.org/10.1007/s10755-024-09747-z

Mohammed, P. S., & Watson, E. (2019). Towards inclusive education in the age of artificial intelligence: Perspectives, challenges, and opportunities. *Artificial Intelligence and Inclusive Education: Speculative futures and emerging practices*, 17–37. https://doi.org/10.1007/978-981-13-8161-4_2

Murtaza, M., Ahmed, Y., Shamsi, J. A., Sherwani, F., & Usman, M. (2022). AI-based personalized e-learning systems: Issues, challenges, and solutions. *Ieee Access: Practical Innovations, Open Solutions*, *10*, 81323–81342. https://doi.org/10.1109/ACCESS.2022.3193938

Mynard, J. (2019). Self-access learning and advising: Promoting language learner autonomy beyond the classroom. *Innovation in Language Teaching and Learning: The case of Japan*, 185–209. https://doi.org/10.1007/978-3-030-12567-7_10

Nong, L., Liu, G., & Tan, C. (2021, December). An Empirical Study on the Implementation of AI Assisted Language Teaching for Improving Learner's Learning Ability. In *2021 Tenth International Conference of Educational Innovation through Technology (EITT)* (pp. 215–221). IEEE. https://doi.org/10.1109/EITT53287.2021.00050

Ntoutsi, E., Fafalios, P., Gadiraju, U., Iosifidis, V., Nejdl, W., Vidal, M. E., & Staab, S. (2020). Bias in data-driven artificial intelligence systems—An introductory survey. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, *10*(3), e1356. https://doi.org/10.1002/widm.1356

Paas, F., & Sweller, J. (2012). An evolutionary upgrade of cognitive load theory: Using the human motor system and collaboration to support the learning of complex cognitive tasks. *Educational Psychology Review*, *24*, 27–45. https://doi.org/10.1007/s10648-011-9179-2

Paladines, J., & Ramirez, J. (2020). A systematic literature review of intelligent tutoring systems with dialogue in natural language. *Ieee Access: Practical Innovations, Open Solutions*, *8*, 164246–164267. https://doi.org/10.1109/ACCESS.2020.3021383

Pradana, M., Rintaningrum, R., Kosov, M., Bloshenko, T., Rogova, T., & Singer, N. (2022, October). Increasing the effectiveness of educational technologies in the foreign languages learning process by linguistic students (comparative analysis of Russian, Indonesian and Egyptian experience). In Frontiers in Education (Vol. 7, p. 1011842). Frontiers. https://doi.org/10.3389/feduc.2022.1011842

Pu, P., & Chang, D. Y. S. (2023). Effects of different input modes on blended EFL speaking instruction: A quasi-experimental study. *Computer Assisted Language Learning*, 1–26. https://doi.org/10.1080/09588221.2023.2273853

Rad, H. S., Alipour, R., & Jafarpour, A. (2023). Using artificial intelligence to foster students' writing feedback literacy, engagement, and outcome: A case of Wordtune application. *Interactive Learning Environments*, *32*(9), 5020–5040. https://doi.org/10.1080/10494820.2023.2208170

Rahimzadeh, V., Kostick-Quenet, K., Blumenthal Barby, J., & McGuire, A. L. (2023). Ethics education for healthcare professionals in the era of chatGPT and other large language models: Do we still need it? *The American Journal of Bioethics*, *23*(10), 17–27. https://doi.org/10.1080/15265161.2023.2233358

Salih, A. A., & Omar, L. I. (2021). Season of Migration to Remote Language Learning platforms: Voices from EFL University Learners. *International Journal of Higher Education*, *10*(2), 62–73.

Sayed, W. S., Noeman, A. M., Abdellatif, A., Abdelrazek, M., Badawy, M. G., Hamed, A., & El-Tantawy, S. (2023). AI-based adaptive personalized content presentation and exercises navigation for an effective and engaging E-learning platform. *Multimedia Tools and Applications*, *82*(3), 3303–3333. https://doi.org/10.1007/s11042-022130768

Shardlow, M., Sellar, S., & Rousell, D. (2022). Collaborative augmentation and simplification of text (CoAST): Pedagogical applications of natural language processing in digital learning environments. *Learning Environments Research*, *25*, 399–421. https://doi.org/10.1007/s10984-021-09368-9

Shin, J., Balyan, R., Banawan, M. P., Arner, T., Leite, W. L., & McNamara, D. S. (2023). Pedagogical discourse markers in online algebra learning: Unraveling instructor's communication using natural language processing. *Computers & Education*, *205*, 104897. https://doi.org/10.1016/j.compedu.2023.104897

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics*. Pearson.

