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The impact of generative artificial intelligence on language teaching and learning

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Abstract
This paper examines the existing research on generative artificial intelligence (GenAI) in language education and highlights its potential to reshape teaching practices, learner engagement, and pedagogical design. By leveraging co-word analysis and BERTopic modeling on 908 publications from 2023 to the end of 2025, the article traces thematic patterns and conceptual developments in the GenAI field. The co-word analysis identifies key clusters at the intersection of GenAI and English language instruction, including its use in academic writing, translation, assessment, and learner-centered pedagogy. These themes demonstrate the critical role of GenAI in enabling personalized feedback, adaptive learning environments, and enhanced teacher–student interaction. The application of BERTopic modeling adds a semantic layer to this analysis and reveals diverse topics such as AI-assisted writing, teacher engagement with AI tools, emotional and motivational dynamics, and technology acceptance among learners. Results also indicate a progression from broad pedagogical experimentation toward more focused inquiries into learner psychology, ethical use, and professional development. This trend reflects the maturation of GenAI applications in both formal and informal educational contexts. The findings offer implications for language educators, curriculum designers, and policymakers by highlighting the need to integrate GenAI through pedagogically grounded, ethically responsible, and learner-centered approaches. They also suggest that future language education practices should combine AI literacy, transparent assessment policies, and teacher professional development to support effective and equitable GenAI adoption. Ultimately, the article positions GenAI as a transformative force in language education that offers technological innovation and new frameworks for inclusive, responsive, and emotionally attuned instruction.

Keywords Generative AI · Language education · ChatGPT · BERTopic · Educational technology

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1 Introduction

In recent years, the emergence of generative artificial intelligence (GenAI) has begun to radically transform the field of language teaching and learning, reshaping pedagogical models, learner agency, and instructional practices across diverse educational contexts (Chapelle 2025; Law 2024; Pegrum 2025). Built on large language models capable of producing coherent, context-sensitive, and human-like outputs, GenAI offers unique affordances for both formal education and informal language acquisition (Pack and Maloney 2023; Dong et al. 2024; Xiaoet al. 2025). Scholars now recognize GenAI not as a supplementary tool, but as a game-changing force in reconfiguring the nature of interaction, personalization, and creativity in second language pedagogy (Tafazoli 2024; Mizumoto 2023; Godwin-Jones 2024).

A growing body of empirical work supports GenAI's potential to improve learner engagement, motivation, and self-efficacy. For instance, Kittredge et al. (2025) found that mobile language learners using GenAI reported significantly increased self-efficacy, aligning with broader findings that AI-supported environments can empower learners through personalization and immediate feedback (Evmenova et al. 2024; Wang et al. 2025). These effects are particularly salient in informal and mobile contexts, where GenAI enables flexible and user-driven language experiences (Guan et al. 2024a; Li et al. 2024a). Moreover, learners increasingly adopt AI-powered tools such as Call Annie and ChatGPT as conversational partners, which support speaking fluency and reduce foreign language anxiety (Wan and Moorhouse 2024; Wang et al. 2024a).

At the same time, GenAI has been instrumental in transforming teacher preparation and professional identity. Moorhouse (2024) and Kohnke et al. (2023) emphasize that many novice teachers are unprepared for GenAI integration, though targeted interventions can enhance their readiness. For example, formative interventions help preservice teachers develop transformative agency to navigate AI's pedagogical implications (Yang and Markauskaite 2025). Similarly, structured teacher education programs have successfully increased AI literacy and competence, as demonstrated by Moorhouse et al. (2024) and Barnes and Tour (2025). The emotional and cognitive demands of these transitions, however, cannot be ignored; educators often report feelings of technostress, particularly in the face of rapid innovation and institutional pressure (Kohnke et al. 2024; Moorhouse and Kohnke 2024).

Despite concerns, GenAI's affective impact on learners is promising. For instance, Kohnke and Moorhouse (2025) reveal that GenAI enhances learners' emotional connection to content and fosters greater intrinsic motivation. These findings are echoed by Khoso et al. (2025), who demonstrate that English as a Foreign Language (EFL) students in China became more creative and engaged when using GenAI-enhanced learning environments. Positive psychology frameworks (Wang et al. 2025) also demonstrate how GenAI boosts learners' confidence and willingness to communicate, contributing to healthier, more sustainable language acquisition experiences. Additionally, GenAI is reshaping classroom practices through innovations in content creation and instructional design. Xin (2024) shows how EFL teachers utilize GenAI to generate customized reading materials, while Mizumoto (2023) introduces a framework linking GenAI to metacognitive resource use in data-driven learning. In university courses, instructors have integrated GenAI into curriculum design, assessment, and classroom interaction with promising results (Lee and Davis 2024; Zaim

et al. 2024). Still, ethical concerns regarding academic integrity, learner dependency, and the validity of AI-generated assessments remain pressing (Pack and Maloney 2023; Voss et al. 2023).

From a theoretical standpoint, the application of social cognitive theory and activity theory has deepened our understanding of how learners interact with GenAI (Guan et al. 2024a; Zaim et al. 2024). Distributed agency frameworks further suggest that learners, teachers, and AI agents now collaboratively shape learning pathways (Godwin-Jones 2024). As such, GenAI not only transforms pedagogy but also challenges foundational assumptions about agency, authorship, and human–machine collaboration in language education (Yeh 2025; Pym and Hao 2024). Furthermore, researchers have explored the pedagogical potential of GenAI across a range of modalities, including AI-supported writing instruction (Xiao et al. 2025), inquiry-based learning (Yeh 2025), and translator training (Pym and Hao 2024). GenAI has also been used to democratize access to English education by providing scalable, cost-effective, and inclusive alternatives to traditional instruction, especially in under-resourced contexts (Tafazoli 2024; Waluyo and Kusumastuti 2024). The role of YouTube content creators in fostering self-directed GenAI-powered learning also illustrates how informal education spaces are rapidly adapting (Li et al. 2024a). Learners now engage with AI-generated content not just as consumers but as co-creators, reimagining the boundaries of digital literacy and language production (Dong et al. 2024; Hınız 2024). Yet, practical challenges remain. Issues of authenticity, data privacy, and digital equity continue to complicate GenAI's full integration into educational systems (Law 2024; Crompton et al. 2024). Teachers' usage of GenAI often remains unacknowledged or unofficial—what Barnes and Tour (2025) call a "dirty little secret"—highlighting the need for clearer institutional guidance and policy frameworks.

In light of these developments, there is a growing demand for systematic syntheses of how GenAI is being adopted and adapted across language education. Xiao et al. (2025) stress the fragmented nature of existing research and call for deeper investigations into long-term impacts, while Chapelle (2025) argues that GenAI demands a fundamental rethinking of language learning theory, not merely its tools. Pegrum (2025) similarly notes that although the technology has advanced rapidly, pedagogical models have yet to adapt to ensure a meaningful transformation fully.

Although several review studies have examined the role of generative artificial intelligence in language education, several limitations remain in current syntheses. Existing reviews largely adopt narrative or scoping approaches, emphasizing pedagogical affordances of tools such as ChatGPT without systematically mapping the intellectual structure of the research domain. For example, Law (2024) provides a scoping review of GenAI applications, while Xiao et al. (2025) focus specifically on AI-powered writing instruction. Similarly, Pack and Maloney (2023) discuss methodological implications of using ChatGPT in language education research, and Bhullar et al. (2024) synthesize literature on ChatGPT in higher education more broadly. While these studies offer valuable pedagogical and conceptual insights, they tend to provide descriptive summaries rather than large-scale structural analyses of thematic relationships across the field. Moreover, prior syntheses often concentrate on specific tools or subdomains, such as writing instruction or higher education, leading to a fragmented understanding of how generative AI intersects with diverse dimensions of language education, including teacher professional development, affective engagement, ethical governance, translation pedagogy, and technology acceptance. In addition, earlier

bibliometric reviews in education and AI typically rely on traditional scientometric indicators or manual thematic coding (Bhullar et al. 2024; Fan et al. 2023; Kavitha and Joshith 2024; Marchena Sekli 2024; Che Ghazali et al. 2025), and few apply transformer-based topic modeling approaches capable of detecting latent semantic structures across large corpora (Klarin 2024; Mishra 2025). As a result, the conceptual evolution of GenAI research in language education and the relationships among emerging themes remain underexplored.

To address these methodological and conceptual gaps, the present study integrates co-word network analysis with BERTopic modeling on a corpus of 908 publications, enabling both structural mapping of dominant keyword clusters and semantically informed detection of emerging research topics. This paper, therefore, provides a comprehensive, data-driven, and temporally sensitive analysis of the impact of GenAI on language teaching and learning. Specifically, it aims to answer the following research questions (RQ):

- RQ1: What are the primary thematic clusters that represent prevailing trends in the integration of generative AI within language education?
- RQ2: Which emerging areas of research are anticipated to influence the future direction of generative AI applications in language teaching and learning?

In answering these questions, the study draws on a wide array of empirical, theoretical, and practice-based research to articulate a critical and forward-looking understanding of GenAI's role in shaping the future of language education. For educators, the findings provide practical strategies and reflective insights. For researchers, this work identifies pressing areas for inquiry, and for policymakers, it offers evidence to guide responsible innovation and inclusive educational design in the age of AI.

This study is structured to provide a comprehensive exploration of the impact of GenAI on language teaching and learning. Section 2 outlines the methodology adopted to conduct the review, including the selection criteria and analytical strategies used to examine and synthesize the growing body of research in this domain. Section 3 delves into the findings, offering an analysis of the key themes and patterns that have emerged. Section 4 builds on these insights to propose a forward-looking research agenda, identifying critical gaps and suggesting directions for future inquiry that address both practical and theoretical challenges. Finally, the concluding section reflects on the contributions of this review, highlighting its relevance for educators, researchers, and policymakers while acknowledging its limitations and pointing toward meaningful next steps in advancing the responsible use of generative AI in language education.

2 Methodology

The adoption of GenAI into educational contexts has radically transformed how languages are taught and learned. From AI-powered chatbots to large language models (LLMs), these technologies have not only reshaped pedagogical approaches but also influenced learners' autonomy, engagement, and achievement. Existing bibliometric studies have increasingly mapped this evolution, offering systematic insights into the thematic trajectories, knowledge structures, and emerging challenges surrounding GenAI in language education (Fan et al. 2023; Kavitha and Joshith 2024; Marchena Sekli 2024; Yun et al. 2025). Unlike these

studies, the current work is the first to apply both co-word analysis and BERTopic modeling specifically to the domain of GenAI in language learning. Importantly, none of these prior bibliometric works adopted BERTopic or co-word analysis as core techniques, highlighting a methodological gap that this research seeks to fill (Klarin 2024; Mishra 2025; Raman et al. 2024; Rejeb et al. 2025a). Co-word analysis was employed to identify patterns of keyword co-occurrence and the relational structure of major research themes, whereas BERTopic modeling was used to uncover semantically rich and contextually grounded topics through transformer-based embeddings (Rejeb et al. 2025a, Rejeb et al. 2025b). The complementary use of these approaches enables the analysis to capture both explicit relationships among keywords and deeper semantic patterns within the literature. This study synthesizes existing research, drawing on co-word analysis and BERTopic modeling, to examine the impact of GenAI on language learning and instruction, while identifying research gaps and outlining future directions for this field.

2.1 Data collection

To ensure a comprehensive and systematic review, this study followed a structured data collection process (Fig. 1). The study followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to guide the identification, screening, and selection of relevant literature. PRISMA provides structured procedures that enhance transparency, replicability, and methodological rigor in review-based research by documenting how studies are located, filtered, and included (Page et al. 2020). Although the present study combines bibliometric and topic modeling techniques, PRISMA principles were used to ensure a systematic and traceable data collection process. The timeframe of 2023–2025 was selected because generative AI technologies became widely accessible in late 2022 with the public release of large language model tools such as ChatGPT, which triggered a rapid expansion of research in language education. Focusing on this period allows the study to capture the most recent and formative phase of GenAI integration in educational research while maintaining topical relevance in a fast-evolving field. A targeted literature search was conducted in January 2026 to ensure coverage of publications indexed through the end of 2025, using the Scopus and Web of Science databases, which represent two leading sources for peer-reviewed academic research. The search strategy incorporated a range of keywords

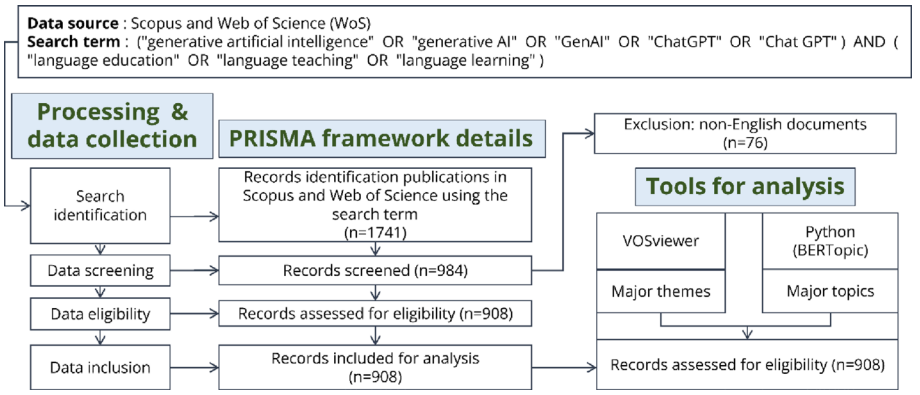

Fig. 1 Review methodology

and Boolean operators, including terms such as *"generative artificial intelligence," "generative AI," "GenAI," "ChatGPT," "Chat GPT," "language education," "language teaching," and "language learning."* This approach aimed to capture a broad yet relevant spectrum of literature at the intersection of GenAI and language education (Fan et al. 2023; Xu 2024; Wang and Kabilan 2024).

The inclusion criteria were established to ensure both breadth and relevance. All English-language peer-reviewed publications, including journal articles, book chapters, and conference papers, published between 2023 and 2025 were included. Documents lacking abstracts, duplicates, and grey literature were excluded to preserve analytical clarity and consistency (Bhullar et al. 2024; Che Ghazali et al. 2025). As GenAI in language education remains a rapidly evolving and emerging research area, incorporating a wide range of publication types was necessary to capture diverse scholarly perspectives and the full scope of ongoing academic discourse. This search initially yielded 1741 records. After a two-step screening process involving title and abstract reviews, 908 articles met the final criteria for full-text analysis. Key metadata, including publication year, document type, author affiliations, and keyword descriptors, were extracted and organized using Microsoft Excel. These data were subsequently prepared for co-word network analysis and topic modeling, supported by tools such as VOSviewer for visualization and structured keyword normalization (Mishra 2025; Lin and Yu 2024; Ogunleye et al. 2025; Su et al. 2025).

2.2 Thematic analysis

Thematic cluster analysis was employed in this study to identify and interpret dominant patterns in the literature on GenAI in language education. This approach is particularly valuable for synthesizing complex and rapidly evolving research landscapes. Thematic analysis (Braun and Clarke 2006) involves systematically identifying, analyzing, and reporting patterns within data. While traditionally qualitative, it has been effectively adapted for bibliometric research to uncover conceptual structures through keyword co-occurrence analysis (Gan et al. 2025; Idrissi Gartoumi 2024; Parappallil Mathew and Bangwal 2024). This study uses VOSviewer, a widely adopted tool for bibliometric mapping (Eck and Waltman 2010), to visualize thematic clusters based on author-supplied keywords. Each keyword was represented as a node, with links indicating co-occurrence frequency, while color-coded clusters highlighted related thematic areas (Abdollahi et al. 2023). In this study, thematic cluster analysis was used to address the research question concerned with the broad intellectual and conceptual structure of GenAI research in language education. Specifically, it helped identify the major thematic areas that organize the field, such as academic writing, assessment, learner-centered pedagogy, translation, and ethical or pedagogical concerns. Thus, this method primarily captured the visible structure of the literature based on recurring author keywords and their co-occurrence relationships. In this article, thematic cluster analysis provided a powerful framework for mapping the intellectual landscape of GenAI in language education. By revealing key research directions and conceptual linkages, this method helps clarify a multidisciplinary field while also guiding future inquiry.

2.3 Topic modeling

To complement the thematic cluster analysis and gain deeper insight into latent patterns within the literature, this study applied BERTopic modeling, which represents an advanced topic modeling technique based on transformer-based embeddings. Unlike traditional models such as Latent Dirichlet Allocation (LDA), BERTopic leverages BERT-derived sentence embeddings along with class-based TF-IDF and HDBSCAN clustering to generate semantically coherent topic clusters (Rejeb et al. 2025a; Madrid-García et al. 2024). This method enables a more nuanced understanding of how ideas are framed and connected across studies, particularly valuable in interdisciplinary domains like GenAI in language education. Preprocessing steps included lemmatization, tokenization, and stopword removal, followed by sentence embedding using the "all-MiniLM-L6-v2" model. Dimensionality reduction was conducted via UMAP to enhance cluster separation and interpretability. The resulting model revealed several key topics, each derived from shared keyword patterns and verified through manual inspection of representative abstracts and titles (Raman et al. 2024; Xue and Liu 2025). While thematic cluster analysis focused on keyword co-occurrence and broader thematic structures, BERTopic modeling was used to address the research question related to the semantic content and latent topical organization of the literature. In other words, topic modeling examined how publications discuss GenAI in language education at a deeper textual level by analyzing titles and abstracts rather than only author-supplied keywords. This allowed the study to identify coherent topics, including AI-assisted writing, teacher engagement with AI tools, learner motivation and emotion, technology acceptance, ethical use, and professional development. Overall, BERTopic modeling enriched the analysis by uncovering both well-established and emerging research directions. It revealed a field that is not only embracing technological innovation but also grappling with its pedagogical and ethical implications.

The two methods, therefore, addressed the research questions collaboratively rather than as isolated procedures. Thematic cluster analysis first mapped the macro-level conceptual structure of the field, showing which concepts frequently appear together and how the literature is organized into major thematic clusters. BERTopic modeling then complemented this by providing a micro- and meso-level semantic interpretation of the literature, revealing more coherent and context-sensitive topics within and across those clusters. Together, the two methods enabled triangulation: co-word analysis showed the structural relationships among visible keywords, whereas BERTopic captured latent meanings and emerging discussions embedded in publication titles and abstracts. This integrated design strengthened the validity of the findings by allowing the study to compare, refine, and extend insights from one method through the other. The combination of these methods also aims to provide a comprehensive overview of the research landscape on GenAI in language education. Co-word analysis identified frequently co-occurring concepts and structural relationships among established themes, while BERTopic modeling uncovered deeper, context-sensitive patterns often missed by traditional bibliometric techniques (Raman et al. 2024). This dual-method approach enabled a nuanced understanding of both dominant and emerging research directions. While bibliometric studies in education are growing (Fan et al. 2023; Che Ghazali et al. 2025), few integrate both co-word and transformer-based modeling. This study addresses that gap and offers a novel lens to track conceptual evolution and guide future inquiry (Ogunleye et al. 2025; Kumar et al. 2024).

3 Results and discussion

3.1 Keyword co-occurrence analysis

In this study, thematic cluster analysis uncovers five distinct research concentrations within the domain of GenAI in language education. As visualized in Fig. 2, the keyword co-occurrence network maps out the interconnectedness of key terms, highlights the thematic density, and signals the evolving directions of inquiry in this interdisciplinary field.

3.1.1 GenAI in English language education and pedagogy

The first thematic cluster revolves around the pedagogical and technological foundations of GenAI in English language education. The centrality of keywords such as "ChatGPT," "AI," "GPT-4," and "AI Tools" demonstrates the increasing integration of large language models (LLMs) into teaching and learning environments, particularly within English as a Foreign Language (EFL) and English Language Teaching (ELT) contexts. These keywords were interpreted together with application-oriented terms such as "academic writing," "feedback," "assessment," "student engagement," and "personalized learning," which more directly indicate how GenAI is being examined in relation to pedagogical practice. Such a reading is reinforced by prior studies describing GenAI tools as intelligent writing assistants and interactive learning agents that can support personalized and adaptive instruction (Huete-García and Tarp 2024; Li et al. 2024b; Li and Tarp 2024). This cluster is

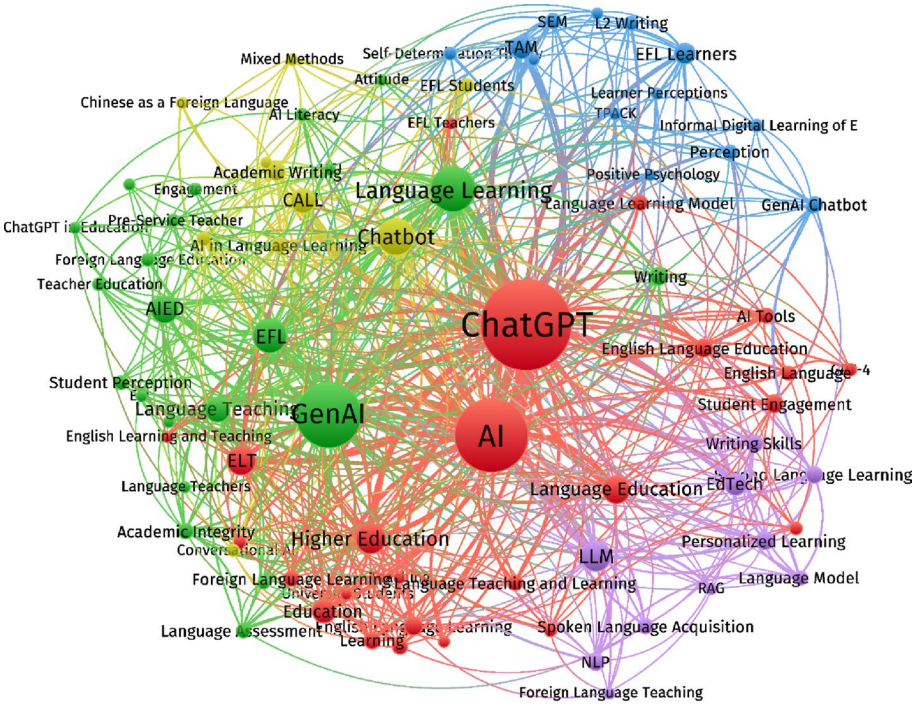

Fig. 2 Keyword co-occurrence network

strongly situated within higher education due to the high frequency of co-occurring terms such as "Higher Education," "University Students," and "Education." This higher-education emphasis also resonates with studies on GenAI use for academic writing, learner autonomy, and instructional efficiency in post-secondary institutions (Bristi et al. 2025; Chen and Gong 2025; Chanpradit 2025). The appearance of "Student Engagement," "Learning," and "Language Learning Model" further indicates that scholars focus on improving learner interaction and motivation through AI-driven pedagogical design, a pattern that echoes previous work on the relationship between AI-supported learning environments, student engagement, and motivational outcomes (Al-khresheh 2024; Niyozov et al. 2023; Vorobyeva et al. 2025).

The recurrence of terms such as "Pedagogy," "EFL Teachers," and "Teaching" indicates that GenAI is closely connected to pedagogical concerns and teacher-related practices in the reviewed literature. Although the keywords do not independently prove that teachers' roles are being transformed, their co-occurrence within the same thematic cluster provides evidence that the literature is increasingly positioning GenAI in relation to teachers' instructional responsibilities and classroom practices. Rather than directly demonstrating pedagogical innovation, these terms show that researchers are increasingly examining how GenAI relates to lesson planning, feedback delivery, formative assessment, and AI-supported instruction. Related studies similarly discuss GenAI in connection with teacher decision-making, instructional design, feedback practices, and classroom-based AI use (Ma et al. 2024; Isiaku et al. 2024; Almulla and Ali 2024). In this sense, the claim is not that the keywords alone establish a complete reshaping of teachers' roles, but that they signal an emerging research focus on the ways teachers engage with, adapt to, and integrate GenAI tools into pedagogical work.

The inclusion of the keywords "English Language Education," "English for Specific Purposes," and "EFL Writing" in the cluster illustrates a growing focus on disciplinary integration and skill development, particularly in academic writing and domain-specific language instruction. This focus corresponds with research on GenAI applications in English language education, ESP contexts, and EFL writing development (Synekop et al. 2024; Kostikova et al. 2024; Tica and Krsmanović 2024). Similarly, "Technology," "Machine Translation," and "Foreign Language Learning" frequently appear in the network and point to a broader ecosystem in which GenAI is embedded within digital education infrastructures. When interpreted together with language-oriented terms such as "English Language Education," "EFL Writing," and "Foreign Language Learning," these terms suggest that GenAI is being examined not only as a general educational technology but also as part of technology-mediated language learning environments where translation, linguistic accessibility, and cross-linguistic communication are relevant concerns. In this respect, studies on AI, machine translation, and digital tools help contextualize the cluster within wider debates on technology-mediated language learning (Tafazoli 2024; Alm and Watanabe 2023). This alignment is further reinforced by studies that explore the integration of GenAI into institutional platforms to support scalable and context-sensitive teaching models (Tran 2025). In short, the first cluster outlines a research trajectory in which GenAI technologies are increasingly discussed in relation to pedagogical practice, learner engagement, and English language instruction across educational contexts.

3.1.2 GenAI, academic integrity, and learner engagement in language education

The second thematic cluster centers on the intersection of GenAI, educational integrity, and the evolving roles of learners and educators within digitally mediated language learning environments. In the cluster, frequently occurring keywords such as "GenAI," "AIED" (Artificial Intelligence in Education), "AI Literacy," and "ChatGPT in Education" reveal a strong focus on how intelligent systems are transforming instructional design, learner engagement, and academic accountability in the language education domain (Cherednichenko et al. 2024; Young and Shishido 2023; Wazan et al. 2024). Furthermore, the ethical, pedagogical, and perceptual dimensions of AI integration have been extensively studied by scholars (Neff et al. 2024; Yang et al. 2024; Zhang and Dong 2024a). The co-occurrence of terms like "Academic Integrity," "Ethical Considerations," and "Assessment" stresses a critical concern with the implications of AI-generated content in student submissions, particularly in writing tasks (Chanpradit 2025; Bin-Nashwan et al. 2023; Alharbi 2024). More specifically, ethical use in this cluster extends beyond general concerns about misconduct and includes issues such as transparency in AI-assisted writing, appropriate disclosure of GenAI use, authorship attribution, data privacy, algorithmic bias, unequal access to AI tools, and the risk of overreliance on automated feedback. These issues are especially significant in language education, where writing, translation, revision, and feedback practices are closely linked to learner identity, linguistic development, and assessment validity. Researchers are examining the potential for GenAI to both support and challenge standards of authenticity, prompting institutions to rethink traditional assessment models (Tian and Wang 2025). Accordingly, recent discussions emphasize the need for clear institutional guidelines, AI literacy training for both teachers and learners, assessment designs that distinguish between acceptable AI-supported learning and inappropriate outsourcing of cognitive work, and pedagogical practices that promote responsible, reflective, and equitable use of GenAI in language classrooms.