Tafazoli, D., María, E. G., & Abril, C. A. H. (2019). Intelligent language tutoring system: Integrating intelligent computer-assisted language learning into language education. *International Journal of Information and Communication Technology Education (IJICTE)*, *15*(3), 60–74. https://doi.org/10.4018/IJICTE.2019070105

Tai, T. Y. (2022). Effects of intelligent personal assistants on EFL learners' oral proficiency outside the classroom. *Computer Assisted Language Learning*, *37*(5–6), 1281–1310. https://doi.org/10.1080/09588221.2022.2075013

Tai, T. Y. (2024). Comparing the effects of intelligent personal assistant-human and human-human interactions on EFL learners' willingness to communicate beyond the classroom. *Computers & Education*, *210*, 104965. https://doi.org/10.1016/j.compedu.2023.104965

Tai, T. Y., & Chen, H. H. J. (2023). The impact of Google Assistant on adolescent EFL learners' willingness to communicate. *Interactive Learning Environments*, *31*(3), 1485–1502. https://doi.org/10.1080/10494820.2020.1841801

Teng, M. F. (2023). The effectiveness of multimedia input on vocabulary learning and retention. *Innovation in Language Learning and Teaching*, *17*(3), 738–754. https://doi.org/10.1080/17501229.2022.2131791

Valledor, A., Olmedo, A., Hellín, C. J., Tayebi, A., Otón-Tortosa, S., & Gómez, J. (2023). The Eclectic Approach in English Language Teaching applications: A qualitative synthesis of the literature. *Sustainability*, *15*(15), 11978. https://doi.org/10.3390/su151511978

Vygotsky, L. S. (1978). *Mind in society*. Harvard University Press.

Wang, Z. (2022). Computer-assisted EFL writing and evaluations based on artificial intelligence: A case from a college reading and writing course. *Library Hi Tech*, *40*(1), 80–97. https://doi.org/10.1108/LHT-05-2020-0113

Wang, Z., & Han, F. (2021). Developing English language learners' oral production with a digital game-based mobile application. *Plos One*, *16*(1), e0232671. https://doi.org/10.1371/journal.pone.0232671

Wang, C., & Xu, W. (2023). Book Review: Taking Literature and Language Learning Online: New perspectives on Teaching, Research, and Technology. *International Journal of Computer-Assisted Language Learning and Teaching (IJCALLT)*, *13*(1), 1–5. https://doi.org/10.4018/IJCALLT.324059

Wang, X., Pang, H., Wallace, M. P., Wang, Q., & Chen, W. (2022). Learners' perceived AI presences in AI-supported language learning: A study of AI as a humanized agent from community of inquiry. *Computer Assisted Language Learning*, *37*(4), 814–840. https://doi.org/10.1080/09588221.2022.2056203

Wang, S., Christensen, C., Cui, W., Tong, R., Yarnall, L., Shear, L., & Feng, M. (2023). When adaptive learning is effective learning: Comparison of an adaptive learning system to teacher-led instruction. *Interactive Learning Environments*, *31*(2), 793–803. https://doi.org/10.1080/10494820.2020.1808794

Weng, X., & Chiu, T. K. (2023). Instructional design and learning outcomes of intelligent computer assisted language learning: Systematic review in the field. *Computers and Education: Artificial Intelligence*, 100117. https://doi.org/10.1016/j.caeai.2022.100117

Wu, T. T., Lee, H. Y., Li, P. H., Huang, C. N., & Huang, Y. M. (2023). Promoting self-regulation progress and knowledge construction in blended learning via ChatGPT-based learning aid. *Journal of Educational Computing Research*, 07356331231191125. https://doi.org/10.1177/07356331231191125