Moreover, a central research topic of the cluster is learner-centered dynamics. For instance, keywords such as "Student Perception," "Engagement," "Attitude," and "Learner Perceptions" point to a rich body of work that investigates how students interpret, interact with, and respond to AI tools in language learning contexts (Aksakallı and Daşer 2025; Lai and Lee 2024; Cong-Lem et al. 2024). Related studies often investigate affective, cognitive, and behavioral responses, including motivation, trust, and perceived usefulness (Bristi et al. 2025; Almineeai et al. 2025; Deng et al. 2025). In addition, "Pre-Service Teacher," "Teacher Education," and "Language Teachers" signal attention to educator readiness and the need for professional development in AI-enhanced pedagogy (Kohnke et al. 2024; Al-khresheh 2024; Rahimi and Sevilla-Pavón 2024). There is also a notable research interest in assessment innovation and inclusivity. This is illustrated by the presence of "Language Assessment," "Writing," and "ESL/EFL", which reflect the application of AI for formative and summative evaluation (Ma et al. 2024; Escalante et al. 2023). Besides, the appearance of the keyword "Chinese EFL Learners" demonstrates the cultural and linguistic specificity in the adoption of AI tools (Khoso et al. 2025; Liu and Wang 2024; Gao et al. 2024). Terms such as "HCI" (Human–Computer Interaction) and "Language Teaching" co-occur frequently and suggest that researchers are engaging in an ongoing exploration into user experience design and the ethical-humanistic integration of AI into classroom practice (Guan et al. 2024a; Alm and Watanabe 2023). In summary, the second cluster reveals a research trajectory commit-

ted to understanding the implications of generative AI for equitable, ethical, and effective language education. It places considerable emphasis on the opportunities and challenges of integrating intelligent technologies into learner-centered, culturally diverse, and pedagogically sound environments.

3.1.3 Learner-centered adoption of GenAI in EFL contexts

The third thematic cluster gravitates around the nexus of learner psychology, behavioral intention, and technology acceptance in the adoption of GenAI tools within EFL learning environments. Central to this cluster are keywords such as "TAM" (Technology Acceptance Model), "GenAI Chatbot," "Behavioral Intention," and "SEM" (Structural Equation Modeling). As such, scholars have adopted both theoretical and empirical approaches to understand how learners interact with AI-driven systems and what motivates or hinders their adoption (Zhang and Dong 2024a; Hwang et al. 2025; Zheng et al. 2024). This body of research draws heavily from established psychological and motivational frameworks, notably "Self-Determination Theory" and "Positive Psychology," to explore individual differences in learners' responses to GenAI tools (Zheng et al. 2024; Li and Chiu 2025). The cluster consists of keywords like "Perception," "Learner Perceptions," and "Willingness to Communicate," which relate to students' attitudes, beliefs, and emotional readiness in engaging with AI chatbots for language learning tasks, particularly in writing and academic English (e.g., "L2 Writing," "EAP") (Li and Kim 2024; Hellmich et al. 2024; Xiao and Zhi 2023).

Furthermore, the cluster groups keywords associated with "Informal Digital Learning of English", reflecting an enormous interest in how generative AI is leveraged outside formal classroom settings to support learner autonomy, self-regulated learning, and skill development in unstructured or self-directed environments (Liu et al. 2024, 2025; Guan et al. 2024b). According to Al-Khresheh (2024), these AI tools often act as always-available language partners allowing practice, feedback, and interaction that align with students' personal learning rhythms and preferences. Pedagogical considerations are reflected in the presence of "TPACK" (Technological Pedagogical Content Knowledge), suggesting that effective integration of GenAI into EFL instruction requires technical familiarity as well as pedagogical and content expertise (Parviz and Arthur 2025; Bao and Li 2023). The interplay between learner motivation, perceived usefulness, and educational value is frequently analyzed through models like TAM and SEM, which help quantify and predict student engagement and acceptance of these tools (Parviz and Arthur 2025). Therefore, researchers in the first cluster discuss a nuanced and learner-centered research trajectory that prioritizes psychological, motivational, and pedagogical dimensions in the implementation of GenAI.

3.1.4 Chatbots and conversational AI in language learning

The fourth thematic cluster is mainly related to the use of conversational AI and chatbot technologies in second language learning and academic writing, particularly among EFL students (Alotaibi et al. 2025; Lyu et al. 2025; Zheng 2024). The cluster contains dominant keywords such as "Chatbot," "CALL" (Computer-Assisted Language Learning), and "Conversational AI". These keywords are linked to the discussion of how interactive AI systems are being deployed to facilitate personalized, scalable, and responsive language education

(Yang et al. 2024; Oktarin et al. 2024; Tutton and Cohen 2025). Babu and Adhithya (2023) argue that these tools are increasingly considered language partners, writing assistants, and feedback providers that can provide on-demand linguistic interaction that mimics human dialogue while supporting learner autonomy. A defining feature of this cluster is the applied nature of the research, which is evident through terms like "Academic Writing," "EFL Students," and "AI in Language Learning." Related studies tend to focus on the pedagogical implications of GenAI systems in guiding students through writing processes, from brainstorming and drafting to revising and editing, with a particular focus on improving academic literacy skills (Rejeb et al. 2024; Foroughi et al. 2024; Buruk 2023). The use of chatbots for scaffolding complex tasks has opened new avenues for instructional support, especially in higher education and EFL contexts where individualized feedback is often limited (Behzad et al. 2024; Naz and Robertson 2024).

Based on the keyword "Chinese as a Foreign Language", it appears that the scope of research extends beyond English, suggesting that chatbot-enhanced instruction is gaining relevance in diverse linguistic settings (Zheng 2024). Meanwhile, keywords like "Gemini" and "AI in Language Learning" represent key research issues related to the exploration and comparison of different GenAI platforms, as educators seek tools that align with pedagogical goals, linguistic complexity, and student engagement levels (Strzalkowski et al. 2024). Additionally, the presence of "Systematic Review" and "Mixed Methods" underscores a maturing research base that is not only empirical but also reflective (Law 2024; Chen and Gong 2025; Aksakallı and Daşer 2025). Scholars are increasingly drawing on mixed methodologies to evaluate both the effectiveness and the learner experience of AI-integrated environments (Vorobyeva et al. 2025). These approaches provide a more holistic understanding of how conversational AI is reshaping language instruction. In a nutshell, the fourth cluster aggregates studies that are committed to investigating the real-world deployment of chatbots and conversational AI in language education. It introduces their instructional affordances and the need for continued evaluation to ensure that these technologies are meaningfully and ethically integrated into diverse language learning contexts.

3.1.5 LLM-driven personalized language learning

The fifth cluster concerns the transformative role of LLMs and related AI technologies in enabling personalized and adaptive approaches to language learning (Tian and Wang 2025; Caines et al. 2023; Gu 2025). Frequently occurring keywords such as "LLM," "EdTech," "Personalized Learning," and "Language Model" indicate that scholars have paid attention to the capacity of GenAI to tailor educational content, scaffold instruction, and respond dynamically to learner needs in real-time (Almashy et al. 2024; Campos 2025). Several studies have focused on the emergence of LLMs as both content generators and conversational tutors, capable of facilitating skill development across multiple language domains, including "Writing Skills," "Spoken Language Acquisition," and "Second Language Learning" (Gao et al. 2024; Pack et al. 2024; Borghi et al. 2023). These technologies are reshaping traditional teaching practices by providing individualized feedback, simulating dialogue-based learning, and adapting to student proficiency levels—all of which are central to effective language acquisition (Gervás et al. 2025).

With respect to natural language technologies, the presence of "NLP" (Natural Language Processing) and "RAG" (Retrieval-Augmented Generation) suggests a dual emphasis on

linguistic processing and contextual retrieval (Caines et al. 2023; Eronen et al. 2024; Dalaylı et al. 2023). These underlying capabilities allow AI systems to generate coherent and context-aware outputs that mirror authentic language use, thereby supporting both receptive and productive skills (Parviz and Arthur 2025). Scholars are increasingly exploring how these functionalities can be used to model and enhance learner interaction, vocabulary development, and grammar acquisition (Lee and Davis 2024; Kucuk et al. 2022; Dinh 2025). "EdTech" and "Foreign Language Teaching" appear as relevant themes due to the pedagogical shift toward AI-integrated instructional platforms that blend content delivery, assessment, and feedback into cohesive and personalized learning environments (Caines et al. 2023; Saville 2023). Rejeb et al. (2024) note that this technological convergence increases access to quality education and supports inclusive and learner-centered design in both formal and informal settings. Moreover, the recurring emphasis on personalization aligns closely with broader educational goals focused on learner autonomy, differentiation, and scalability. The use of LLMs in adaptive learning systems raised the potential for an evolving research agenda in which GenAI serves as a tool for language instruction and a foundation for rethinking how learning is delivered, assessed, and experienced (Gao et al. 2024; Pack et al. 2024).

3.2 Results from BERTopic modeling

The application of BERTopic modeling can capture both surface-level keyword co-occurrences and deeper semantic alignments, thereby revealing a comprehensive map of research topics within the corpus. The thematic content, relative weight, and internal consistency of the identified topics are detailed in this section. Table 1 presents the six discovered topics, each represented by the ten most prominent keywords ranked by probability.

Titled "ChatGPT and AI in Language Education," Topic 0 emerges as the most significant theme and accounts for 39.59% of the literature. This topic encapsulates a broad exploration of how ChatGPT and similar AI tools are being integrated across teaching, learning, and institutional contexts. It also addresses widespread academic engagement with the pedagogical implications of GenAI. The second most dominant theme, Topic 1 is labeled "AI-Assisted Writing and Feedback in Language Learning". This topic represents 12.40% of the content, and its focus is on the ability of GenAI to support students' writing development, provide automated feedback, and increase learner engagement in writing-related tasks.

Topic 2 is labeled "Teachers' Engagement with Generative AI in Language Education". It contributes 10.03% of the whole literature, addressing educators' perceptions, training, and practical use of AI tools in classroom settings, especially for lesson planning and materials development. Other topics demonstrate a wide array of focus areas within the GenAI field, including the technology acceptance of ChatGPT among EFL learners (Topic 3), machine translation and AI in translator training (Topic 4), and the emotional and affective dynamics of AI-assisted language learning (Topic 5). The spatial distribution of the identified topics, as illustrated in the inter-topic distance map (Fig. 3), further validates their distinctiveness. In other words, the clear separation among topics indicates that each topic occupies a unique thematic space within the research landscape, with no significant overlaps. This distinctiveness reinforces the robustness of BERTopic in modeling the evolving structure of scholarship on GenAI in language education.

Table 1 Top keywords for each topic identified through BERTopic modeling

Topic	Keywords
0	'language' 0.04236198675056315 'chatgpt' 0.03976198873993329 'learning' 0.03429861945315879 'ai' 0.03091685031662126 'education' 0.024152558750298772 'student' 0.02244692843955679 'teacher' 0.020947517639608542 'chatbot' 0.019139933118641806 'language learning' 0.018719841276192032 'teaching' 0.018712247832795438
1	'writing' 0.07973887974664841 'feedback' 0.03781876111072473 'chatgpt' 0.03545499082375253 'ai' 0.03210489513631245 'student' 0.02998544120486138 'language' 0.02798848198924684 'writing skill' 0.02261331000902208 'skill' 0.01978095775557665 'tool' 0.01874253599227355 'learner' 0.017979307506387935
2	'generative' 0.05318786701981369 'ai' 0.044639886806111195 'language' 0.042191509740970475 'generative ai' 0.03913215936311401 'genai' 0.035372770104092684 'teacher' 0.03146235403935654 'education' 0.02978627589743226 'learning' 0.029224323248623403 'tool' 0.023418325348122302 'gai' 0.02301124166892205
3	'acceptance' 0.05019322124690674 'chatgpt' 0.04587543329042611 'perceived' 0.03745650190324307 'intention' 0.03620346984258223 'efl' 0.034771622136199984 'language' 0.03359905543591833 'learner' 0.03351552371290554 'technology' 0.03115097829877924 'model' 0.03062101214460785 'technology acceptance' 0.030186013796387662
4	'translation' 0.11929316432739262 'machine translation' 0.04037958731754532 'machine' 0.03969110842336849 'language' 0.03821241458521228 'translator' 0.030760979528827177 'teaching' 0.029949631296071665 'chatgpt' 0.028883051914085165 'learning' 0.02450360495549395 'nmt' 0.023358513788466324 'artificial' 0.021555885840234813
5	'student' 0.040511127661742564 'emotion' 0.03837337440438108 'ai' 0.037041640580896935 'efl' 0.031239334976410578 'engagement' 0.031151375613183055 'efl learner' 0.029487476763028746 'learning' 0.02873247446420742 'chatgpt' 0.027976747396993202 'learner' 0.024841441137340638 'language' 0.024643944250396222

3.2.1 ChatGPT and AI in language education

Topic 0 emerges as the most prominent theme in the dataset and captures the integration of ChatGPT and AI tools into English language education. The topic discusses both pedagogical opportunities and critical concerns surrounding their implementation. The studies in this cluster collectively examine how GenAI technologies are reshaping instructional practices, learner engagement, and professional development in the language learning ecosystem. For example, Eragamreddy (2025) investigates the role of ChatGPT in enhancing ELT from the perspective of 50 educators. The author notes ChatGPT's capacity to support instructional efficiency, student engagement, and linguistic skill development. However, concerns over learner over-reliance and cultural nuance remain critical, requiring teacher training programs to promote responsible use.

Another study by Wang et al. (2024) conducts a systematic literature review to assess global trends, opportunities, and challenges in ChatGPT-enhanced ELT. Their analysis reveals significant growth in scholarly attention toward AI-assisted teaching while stressing the need for deeper inquiry into context-specific applications and ethical considerations. From the learner perspective, Zakwani and Binu (2025) explore how EFL students use ChatGPT to support English learning and develop autonomy. Through surveys and interviews, the findings indicate that students appreciate ChatGPT for its accessibility and adaptability and view it as a tool that promotes self-directed learning and task completion. Xue and Li (2025) investigate human–machine symbiosis in higher education contexts and demonstrate how ChatGPT facilitates customized language instruction through diagnostic learning, real-

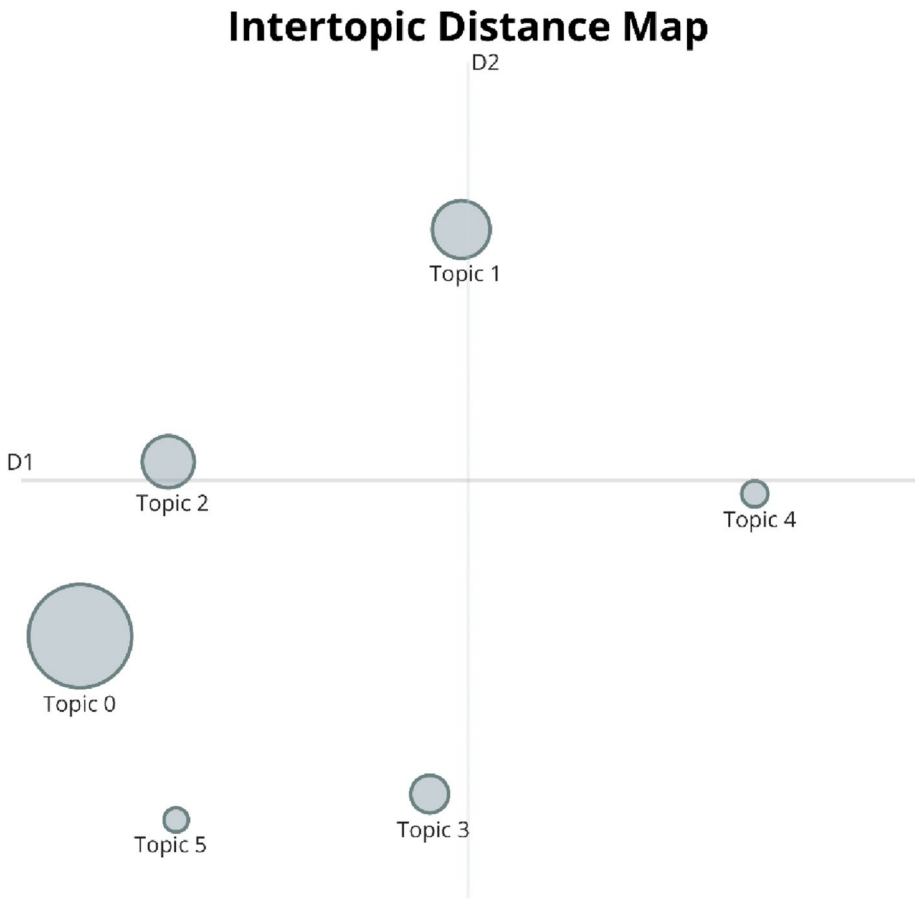

Fig. 3 Intertopic distance map visualizing the semantic relationships among topics

time feedback, and post-task evaluation. The authors also acknowledge the potential risks of diminished human oversight. Finally, Alruwaili and Kianfar (2025) analyze Saudi EFL teachers' attitudes toward ChatGPT in classroom settings. Participants express optimism about AI's utility in planning lessons and designing assessments, but caution against the erosion of critical thinking and learner independence. The authors argue for balanced integration supported by ongoing professional development. Collectively, Topic 0 clarifies the role of ChatGPT in language education and advocates for pedagogically sound, ethically grounded, and context-aware deployment strategies.

3.2.2 AI-assisted writing and feedback in language learning

Topic 1 centers on AI-assisted writing and feedback in language education. This topic addresses how GenAI tools, especially ChatGPT and similar LLMs, are reshaping the feedback dynamics in second language writing instruction. Key studies related to the topic examine the synergy between human and machine-generated feedback, learner engagement,

and instructional outcomes. For instance, Tran (2025) explores the integration of AI- and teacher-generated feedback in a Vietnamese EFL writing course. The study results suggest that combining both feedback types, regardless of order, yields higher revision rates, with AI offering actionable surface-level suggestions while teachers focus on global content and organization. This dual strategy enhances revision quality and frequency. In a separate study, Polakova and Ivenz (2024) evaluate the effectiveness of ChatGPT in improving writing proficiency among EFL university students. Using pre- and post-testing along with qualitative interviews, the authors observe marked improvements in grammar, clarity, and structure. Participants also report high engagement and motivation when using AI for feedback. In addition, Ghafouri et al. (2024) introduce a structured writing protocol, ChatGPT-Guided Writing Instruction Protocol (CGWIP), to support Iranian EFL teachers and learners. Their intervention boosts learners' writing skills and improves teachers' self-efficacy, demonstrating the tool's value beyond learner outcomes.

Cheng et al. (2024) explore how learners at varying proficiency levels interact with ChatGPT in essay writing. Their findings reveal diverse metacognitive strategies: high-proficiency learners apply AI feedback critically, while lower-level learners depend more heavily on AI for planning. Lastly, Escalante et al. (2023) conducted two longitudinal studies comparing AI and human-generated feedback among English as a New Language (ENL) students. While learning outcomes remain comparable, students express mixed preferences, underscoring the importance of a blended approach to feedback. In short, Topic 1 shows an increasing academic focus on AI as a co-instructor in the writing process. The technology has the potential to enhance learner autonomy, improve instructional efficiency, and redefine traditional feedback mechanisms in second language writing education.

3.2.3 Teachers' engagement with GenAI in language education

Topic 2 focuses on teachers' engagement with GenAI in language education, with scholars researching the evolving role of educators as both users and facilitators of GenAI tools in foreign language instruction. Related to the topic, several studies have been conducted to explain teacher training, professional development, and perceptions regarding AI's pedagogical integration. For example, in a case study by Kerr and Kim (2025), pre-service EFL teachers in South Korea used GenAI tools to create middle school lesson plans. Although the tools supported efficiency and creativity in topic selection and content creation, limitations were noted in the pedagogical quality of AI-generated outputs. As a result, there is a need for structured training in prompt design, ethical AI use, and collaborative planning.

Furthermore, Moorhouse et al. (2024) conducted an intervention study within a Hong Kong teacher education program to build professional GenAI competence (P-GenAI-C) among M.Ed candidates. Notable gains were reported in pedagogical and critical awareness of AI tools, although guidance skills remained underdeveloped, hence requiring more holistic training in GenAI use. Likewise, Chung and Jeong (2024) surveyed 134 Chinese pre-service teachers on their views of AI integration in EFL. Participants acknowledged the usefulness of AI for grammar and writing but raised concerns over reduced critical thinking, over-reliance, and ethical issues such as data privacy. Thus, it is imperative to balance AI adoption with core pedagogical principles. In a qualitative study by Barnes and Tour (2025), EAL teachers in Australia disclosed covert use of GenAI due to perceived stigma. While the authors valued AI's utility, their cautious and often hidden engagement reflected

tensions around academic integrity and relational teaching values. Finally, Liu and Xiao (2025) applied the ADDIE framework to examine GenAI's presence across instructional stages among Chinese university teachers. They found AI was mostly used during content development, with limited integration in implementation or evaluation. This also indicates uneven adoption and the need for stage-specific training. In summary, Topic 2 sheds light on both the potential and the hesitancies educators face when integrating GenAI, calling for more targeted professional development and ethical guidance.

3.2.4 Technology acceptance of ChatGPT in EFL learning

Topic 3 explores the technology acceptance of ChatGPT among EFL learners and addresses the psychological and behavioral dimensions influencing learners' adoption of ChatGPT as a language learning tool, primarily through the lens of theoretical frameworks such as the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT2). Representative studies include the work of Hwang et al. (2025), who explore Korean university students' perceptions of ChatGPT through the extended TAM. Through the analysis of 400 survey responses, the authors discover that perceived usefulness strongly predicted learners' intention to continue using ChatGPT, while ease of use alone was insufficient. Notably, result demonstrability and output quality were key influencers of learners' acceptance, which reinforces the importance of transparent, effective, and user-friendly AI integration in education.

In a Saudi Arabian context, Alotaibi et al. (2025) studied factors shaping ChatGPT usage among EFL learners. Their study revealed that while perceived usefulness drove positive attitudes and behavioral intention, ease of use did not significantly influence attitudes. The research also found gender, educational level, and digital literacy to be moderating factors. This also suggests that learners' demographic profiles shape their engagement with AI tools. In addition, Ho and Nguyen (2024), working in Vietnam, surveyed 369 English majors and found high general attitudes toward ChatGPT despite ambivalence about its actual usefulness. Even though students appreciated its accessibility and functionality, concerns about over-reliance and the diminished role of human interaction were evident. Liu and Ma (2024) extended TAM to informal learning settings, analyzing 405 students' behavior. The findings of the structural equation modeling showed that perceived usefulness significantly mediated the relationship between ease of use and attitude, which in turn predicted actual usage in digital learning contexts. Finally, Zheng et al. (2024) adopted the UTAUT2 framework and integrated Self-Determination Theory (SDT) to assess 620 Chinese students. According to the authors, motivation significantly moderated the relationship between facilitating conditions and both behavioral intention and actual use. In conclusion, Topic 3 reveals that learners' acceptance of ChatGPT in EFL is shaped by usefulness, motivation, and contextual factors. This also requires the development of tailored and learner-centered AI adoption strategies.

3.2.5 Machine translation and GenAI in language education

Topic 4 revolves around the integration of machine translation and GenAI into language education. Related research focuses on the evolving pedagogical landscape, where translation tools and interactive AI systems like ChatGPT are increasingly employed to support

language learning, translation training, and instructional innovation. For instance, Xu et al. (2025) developed a ChatGPT-powered translation platform designed for student training and feedback. Their system integrates translation, post-editing, and evaluation, offering both learners and instructors a cohesive digital environment. A pilot study conducted on this platform noted students' engagement and revealed that while AI-generated feedback enhanced translation output, pedagogical challenges related to critical thinking and ethical AI use remain. Likewise, Ohashi (2024) provided a comprehensive overview of MT and GenAI in the language classroom. Opportunities of leveraging these technologies include skill enhancement; however, the associated risks consist of overreliance, AIgiarism, and data privacy concerns. Consequently, there is a need for teacher training and the development of clear usage guidelines to ensure ethical and effective implementation of AI tools.

In another study, Zhao et al. (2024) studied how interactive AI systems like ChatGPT are shaping the competencies of future translators. The authors demonstrated the role of AI in enhancing feedback quality and communication realism in translation instruction. However, AI integration must be accompanied by strategies to maintain students' professional autonomy and ethical awareness. Coulson and Denman (2025) assessed the intersection of translanguaging and MT in foreign language education. Technologies such as DeepL and ChatGPT have the potential to reshape traditional instructional paradigms, prompting a reevaluation of the role of translation in pedagogical practice. Thus, it is essential to establish balanced integration that supports multilingual competence while acknowledging AI's limitations. Finally, Zhang et al. (2025) scrutinized university students' perceptions of GenAI in translation practice. While students valued AI for improving translation speed and quality, concerns over prompt engineering, reliability, and potential overdependence were noted.

3.2.6 Affective engagement and emotions in AI-assisted language learning

The sixth topic points out the affective dimensions of AI-assisted language learning and focuses on how GenAI, particularly ChatGPT, influences emotional engagement, motivation, and learner well-being. Several studies strive to capture emerging scholarship that explores the relationship between emotional states and technological tools in second language acquisition. In one qualitative study, Kohnke and Moorhouse (2025) evaluated the impact of GenAI on emotional engagement among first-year university students in Hong Kong. Through interviews with students and instructors, the study revealed that GenAI use reduced anxiety, enhanced motivation, and created emotionally supportive learning environments. However, concerns around cultural relevance and technical limitations were also reported, necessitating instructor guidance and contextual adaptation.

Similarly, Li and Chiu (2025) drew on Self-Determination Theory (SDT) to study the mediating role of needs satisfaction (autonomy, competence, relatedness) in students' engagement with GenAI chatbots. The results of the survey indicated that emotional engagement was fully mediated by needs satisfaction. This suggests that AI tools can effectively foster stress-free and enjoyable learning experiences, provided teacher support is present. Another contribution by Ismail and Alharkan (2024) examines how ChatGPT can influence positive psychological traits such as enjoyment, self-efficacy, and resilience among Saudi EFL learners. According to the experiment, students trained with ChatGPT significantly outperformed a control group across all affective measures, reinforcing AI's potential to nurture

emotional strengths in language education. In a related study, Ghafouri (2024) introduced a ChatGPT-based rapport-building protocol (CGRBP) aimed at improving teacher–student relationships and second language grit. Conducted over 16 weeks with Iranian EFL learners, the intervention led to significantly higher levels of grit and proved the notion that structured AI use can positively influence learner perseverance and emotional bonds. Finally, Annamalai et al. (2025) applied a modified SDT framework to model students' motivation for continued ChatGPT use. The study identified autonomy and relatedness as key predictors of both competence and sustained usage motivation, showcasing the psychological drivers that underpin long-term engagement with GenAI. In general, the final topic accentuates the growing recognition of emotional and motivational factors in AI-enhanced language learning and advocates for pedagogical strategies that support affective engagement alongside cognitive development.