Xia, Q., Chiu, T. K., Zhou, X., Chai, C. S., & Cheng, M. (2022). Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education. *Computers and Education: Artificial Intelligence*, 100118. https://doi.org/10.1016/j.caeai.2022.100118

Xiao, F., Zhao, P., Sha, H., Yang, D., & Warschauer, M. (2023). Conversational agents in language learning. *Journal of China Computer-Assisted Language Learning*, *0*. https://doi.org/10.1515/jccall-2022-0032

Yang, X., Kuo, L. J., Ji, X., & McTigue, E. (2018). A critical examination of the relationship among research, theory, and practice: Technology and reading instruction. *Computers & Education*, *125*, 62–73. https://doi.org/10.1016/j.compedu.2018.03.009

Yang, Y. T. C., Chen, Y. C., & Hung, H. T. (2022). Digital storytelling as an interdisciplinary project to improve students' English speaking and creative thinking. *Computer Assisted Language Learning*, *35*(4), 840–862. https://doi.org/10.1080/09588221.2020.1750431

Yeh, H. C., & Heng, L. (2022). Creating a virtual third space in a telecollaborative project to promote English as a Foreign Language (EFL) learners' language proficiency and intercultural awareness. *Interactive Learning Environments*, *31*(10), 6667–6677. https://doi.org/10.1080/10494820.2022.2043384

Yeh, E., & Mitric, S. (2023). Social media and learners-as-ethnographers approach: Increasing target-language participation through community engagement. *Computer Assisted Language Learning*, *36*(8), 1558–1586. https://doi.org/10.1080/09588221.2021.2005630

Yesilyurt, Y. E. (2023). AI-Enabled Assessment and Feedback Mechanisms for Language Learning: Transforming Pedagogy and Learner Experience. In *Transforming the Language Teaching Experience in the Age of AI* (pp. 25–43). IGI Global. https://doi.org/10.4018/978-1-6684-9893-4.ch002

Zhai, C. (2023). A systematic review on artificial intelligence dialogue systems for enhancing English as foreign language students' interactional competence in the university. *Computers and Education: Artificial Intelligence*, *4*, 100134. https://doi.org/10.1016/j.caeai.2023.100134

Zhang, R., & Zou, D. (2022). Types, purposes, and effectiveness of state-of-the-art technologies for second and foreign language learning. *Computer Assisted Language Learning*, *35*(4), 696–742. https://doi.org/10.1080/09588221.2020.1744666

Zhang, Y., Zheng, B., & Tian, Y. (2022). An exploratory study of English-language learners' text chat interaction in synchronous computer-mediated communication: Functions and change over time. *Computer Assisted Language Learning*, *37*(7), 1975–2006. https://doi.org/10.1080/09588221.2022.2136202

Zhao, R., Zhuang, Y., Zou, D., Xie, Q., & Yu, P. L. (2023). AI-assisted automated scoring of picture-cued writing tasks for language assessment. *Education and Information Technologies*, *28*(6), 7031–7063. https://doi.org/10.1007/s10639-022-11473-y

Zou, B., Liviero, S., Hao, M., & Wei, C. (2020). Artificial Intelligence Technology for EAP speaking skills: Student perceptions of opportunities and challenges. In M. R. Freiermuth, & N. Zarrinabadi (Eds.), *Technology and the psychology of Second Language Learners and users. New Language Learning and Teaching environments*. Palgrave Macmillan. https://doi.org/10.1007/978-3-030-34212-8_17

Zou, B., Du, Y., Wang, Z., Chen, J., & Zhang, W. (2023a). An investigation into artificial intelligence speech evaluation programs with automatic feedback for developing EFL learners' speaking skills. *Sage Open*, *13*(3), 21582440231193818. https://doi.org/10.1177/21582440231193818

Zou, B., Guan, X., Shao, Y., & Chen, P. (2023b). Supporting speaking practice by Social Network-Based Interaction in Artificial Intelligence (AI)-Assisted Language Learning. *Sustainability*, *15*(4), 2872. https://doi.org/10.3390/su15042872

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