3.2.7 Evolution of research topics in GenAI for language learning

The temporal evolution of research on GenAI in language education depicts a dynamic and steadily diversifying field, as shown in Figs. 4 and 5. Figure 4 presents the annual evolution of the identified BERTopic themes, while Fig. 5 shows the trend of annual academic output for each topic. Together, these figures provide the empirical basis for interpreting how research attention has shifted across topics from 2023 to 2025. Topic 0, focusing on ChatGPT and AI in language education, has remained the dominant area and showed a marked rise from 2023 to a peak in 2024, followed by continued strong interest into 2025. This trend can be explained by the rapid public release and educational uptake of ChatGPT and related GenAI tools, which created immediate scholarly interest in their pedagogical affor-

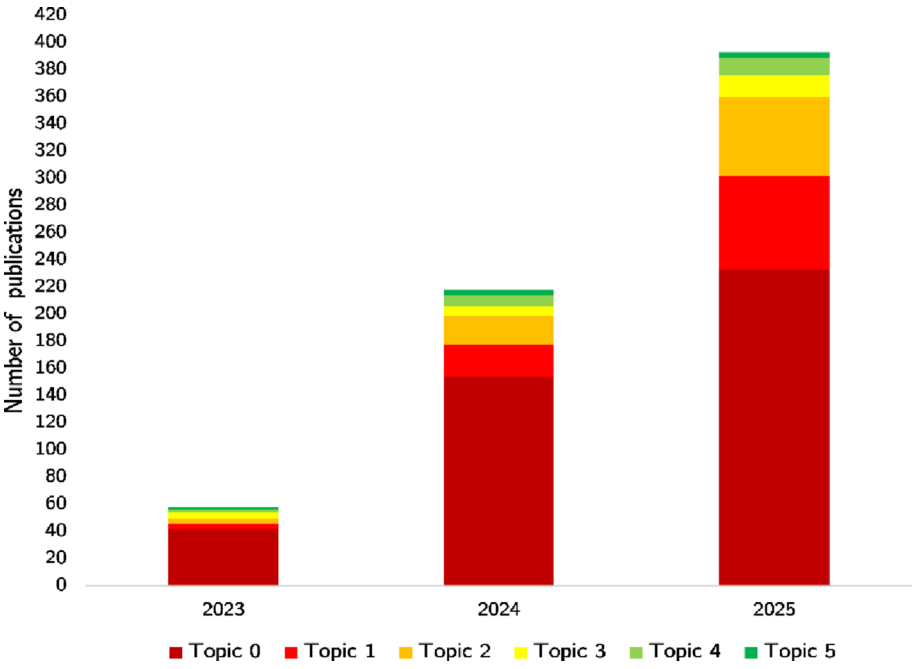

Fig. 4 Annual evolution of identified topics

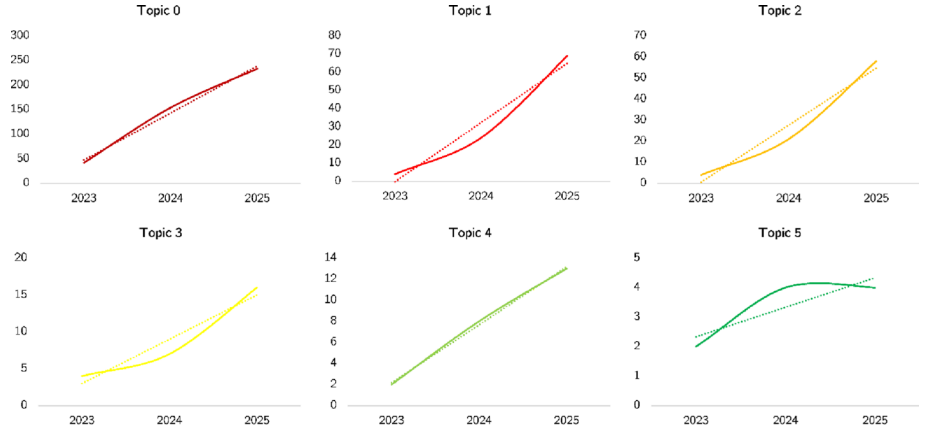

Fig. 5 Trend of annual academic output for each topic

dances, risks, and classroom applications. This pattern mirrors the central role of ChatGPT in discussions around AI-assisted pedagogy and its rapid uptake across diverse educational settings. Topic 1, which focuses on AI-assisted writing and feedback, also shows steady growth and illustrates the increasing interest in the potential of generative tools to support writing instruction and formative assessment. The growth of this topic is likely driven by the direct relevance of GenAI to language production, writing revision, automated feedback, and assessment practices, which are core concerns in language education. Meanwhile, Topic 2, which explores teachers' engagement with GenAI, has grown substantially from 2023 to 2024. This topic maintains its momentum in the subsequent year and suggests a shift from learner-focused studies to educator agency and pedagogical integration. This increase may be attributed to the growing realization that successful GenAI adoption depends not only on tool availability but also on teachers' AI literacy, instructional decision-making, ethical awareness, and capacity to redesign classroom practices.

Topic 3, which concerns the technology acceptance of ChatGPT, shows a more recent but accelerating trajectory, with increasing publications from 2023 onward. This suggests that scholars have become more interested in learner attitudes, behavioral intentions, and the psychological constructs that mediate the uptake of GenAI. This trend is probably caused by the movement from early descriptive studies of ChatGPT toward more explanatory research that seeks to understand why learners accept, resist, trust, or rely on GenAI tools. Although Topics 4 and 5, related to machine translation and affective engagement, respectively, have smaller publication volumes, their stable presence indicates emerging but important lines of inquiry. The modest growth of Topic 4 from 2023 to 2025 points to a growing body of knowledge on translation pedagogy and language mediation via AI tools. This trend may be linked to the increasing convergence between GenAI, machine translation, multilingual communication, and translator training, especially as AI tools become more capable of producing and revising multilingual texts. Although it represents a relatively new entrant, Topic 5 indicates that researchers have started to tackle growing concerns with the emotional and motivational dimensions of AI-supported learning. The emergence of this topic can be explained by the broader shift from evaluating GenAI only as a cognitive or productivity tool toward examining its effects on learner confidence, anxiety, motivation, engagement,

and well-being. To sum up, the analysis of temporal trends shows an ongoing transition from early experimentation with GenAI toward more specialized investigations into its pedagogical, psychological, and disciplinary applications. This transition appears to be driven by three interrelated factors: the rapid diffusion of ChatGPT into educational settings, the immediate relevance of GenAI to language production and feedback, and the growing need to address ethical, affective, and instructional challenges associated with AI-mediated learning. This evolution reveals the maturation of the field and the embedding of GenAI as a critical component of language education research and practice.

4 Conclusion

The academic literature pertaining to the nexus of GenAI and language education reveals a rapidly evolving and multidimensional research landscape. To comprehensively map this terrain, we employed co-word analysis and BERTopic topic modeling. These techniques represent two complementary methodologies that offer different but related forms of evidence: co-word analysis identifies structural relationships among author keywords through their co-occurrence patterns, whereas BERTopic modeling identifies semantic topics from the contextual meanings expressed in titles, abstracts, and keywords. In the present study, co-word analysis was used to detect the structural organization of the field based on the co-occurrence of author keywords. Therefore, the clusters reported in this study identify how major concepts are connected at the keyword level. By contrast, BERTopic modeling was applied to the textual content of the publications to identify semantically coherent topics based on the contextual meaning of terms within titles, abstracts, and keywords. Thus, the BERTopic results do not repeat the cluster analysis; rather, they provide a second layer of evidence by showing how the same research area is articulated through broader semantic patterns and temporal topic development.

The co-word analysis enabled the identification of major thematic clusters based on keyword co-occurrence patterns. These clusters confirmed the critical role played by tools like ChatGPT and other large language models in revisiting English language pedagogy. More specifically, Cluster 1 noted the pedagogical integration of GenAI into English as a foreign language and English for specific purposes, with particular focus on enhancing writing skills, learner autonomy, and instructional adaptability in higher education. Meanwhile, Clusters 2 and 3 elaborated on critical issues around teacher engagement, AI ethics, academic integrity, and the psychological and behavioral responses of learners. These clusters equally presented the opportunities and challenges posed by AI integration in formal and informal learning contexts (Rejeb et al. 2024; Foroughi et al. 2024).

The application of BERTopic modeling in this study aims to expand the thematic map by uncovering semantically coherent and temporally dynamic topic clusters. Unlike the co-word clusters, which are based on keyword co-occurrence, the BERTopic topics capture the dominant meanings expressed across the textual corpus. Topic 0 (ChatGPT and AI in language education) emerged as the most dominant theme and shed light on the field's broad engagement with ChatGPT's pedagogical potential across institutional and learner settings. Moreover, topic 1 (AI-assisted writing and feedback) explained how GenAI is ameliorating writing instruction through real-time feedback and scaffolded learning support. Topic 1 is complemented by Topic 2, which reveals the importance of teacher training, ethical con-

cerns, and the evolving instructional roles of educators in AI-mediated classrooms. Topics 3 through 5 capture more specialized yet emerging domains. In particular, Topic 3, on the technology acceptance of ChatGPT, deals with how learners' motivation, perceived usefulness, and behavioral intention shape AI adoption. Scholars framed these issues through theoretical models such as TAM and UTAUT2 (Parviz and Arthur 2025; Dolenc and Brumen 2024). Topic 4 reinforces the promising application of AI and machine translation in translation pedagogy, with implications for translator training and multilingual instruction. Topic 5 introduces and discusses the affective dimensions of learning, including how GenAI can foster emotional engagement, resilience, and learner motivation through supportive and personalized learning environments.

As the GenAI field matures, it is increasingly featured by a significant scholarly focus on learner-centered design, professional development, and socio-technical alignment. In this study, the contribution of BERTopic lies in clarifying the semantic evolution of the field: while co-word analysis maps the structural relationships among research keywords, BERTopic shows how the content of the literature is moving from general discussions of ChatGPT and AI tools toward more specialized concerns such as writing feedback, learner acceptance, translation pedagogy, teacher preparation, and affective learning. Overall, the combined results of our co-word and BERTopic analyses support the idea that GenAI is not merely an assistive technology in language education but a transformative force that is reconfiguring pedagogical practices, learner experiences, and institutional strategies. Much like the trajectory of AI in broader educational contexts, research on GenAI signals a radical shift toward more personalized, ethical, and human-centered learning ecosystems. This is where GenAI serves as a tool for instruction and a catalyst for rethinking the very nature of teaching, learning, and educational engagement in the digital age.

4.1 Future research directions

The insights gained from this study uncover multiple compelling directions for advancing research on GenAI within language education. As AI-powered tools like ChatGPT become increasingly embedded in instructional practices (Bin-Nashwan et al. 2023; Rejeb et al. 2024), one key area for further exploration involves creating more context-sensitive and pedagogically responsive systems. Future investigations should examine how GenAI can be tailored to accommodate diverse learner needs, language proficiency levels, and curricular goals, especially in areas such as academic writing, speaking practice, and feedback automation (Isiaku et al. 2024).

Another promising avenue involves deepening the understanding of the psychological and emotional dimensions of learner interaction with GenAI (Isiaku et al. 2024). While current studies describe benefits such as reduced anxiety and increased motivation, additional research should focus on how these effects manifest across different age groups, cultural backgrounds, and learning environments (Shaikh et al. 2023; Alsaawi et al. 2025). This includes exploring how GenAI can be purposefully designed to support student well-being, promote engagement, and sustain motivation over longer learning trajectories. The evolving role of educators also warrants continued inquiry (Alharbi 2024). Given that GenAI shifts teaching practices, research should focus on empowering teachers through targeted professional development, helping them navigate the ethical, pedagogical, and practical challenges of integrating AI into their classrooms (Chanpradit 2025; Adipat 2025; Faisal 2024).

Questions around teacher agency, instructional trust, and collaborative GenAI usage models remain underexplored and are critical to successful adoption (Barnes and Tour 2025).

In addition, the ethical considerations and governance of AI in education must remain a central focus. With concerns around authorship, data security, algorithmic bias, and over-reliance on automation, scholars should work toward frameworks that guide responsible AI use while protecting academic integrity and learner autonomy (Rejeb et al. 2024; Zhang and Dong 2024b; Mohamed 2024). Comparative and cross-institutional studies could shed light on best practices in regulating GenAI in both policy and classroom contexts (Cheon et al. 2025). Finally, future research should establish robust evaluation frameworks to assess the effectiveness and impact of GenAI across cognitive, emotional, and behavioral domains. Developing metrics that go beyond achievement scores to include learner engagement, creativity, and equitable access will be essential for aligning AI-enhanced instruction with inclusive and high-quality education. With the continued evolution of GenAI, such multi-dimensional research efforts will be vital for shaping its role in building more personalized, ethical, and learner-centered language learning environments.

5 Research implications

This review deepens the understanding of how GenAI contributes to language education, with implications that extend across theory, pedagogy, and educational practice. The analysis supports the argument that generative tools such as ChatGPT represent technological novelties that drive fundamental changes in how languages are taught, learned, and assessed. By enabling adaptive feedback, fostering learner autonomy, and supporting personalized learning trajectories, GenAI has the potential to transform the dynamics of classroom interaction, instructional design, and educational engagement.

At a conceptual level, the study brings to light how the integration of GenAI intersects with existing frameworks in educational psychology, digital pedagogy, and applied linguistics. The review emphasizes the nexus of cognitive, emotional, and behavioral responses to AI, revealing new dimensions of learner experience and teacher adaptation. Importantly, the article underscores the emerging role and impact of GenAI on the mechanics and ethics of language instruction, whether through redefining authorship and assessment or through augmenting teacher–student interaction in hybrid learning environments. From a practical perspective, the findings offer actionable insights for educators, institutions, and policy-makers seeking to responsibly implement AI in language learning contexts. The evidence points to the need for robust professional development programs, clear ethical guidelines, and learner-centered design approaches that prioritize inclusivity, trust, and transparency. Therefore, institutions must also consider how AI can support, not replace, human pedagogical judgment and ensure that its adoption enhances rather than erodes critical thinking, creativity, and communicative competence. Taken together, this review documents the position of AI as a powerful agent of transformation in language education, which is capable of delivering more personalized, equitable, and scalable learning experiences. However, this depends on the need to develop a balanced approach that integrates technological innovation with pedagogical insight. Ethical foresight will also be key to realizing the full potential of GenAI in supporting the diverse and dynamic requirements of 21st-century language learners.

5.1 Study limitations

While the current study offers a thorough exploration of the role of GenAI in language teaching and learning, certain limitations should be recognized. Although the application of co-word analysis is effective in revealing central research directions, it may underrepresent less mainstream or emerging pedagogical uses of GenAI that are still developing or marginal in the current literature. Similarly, the BERTopic modeling approach, while powerful in detecting thematic structures, is inherently shaped by the scope and representativeness of the dataset. If the literature sampled is uneven in disciplinary focus or geographic coverage, some relevant perspectives may be inadvertently excluded. Moreover, this review may not fully account for practical innovations occurring in real-time within classrooms or through institutional pilots that have yet to reach formal publication. Given the rapid pace at which AI tools like ChatGPT are evolving and proliferating, some of the most recent and impactful applications in educational settings may still be in flux or shared informally through grey literature and educator communities. Furthermore, the dataset was restricted to publications indexed in Scopus and Web of Science to ensure quality control and bibliometric consistency. As a result, some emerging research disseminated through practitioner-oriented community reports may not be represented. Future studies could incorporate additional sources to capture these rapidly developing and practice-driven perspectives. Lastly, even though the chosen methods effectively capture high-level patterns and thematic developments, they cannot fully reflect the nuanced and context-dependent ways GenAI interacts with pedagogical goals, learner identities, and institutional policies. As a result, future research would benefit from more localized, empirical, and longitudinal studies to examine how GenAI tools shape educational practices in varied cultural, technological, and curricular environments.

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Declarations

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References

Abdollahi, A., Ghaderi, Z., Béal, L., Cooper, C.: The intersection between knowledge management and organizational learning in tourism and hospitality: a bibliometric analysis. J. Hosp. Tour. Manag. **55**, 11–28 (2023). https://doi.org/10.1016/j.jhtm.2023.02.014

Adipat, S.: Challenging conventions: ChatGPT's controversial impacts on educational and English language teaching practices. Ed. Process. Int. J. (2025). https://doi.org/10.22521/edupij.2025.14.66

Aksakallı, C., Daşer, Z.: Unlocking EFL learners' insights into ChatGPT use for L2 writing: the impacts of usage frequency and gender variations. Curr. Psychol. (2025). https://doi.org/10.1007/s12144-025-07437-3

Alharbi, W.: Mind the Gap, Please! Addressing the mismatch between teacher awareness and student AI adoption in language education within higher education. Int. J. Comput.-Assisted Lang. Learning. Teach. (2024). https://doi.org/10.4018/IJCALLT.351245

Al-khresheh, M.H.: Bridging technology and pedagogy from a global lens: teachers' perspectives on integrating ChatGPT in English language teaching. Comput. Educ. (2024). https://doi.org/10.1016/j.caeai.2024.100218

Alm, A., Watanabe, Y.: Integrating ChatGPT in language education: a freirean perspective. Iran J Lang Teach Res **11**(3), 19–30 (2023). https://doi.org/10.30466/IJLTR.2023.121404

Almashy, A., Ahmed, A.S.M.M., Jamshed, M., Ansari, M.S., Banu, S., Warda, W.U.: Analyzing the impact of CALL tools on English learners' writing skills: a comparative study of errors correction. World J. Engl. Lang. **14**(6), 657–667 (2024). https://doi.org/10.5430/wjel.v14n6p657

Almineeai, A.M., Alrashed, M.A., Hezam, T.A., Alharthi, A.F., Alharthi, S.F.: The impact of ChatGPT on EFL medical track students' affective filter. J. Lang. Teach. Res. **16**(1), 158–167 (2025). https://doi.org/10.17507/jltr.1601.17

Almulla, M., Ali, S.I.: The changing educational landscape for sustainable online experiences: implications of ChatGPT in arab students' learning experience. Int. J. Learn. Teach. Educ. Res. **23**(9), 285–306 (2024). https://doi.org/10.26803/ijlter.23.9.15

Alotaibi, H.M., Sonbul, S.S., El-Dakhs, D.A.: Factors influencing the acceptance and use of ChatGPT among English as a foreign language learners in Saudi Arabia. Hum. Soc. Sci. Commun. (2025). https://doi.org/10.1057/s41599-025-04945-2

Alruwaili, A.R., Kianfar, Z.: Investigating EFL female Saudi teachers' attitudes toward the use of ChatGPT in English language teaching. Forum Linguist Stud. **7**(2), 203–216 (2025). https://doi.org/10.30564/fls.v7i2.7937

Alsaawi, A., Almoaily, M., Almulhim, F., Alahmadi, N., Alshenqeeti, H.: Attitudes to the use of artificial intelligence in language learning: the case of chatbots in Saudi Arabia. Int. J. Comput.-Assist. Lang. Learn. Teach. (2025). https://doi.org/10.4018/IJCALLT.376344

Annamalai, N., Bervell, B., Mireku, D.O., Andoh, R.P.K.: Artificial intelligence in higher education: modelling students' motivation for continuous use of ChatGPT based on a modified self-determination theory. Comput. Educ. (2025). https://doi.org/10.1016/j.caeai.2024.100346

Babu, C.V.S., Adhithya, S.: ChatGPT and other generative AI tools in education: transformative potential and ethical considerations. In: Creat AI Tools and Ethical Implic in Teach and Learn, pp. 135–152. IGI Global (2023). https://doi.org/10.4018/979-8-3693-0205-7.ch007

Bao, Y., Li, B.: A preliminary study on graduate student instructors' exploration, perception, and use of ChatGPT. Int. J. Comput.-Assist. Lang. Learn. Teach. (2023). https://doi.org/10.4018/IJCALLT.332873

Barnes, M., Tour, E.: Teachers' use of generative AI: A 'dirty little secret'? Lang. Educ. (2025). https://doi.org/10.1080/09500782.2025.2485935

Behzad, S., Kashefi, O., Somasundaran, S.: Assessing online writing feedback resources: generative AI versus good samaritans. In: Calzolari, N., Kan, M.-Y., Hoste, V., Lenci, A., Sakti, S., Xue, N. (eds). Jt Int Conf Comput Linguist, Lang Resour Eval, LREC-COLING - Main Conf Proc. European Language Resources Association (ELRA), pp. 1638–1644 (2024)

Bhullar, P.S., Joshi, M., Chugh, R.: ChatGPT in higher education - a synthesis of the literature and a future research agenda. Educ. Inf. Technol. **29**(16), 21501–21522 (2024). https://doi.org/10.1007/s10639-024-12723-x

Bin-Nashwan, S.A., Sadallah, M., Bouteraa, M.: Use of ChatGPT in academia: academic integrity hangs in the balance. Technol. Soc. (2023). https://doi.org/10.1016/j.techsoc.2023.102370

Borghi, A.M., De Livio, C., Mannella, F., Tummolini, L., Nolfi, S.: Exploring the prospects and challenges of large language models for language learning and production. Sist. Intell. **35**(2), 361–377 (2023). https://doi.org/10.1422/108135

Braun, V., Clarke, V.: Using thematic analysis in psychology. Qual. Res. Psychol. **3**(2), 77–101 (2006). https://doi.org/10.1191/1478088706qp063oa

Bristi, N.L., Shafie, L.A., Hajimia, H.B., Hasan, Md.K..: Decoding EFL learners' intention to use ChatGPT for academic writing: cognitive and emotional drivers. Intl. J. Learn. Teach. Edu. Res. **24**(3), 1–28 (2025). https://doi.org/10.26803/ijlter.24.3.1

Buruk O. Academic Writing with GPT-3.5 (ChatGPT): reflections on practices, efficacy and transparency. In: ACM International Conference Proceeding Series Association for Computing Machinery, pp. 144–53 (2023). https://doi.org/10.1145/3616961.3616992

Caines, A., Benedetto, L., Taslimipoor, S., Davis, C., Gao, Y., Andersen, Ø., et al.: On the application of large language models for language teaching and assessment technology. In: Moore S., Stamper J., Tong R., Cao C., Liu Z., Hu X., et al. (eds.). CEUR Workshop Proceedings CEUR-WS, pp. 173–197 (2023).

Campos, M.: AI-assisted feedback in CLIL courses as a self-regulated language learning mechanism: students' perceptions and experiences. Eur. Public Soc. Innov. Rev. (2025). https://doi.org/10.31637/epsir-2025-1568

Chanpradit, T.: Generative artificial intelligence in academic writing in higher education: a systematic review. Edelweiss Appl. Sci. Technol. **9**(4), 889–906 (2025). https://doi.org/10.55214/25768484.v9i4.6128

Chapelle, C.A.: Generative AI as game changer: implications for language education. System **132**, 103672 (2025). https://doi.org/10.1016/j.system.2025.103672

Che Ghazali, R., Abdul Hanid, M.F., Mohd Said, M.N.H., Lee, H.Y.: The advancement of Artificial Intelligence in education: insights from a 1976–2024 bibliometric analysis. J. Res. Technol. Educ. (2025). https://doi.org/10.1080/15391523.2025.2456044

Chen, C., Gong, Y.: The role of AI-assisted learning in academic writing: a mixed-methods study on Chinese as a second language students. Educ. Sci. (2025). https://doi.org/10.3390/educsci15020141

Cheng, H., Liu, H., Xu, Y., Gao, C., Yang, J., Jia, M., et al.: Students' engagement in seeking and accepting ChatGPT feedback in essay writing: a study of second language learners at varying proficiency levels. In: Global Chinese Conference on Computers in Education (GCCCE) Main Conference Proceedings, pp. 38–45 (2024)

Cheon, G., Choi, Y., Lee, D., Baek, J.: Generative AI agents in language learning: a randomized field experiment. In: Bui, T.X. (ed). In: Proceedings of the Annual Hawaii International Conference on System Sciences, pp. 4949–4958. IEEE Computer Society (2025)

Cherednichenko, O., Yanholenko, O., Badan, A., Onishchenko, N., Akopiants, N.: Large language models for foreign language acquisition. In: Khairova N., Umea University U 4 Umea, Khairova N., National Technical University "Kharkiv Polytechnic Institute" K 2 Kharkiv, Vysotska V., Osnabruck University F-J-Str 1 Osnabruck, et al., editors. CEUR Workshop Proc. CEUR-WS, pp. 101–130 (2024).

Chung, J.Y., Jeong, S.-H.: Exploring the perceptions of Chinese pre-service teachers on the integration of generative AI in English language teaching: benefits, challenges, and educational implications. Online J. Commun. Media Technol. (2024). https://doi.org/10.30935/ojcmt/15266

Cong-Lem, N., Tran, T.N., Nguyen, T.T.: Academic integrity in the age of generative AI: perceptions and responses of vietnamese efl teachers. Teach. Engl. Technol. **24**(1), 28–47 (2024). https://doi.org/10.56297/FSYB3031/MXNB7567

Coulson, D., Denman, C.: Translation, Translanguaging and Machine Translation in Foreign Language Education, p. 516. Springer Nature (2025). https://doi.org/10.1007/978-3-031-82174-5

Crompton, H., Edmett, A., Ichaporia, N., Burke, D.: AI and English language teaching: affordances and challenges. Br. J. Educ. Technol. **55**(6), 2503–2529 (2024). https://doi.org/10.1111/bjet.13460

Dalaylı, F.: Use of NLP techniques in translation by ChatGPT: case study. In: Haddad, A.H., Terryn, A.R., Mitkov, R., Rapp, R., Rapp, R., Zweigenbaum, P., et al. (eds.) Comput Terminol NLP Transl Stud, ConTeNTS - Inc Workshop Build Using Comp Corpora, BUCC , associated with 14th Int Conf Recent Advances in Natural Language Processing , RANLP - Proc. Incoma Ltd, pp. 19–25 (2023). https://doi.org/10.26615/978-954-452-090-8_003

Deng, R., Jiang, M., Yu, X., Lu, Y., Liu, S.: Does ChatGPT enhance student learning? A systematic review and meta-analysis of experimental studies. Comput. Educ. (2025). https://doi.org/10.1016/j.compedu.2024.105224

Dinh, C.T.: Undergraduate English majors' views on ChatGPT in academic writing: perceived vocabulary and grammar improvement. FWU J. Soc. Sci. **19**(1), 1–11 (2025). https://doi.org/10.51709/19951272/Spring2025/1

Dolenc, K., Brumen, M.: Exploring social and computer science students' perceptions of AI integration in (foreign) language instruction. Comput. Educ. (2024). https://doi.org/10.1016/j.caeai.2024.100285

Dong, W., Pan, D., Kim, S.: Exploring the integration of IoT and generative AI in English language education: smart tools for personalized learning experiences. J. Comput. Sci. **82**, 102397 (2024). https://doi.org/10.1016/j.jocs.2024.102397

Eragamreddy, N.: AI in ELT: ChatGPT's role in English language teaching and learning. In: Using AI Tools in Text Analysis, Simplification, Classific, and Synthesis, pp. 161–197. IGI Global (2025). https://doi.org/10.4018/979-8-3693-9511-0.ch006

Eronen, J., Lee, S.: Improving English education in Japan: leveraging large language models for personalized and skill-diverse learning. In: Rzepka, R., Ptaszynski, M., Dybala, P., Chung, S.-F., Vallverdu, J. (eds). CEUR Workshop Proceedings CEUR-WS, pp. 17–29 (2024)

Escalante, J., Pack, A., Barrett, A.: AI-generated feedback on writing: insights into efficacy and ENL student preference. Int. J. Educ. Technol. High. Educ. (2023). https://doi.org/10.1186/s41239-023-00425-2

Evmenova, A.S., Borup, J., Shin, J.K.: Harnessing the power of generative AI to support ALL learners. TechTrends **68**(4), 820–831 (2024). https://doi.org/10.1007/s11528-024-00966-x

Faisal, E.: Unlock the potential for Saudi Arabian higher education: a systematic review of the benefits of ChatGPT. Front. Educ. (2024). https://doi.org/10.3389/feduc.2024.1325601

Fan, L., Li, L., Ma, Z., Lee, S., Yu, H., Hemphill, L.: A bibliometric review of large language models research from 2017 to 2023. arXiv (2023). https://doi.org/10.48550/arXiv.2304.02020

Foroughi, B., Iranmanesh, M., Ghobakhloo, M., Senali, M.G., Annamalai, N., Naghmeh-Abbaspour, B., et al.: Determinants of ChatGPT adoption among students in higher education: the moderating effect of trust. Electron. Libr. **43**(1), 1–21 (2024). https://doi.org/10.1108/EL-12-2023-0293

Gan, Q., Lau, R.Y.K., Hong, J.: A critical review of blockchain applications to banking and finance: a qualitative thematic analysis approach. Technol. Anal. Strateg. Manag. **37**(4), 387–403 (2025). https://doi.org/10.1080/09537325.2021.1979509

Gao, Y., Wang, Q., Wang, X.: Exploring EFL university teachers' beliefs in integrating ChatGPT and other large language models in language education: a study in China. Asia Pac. J. Educ. **44**(1), 29–44 (2024). https://doi.org/10.1080/02188791.2024.2305173

Gervás, P., León, C., Kumar, M., Méndez, G., Bautista, S.: Prompting an LLM Chatbot to role play conversational situations for language practice. In: du Boulay, B., Di Mascio, T., Tovar, E., Meinel, C. (eds.). International Conference on Computer Supported Education, CSEDU – Proceedings, pp. 257–264. Science and Technology Publications, Lda (2025). https://doi.org/10.5220/0013235400003932

Ghafouri, M.: ChatGPT: the catalyst for teacher-student rapport and grit development in L2 class. System (2024). https://doi.org/10.1016/j.system.2023.103209

Ghafouri, M., Hassaskhah, J., Mahdavi-Zafarghandi, A.: From virtual assistant to writing mentor: exploring the impact of a ChatGPT-based writing instruction protocol on EFL teachers' self-efficacy and learners' writing skill. Lang. Teach. Res. (2024). https://doi.org/10.1177/13621688241239764

Godwin-Jones, R.: Distributed agency in second language learning and teaching through generative AI. arXiv (2024). https://doi.org/10.48550/arXiv.2403.20216

Gu, W.: Linguistically informed ChatGPT prompts to enhance Japanese-Chinese machine translation: a case study on attributive clauses. PLoS ONE (2025). https://doi.org/10.1371/journal.pone.0313264

Guan, L., Zhang, E.Y., Gu, M.M.: Examining generative AI–mediated informal digital learning of English practices with social cognitive theory: a mixed-methods study. ReCALL (2024a). https://doi.org/10.1017/S0958344024000259

Guan, L., Li, S., Gu, M.M.: AI in informal digital English learning: a meta-analysis of its effectiveness on proficiency, motivation, and self-regulation. Comput. Educ. (2024b). https://doi.org/10.1016/j.caeai.2024.100323

Hellmich, E.A., Vinall, K., Brandt, Z.M., Chen, S., Sparks, M.M.: ChatGPT in language education: centering learner voices. Technol. Lang. Teach. Learn. (2024). https://doi.org/10.29140/tltl.v6n3.1741

Hınız, G.: A year of generative AI in English language teaching and learning—A case study. J. Res. Technol. Educ. (2024). https://doi.org/10.1080/15391523.2024.2404132

Ho, A., Nguyen, H.: generative artificial intelligence and ChatGPT in language learning: EFL students' perceptions of technology acceptance. J. Univ. Teach. Learn. Pract. (2024). https://doi.org/10.53761/fr1rkj58

Huete-García, Á., Tarp, S.: Training an AI-based writing assistant for Spanish learners: the usefulness of chatbots and the indispensability of human-assisted intelligence. Lexikos **34**, 21–40 (2024). https://doi.org/10.5788/34-1-1862

Hwang, M., Lee, E., Lee, H.-K.: Exploring EFL learners' acceptance of ChatGPT: application of the extended technology acceptance model. Engl. Teach. **80**(1), 45–69 (2025). https://doi.org/10.15858/engtea.80.1.202503.45

Idrissi Gartoumi, K.: Five-year review of Blockchain in construction management: scientometric and thematic analysis (2017-2023). Autom. Constr. **168**, 105773 (2024). https://doi.org/10.1016/j.autcon.2024.105773

Isiaku, L., Muhammad, A.S., Kefas, H.I., Ukaegbu, F.C.: Enhancing technological sustainability in academia: leveraging ChatGPT for teaching, learning and evaluation. Qual. Educ. All **1**(1), 385–416 (2024). https://doi.org/10.1108/QEA-07-2024-0055

Ismail, S.M., Alharkan, A.: EFL learners' positive emotions in the era of technology: unpacking the effects of artificial intelligence on learning enjoyment, self-efficacy, and resilience. CALL-EJ. **25**(4), 526–551 (2024)

Kavitha, K., Joshith, V.P.: The transformative trajectory of artificial intelligence in education: the two decades of bibliometric retrospect. J. Educ. Technol. Syst. **52**(3), 376–405 (2024). https://doi.org/10.1177/00472395241231815

Kerr, R.C., Kim, H.: From prompts to plans: a case study of pre-service EFL teachers' use of generative AI for lesson planning. Engl. Teach. **80**(1), 95–118 (2025). https://doi.org/10.15858/engtea.80.1.202503.95

Khoso, A.K., Honggang, W., Darazi, M.A.: Empowering creativity and engagement: the impact of generative artificial intelligence usage on Chinese EFL students' language learning experience. Comput. Hum. Behav. Rep. **18**, 100627 (2025). https://doi.org/10.1016/j.chbr.2025.100627

Kittredge, A.K., Hopman, E.W.M., Reuveni, B., Dionne, D., Freeman, C., Jiang, X.: Mobile language app learners' self-efficacy increases after using generative AI. Front. Educ. **10**, 1499497 (2025). https://doi.org/10.3389/feduc.2025.1499497

Klarin, A.: How to conduct a bibliometric content analysis: guidelines and contributions of content co-occurrence or co-word literature reviews. Int. J. Consum. Stud. **48**(2), e13031 (2024). https://doi.org/10.1111/ijcs.13031

Kohnke, L., Moorhouse, B.L.: Enhancing the emotional aspects of language education through generative artificial intelligence (GenAI): a qualitative investigation. Comput. Hum. Behav. **167**, 108600 (2025). https://doi.org/10.1016/j.chb.2025.108600

Kohnke, L., Moorhouse, B.L., Zou, D.: Exploring generative artificial intelligence preparedness among university language instructors: a case study. Comput. Educ. Artif. Intell. **5**, 100156 (2023). https://doi.org/10.1016/j.caeai.2023.100156

Kohnke, L., Zou, D., Moorhouse, B.L.: Technostress and English language teaching in the age of generative AI. Educ. Technol. Soc. **27**(2), 306–320 (2024)

Kostikova, I., Holubnycha, L., Besarab, T., Moshynska, O., Moroz, T., Shamaieva, I.: ChatGPT for professional English course development. Int. J. Interact. Mob. Technol. **18**(2), 68–81 (2024). https://doi.org/10.3991/ijim.v18i02.46623

Kucuk, C., Birant, D., Yildirim Taser, P.: A novel machine learning approach: soil temperature ordinal classification (STOC). Tarim Bilimleri Dergisi **28**(4), 635–649 (2022). https://doi.org/10.15832/ankutbd.866045

Kumar, A., Karamchandani, A., Singh, S.: Topic modeling of neuropsychiatric diseases related to gut microbiota and gut brain axis using artificial intelligence based BERTopic model on PubMed abstracts. Neurosci. Inform. **4**(4), 100175 (2024). https://doi.org/10.1016/j.neuri.2024.100175

Lai, W.Y.W., Lee, J.S.: A systematic review of conversational AI tools in ELT: publication trends, tools, research methods, learning outcomes, and antecedents. Comput. Educ. (2024). https://doi.org/10.1016/j.caeai.2024.100291

Law, L.: Application of generative artificial intelligence (GenAI) in language teaching and learning: a scoping literature review. Comput. Educ. Open **6**, 100174 (2024). https://doi.org/10.1016/j.caeo.2024.100174

Lee, Y.J., Davis, R.O.: A case study of implementing generative AI in university's general English courses. Contemp. Educ. Technol. **16**(4), ep533 (2024). https://doi.org/10.30935/cedtech/15218

Li, Y., Chiu, T.K.F.: The mediating effects of needs satisfaction on the relationship between teacher support and student engagement with generative artificial intelligence (GenAI) chatbots from a self-determination theory (SDT) perspective. Educ. Inf. Technol. (2025). https://doi.org/10.1007/s10639-025-13574-w

Li, L., Kim, M.: It is like a friend to me: critical usage of automated feedback systems by self-regulating English learners in higher education. Australas. J. Educ. Technol. **40**(1), 1–18 (2024). https://doi.org/10.14742/ajet.8821

Li, Q., Tarp, S.: Using generative AI to provide high-quality lexicographic assistance to Chinese learners of English. Lexikos **34**, 397–418 (2024). https://doi.org/10.5788/34-1-1944

Li, B., Wang, C., Bonk, C.J., Kou, X.: Exploring inventions in self-directed language learning with generative AI: implementations and perspectives of YouTube content creators. TechTrends **68**(4), 803–819 (2024a). https://doi.org/10.1007/s11528-024-00960-3

Li, Q., Tarp, S., Nomdedeu-Rull, A.: The necessary symbiosis: how chatgpt co-authored a new type of learner's grammar to be displayed in a digital writing assistant. Circ. Linguist. Apl. Comun. **100**, 145–160 (2024b). https://doi.org/10.5209/clac.97409
Lin, Y., Yu, Z.: A bibliometric analysis of artificial intelligence chatbots in educational contexts. ITSE **21**(2), 189–213 (2024). https://doi.org/10.1108/ITSE-12-2022-0165
Liu, G., Ma, C.: Measuring EFL learners' use of ChatGPT in informal digital learning of English based on the technology acceptance model. Innov. Lang. Learn. Teach. **18**(2), 125–138 (2024). https://doi.org/10.1080/17501229.2023.2240316
Liu, W., Wang, Y.: The effects of using AI tools on critical thinking in English literature classes among EFL learners: an intervention study. Eur. J. Educ. (2024). https://doi.org/10.1111/ejed.12804
Liu, X., Xiao, Y.: Chinese university teachers' engagement with generative AI in different stages of foreign language teaching: a qualitative enquiry through the prism of ADDIE. Educ. Inf. Technol. **30**(1), 485–508 (2025). https://doi.org/10.1007/s10639-024-13117-9
Liu, G.L., Darvin, R., Ma, C.: Exploring AI-mediated informal digital learning of English (AI-IDLE): a mixed-method investigation of Chinese EFL learners' AI adoption and experiences. Comput. Assist. Lang. Learn. (2024). https://doi.org/10.1080/09588221.2024.2310288
Liu, G.L., Zou, M.M., Soyoof, A., Chiu, M.M.: Untangling the relationship between AI-mediated informal digital learning of English (AI-IDLE), foreign language enjoyment and the ideal L2 self: evidence from Chinese University EFL students. Eur. J. Educ. (2025). https://doi.org/10.1111/ejed.12846
Lyu, B., Lai, C., Guo, J.: Effectiveness of chatbots in improving language learning: a meta-analysis of comparative studies. Int. J. Appl. Linguist. **35**(2), 834–851 (2025). https://doi.org/10.1111/ijal.12668
Ma, Q., Crosthwaite, P., Sun, D., Zou, D.: Exploring ChatGPT literacy in language education: a global perspective and comprehensive approach. Comput. Educ. (2024). https://doi.org/10.1016/j.caeai.2024.100278
Madrid-García, A., Freites-Núñez, D., Merino-Barbancho, B., Pérez Sancristobal, I., Rodríguez-Rodríguez, L.: Mapping two decades of research in rheumatology-specific journals: a topic modeling analysis with BERTopic. Ther. Adv. Musculoskelet. Dis. **16**, 1759720X241308037 (2024). https://doi.org/10.1177/1759720X241308037
Marchena Sekli, G.: The research landscape on generative artificial intelligence: a bibliometric analysis of transformer-based models. Kybernetes (2024). https://doi.org/10.1108/K-03-2024-0554
Mishra, M.: A holistic review of customer experience research: topic modelling using BERTopic. MIP **43**(4), 802–820 (2025). https://doi.org/10.1108/MIP-09-2023-0457
Mizumoto, A.: Data-driven learning meets generative AI: introducing the framework of metacognitive resource use. Appl. Corpus Linguist. **3**(3), 100074 (2023). https://doi.org/10.1016/j.acorp.2023.100074
Mohamed, M.S.P.: Exploring ethical dimensions of AI-enhanced language education: a literature perspective. Technol. Lang. Teach. Learn. (2024). https://doi.org/10.29140/tltl.v6n3.1813
Moorhouse, B.L.: Beginning and first-year language teachers' readiness for the generative AI age. Comput. Educ. Artif. Intell. **6**, 100201 (2024). https://doi.org/10.1016/j.caeai.2024.100201
Moorhouse, B.L., Kohnke, L.: The effects of generative AI on initial language teacher education: the perceptions of teacher educators. System **122**, 103290 (2024). https://doi.org/10.1016/j.system.2024.103290
Moorhouse, B.L., Wan, Y., Wu, C., Kohnke, L., Ho, T.Y., Kwong, T.: Developing language teachers' professional generative AI competence: an intervention study in an initial language teacher education course. System **125**, 103399 (2024). https://doi.org/10.1016/j.system.2024.103399
Naz, I., Robertson, R.: Exploring the feasibility and efficacy of ChatGPT3 for personalized feedback in teaching. Electron. J. E-Learn. **22**(2), 98–111 (2024). https://doi.org/10.34190/ejel.22.2.3345
Neff, J., Arciaga, K., Burri, M.: EFL students' and teachers' perceptions of the ethical uses of artificial intelligence tools. Technol. Lang. Teach. Learn. (2024). https://doi.org/10.29140/tltl.v6n3.1714
Niyozov, N., Bijanov, A., Ganiyev, S., Kurbonova, R.: The pedagogical principles and effectiveness of utilizing ChatGPT for language learning. In: Stennikov, V., Senderov, S., Michalevich, A., Guliev, H. (eds.) E3S Web Conferences EDP Sciences (2023). https://doi.org/10.1051/e3sconf/202346101093
Ogunleye, B., Lancho Barrantes, B.S., Zakariyyah, K.I.: Topic modelling through the bibliometrics lens and its technique. Artif. Intell. Rev. **58**(3), 74 (2025). https://doi.org/10.1007/s10462-024-11011-x
Ohashi, L.: AI in language education: the impact of machine translation and ChatGPT. In: Intelligent Systems Reference Library, pp. 289–311. Springer (2024). https://doi.org/10.1007/978-3-031-71232-6_13
Oktarin, I.B., Saputri, M.E.E., Magdalena, B., Hastomo, T., Maximilian, A.: Leveraging ChatGPT to enhance students' writing skills, engagement, and feedback literacy. Edelweiss Appl. Sci. Technol. **8**(4), 2306–2319 (2024). https://doi.org/10.55214/25768484.v8i4.1600
Pack, A., Maloney, J.: Using generative artificial intelligence for language education research: insights from using OpenAI's ChatGPT. TESOL q. **57**(4), 1571–1582 (2023). https://doi.org/10.1002/tesq.3253
Pack, A., Barrett, A., Escalante, J.: Large language models and automated essay scoring of English language learner writing: insights into validity and reliability. Comput. Educ. (2024). https://doi.org/10.1016/j.caeai.2024.100234

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., et al.: The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ (2020). https://doi.org/10.1136/bmj.n71

Parappallil Mathew, B., Bangwal, D.: People centric governance model for smart cities development: a systematic review, thematic analysis, and findings. Res. Globalization **9**, 100237 (2024). https://doi.org/10.1016/j.resglo.2024.100237

Parviz, M., Arthur, F.: Exploring EFL teachers' behavioral intentions to integrate GenAI applications: insights from PLS-SEM and fsQCA. Hum. Behav. Emerg. Technol. **2025**(1), 5582099 (2025). https://doi.org/10.1155/hbe2/5582099

Pegrum, M.: From revolution to evolution: what generative AI really means for language learning. Lang. Teach. (2025). https://doi.org/10.1017/S0261444825000151

Polakova, P., Ivenz, P.: The impact of ChatGPT feedback on the development of EFL students' writing skills. Cogent Educ. (2024). https://doi.org/10.1080/2331186X.2024.2410101

Pym, A., Hao, Y.: How to Augment Language Skills: Generative AI and Machine Translation in Language Learning and Translator Training. Taylor & Francis (2024)

Rahimi, A.R., Sevilla-Pavón, A.: The role of ChatGPT readiness in shaping language teachers' language teaching innovation and meeting accountability: a bisymmetric approach. Comput. Educ. (2024). https://doi.org/10.1016/j.caeai.2024.100258

Raman, R., Pattnaik, D., Hughes, L., Nedungadi, P.: Unveiling the dynamics of AI applications: a review of reviews using scientometrics and BERTopic modeling. J. Innov. Knowl. **9**(3), 100517 (2024). https://doi.org/10.1016/j.jik.2024.100517

Rejeb, A., Rejeb, K., Appolloni, A., Treiblmaier, H., Iranmanesh, M.: Exploring the impact of ChatGPT on education: a web mining and machine learning approach. Int. J. Manag. Educ. **22**(1), 100932 (2024). https://doi.org/10.1016/j.ijme.2024.100932

Rejeb, A., Rejeb, K., Simske, S., Süle, E.: Industry 5.0 research: an approach using co-word analysis and BERTopic modeling. Discov. Sustain. **6**(1), 402 (2025a). https://doi.org/10.1007/s43621-025-01252-3

Rejeb, A., Rejeb, K., Keogh, J.G., Süle, E.: When Industry 5.0 meets the circular economy: a systematic literature review. CircEconSust (2025b). https://doi.org/10.1007/s43615-025-00570-y

Saville, N.: The future of language learning in the era of ChatGPT. J. E-Learn. Knowl. Soc. **19**(3), 6–10 (2023). https://doi.org/10.20368/1971-8829/1135875

Shaikh, S., Yayilgan, S.Y., Klimova, B., Pikhart, M.: Assessing the usability of ChatGPT for formal English language learning. Eur. J. Invest. Health Psychol. Educ. **13**(9), 1937–1960 (2023). https://doi.org/10.3390/ejihpe13090140

Strzalkowski, P., Strzalkowska, A., Chhablani, J., Pfau, K., Errera, M.-H., Roth, M., et al.: Evaluation of the accuracy and readability of ChatGPT-4 and Google Gemini in providing information on retinal detachment: a multicenter expert comparative study. Int. J. Retina Vitr. (2024). https://doi.org/10.1186/s40942-024-00579-9

Su, Y.-S., Wang, J., Tu, S.-H., Liao, K.-T., Lin, C.-L.: Detecting latent topics and trends in IoT and e-commerce using BERTopic modeling. Internet Things **32**, 101604 (2025). https://doi.org/10.1016/j.iot.2025.101604

Synekop, O., Lytovchenko, I., Lavrysh, Y., Lukianenko, V.: Use of Chat GPT in English for engineering classes: are students' and teachers' views on its opportunities and challenges similar? Int. J. Interact. Mob. Technol. **18**(3), 129–146 (2024). https://doi.org/10.3991/ijim.v18i03.45025

Tafazoli, D.: Exploring the potential of generative AI in democratizing English language education. Comput. Educ. Artif. Intell. **7**, 100275 (2024). https://doi.org/10.1016/j.caeai.2024.100275

Tian, Z., Wang, C.: Rethinking Language Education in the Age of Generative AI, p. 228. Taylor and Francis (2025). https://doi.org/10.4324/9781003426929

Tica, L., Krsmanović, I.: Overcoming the writer's block? Exploring students' motivation and perspectives on using ChatGPT as a writing assistance tool in ESP. ELOPE **21**(1), 129–149 (2024). https://doi.org/10.4312/ELOPE.21.1.129-149

Tran, T.T.T.: Enhancing EFL writing revision practices: the impact of AI- and teacher-generated feedback and their sequences. Educ. Sci. (2025). https://doi.org/10.3390/educsci15020232

Tutton, M., Cohen, D.: Reconceptualizing the role of the university language teacher in light of generative AI. Educ. Sci. (2025). https://doi.org/10.3390/educsci15010056

Van Eck, N.J., Waltman, L.: Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics **84**(2), 523–538 (2010). https://doi.org/10.1007/s11192-009-0146-3

Vorobyeva, K.I., Belous, S., Savchenko, N.V., Smirnova, L.M., Nikitina, S.A., Zhdanov, S.P.: Personalized learning through AI: pedagogical approaches and critical insights. Contemp. Educ. Technol. (2025). https://doi.org/10.30935/cedtech/16108

Voss, E., Cushing, S.T., Ockey, G.J., Yan, X.: The use of assistive technologies including generative AI by test takers in language assessment: a debate of theory and practice. Lang. Assess. Q. **20**(4–5), 520–532 (2023). https://doi.org/10.1080/15434303.2023.2288256

Waluyo, B., Kusumastuti, S.: Generative AI in student English learning in Thai higher education: More engagement, better outcomes? Soc. Sci. Humanit. Open. **10**, 101146 (2024). https://doi.org/10.1016/j.ssaho.2024.101146

Wan, Y., Moorhouse, B.L.: Using Call Annie as a generative artificial intelligence speaking partner for language learners. RELC J. (2024). https://doi.org/10.1177/00336882231224813

Wang, Y., Kabilan, M.K.: Integrating technology into English learning in higher education: a bibliometric analysis. Cogent Educ. **11**(1), 2404201 (2024). https://doi.org/10.1080/2331186X.2024.2404201

Wang, C., Zou, B., Du, Y., Wang, Z.: The impact of different conversational generative AI chatbots on EFL learners: an analysis of willingness to communicate, foreign language speaking anxiety, and self-perceived communicative competence. System **127**, 103533 (2024a). https://doi.org/10.1016/j.system.2024.103533

Wang, Y., Zaid, Y.H., Li, J., Pan, Y.: Opportunities and challenges of using ChatGPT as a teaching assistant in English language teaching: a systematic literature review. In: ACM International Conference Proceeding Series Association for Computing Machinery, pp. 375–82 (2024). https://doi.org/10.1145/3700297.3700362

Wang, C., Li, X., Zou, B.: Revisiting integrated model of technology acceptance among the generative AI-powered foreign language speaking practice: through the lens of positive psychology and intrinsic motivation. Eur. J. Educ. **60**(1), e70054 (2025). https://doi.org/10.1111/ejed.70054

Wazan, A.S., Taj, I., Shoufan, A., Laborde, R., Venant, R.: How to design and deliver courses for higher education in the AI era? In: General Aspects of Applying Generative AI in Higher Education: Opportunities and Challenges, pp. 347–384. Springer (2024). https://doi.org/10.1007/978-3-031-65691-0_18

Xiao, Y., Zhi, Y.: An exploratory study of EFL learners' use of ChatGPT for language learning tasks: experience and perceptions. Languages (2023). https://doi.org/10.3390/languages8030212

Xiao, F., Zhu, S., Xin, W.: Exploring the landscape of generative AI (ChatGPT)-powered writing instruction in English as a foreign language education: a scoping review. ECNU Rev. Educ. (2025). https://doi.org/10.1177/20965311241310881

Xin, J.J.: Investigating EFL teachers' use of generative AI to develop reading materials: a practice and perception study. Lang. Teach. Res. (2024). https://doi.org/10.1177/13621688241303321

Xu, B.: Technology integration into Chinese as a foreign language learning in higher education: an integrated bibliometric analysis and systematic review (2000–2024). Lang. Teach. Res. (2024). https://doi.org/10.1177/13621688241277911

Xu, S., Sun, Y., Su, Y., Liu, K.: Translation pedagogy in the AI era: design and application of a ChatGPT-powered platform for training and feedback. In: Translation Stud in the Age of Artificial Intelligence, pp. 100–124. Taylor and Francis (2025). https://doi.org/10.4324/9781003482369-6

Xue, Q., Li, H.: Human-machine symbiosis in action: innovation of foreign language teaching mode in higher education empowered by ChatGPT. ICETM – Proceedings of the International Conference on Educational Technology Management Association for Computing Machinery, Inc., pp. 166–172 (2025). https://doi.org/10.1145/3711403.3711427

Xue, H., Liu, W.: Bibliometric analysis of natural language processing technology in education: hot topics, frontier evolution, and future prospects. SAGE Open **15**(1), 21582440251319891 (2025). https://doi.org/10.1177/21582440251319891

Yang, H., Markauskaite, L.: Fostering language student teachers' transformative agency for embracing GenAI: a formative intervention. Teach. Teach. Educ. **159**, 104980 (2025). https://doi.org/10.1016/j.tate.2025.104980

Yang, S., Dong, Y., Yu, Z.G.: ChatGPT in education: ethical considerations and sentiment analysis. Int. J. Inf. Commun. Technol. Educ. (2024). https://doi.org/10.4018/IJICTE.346826

Yeh, H.-C.: The synergy of generative AI and inquiry-based learning: transforming the landscape of English teaching and learning. Interact. Learn. Environ. **33**(1), 88–102 (2025). https://doi.org/10.1080/10494820.2024.2335491

Young, J.C., Shishido, M.: Investigating OpenAI's ChatGPT potentials in generating Chatbot's dialogue for English as a foreign language learning. Intl. J. Adv. Comput. Sci. Appl. **14**(6), 65–72 (2023). https://doi.org/10.14569/IJACSA.2023.0140607

Yun, G., Lee, K.M., Choi, H.H.: Empowering student learning through artificial intelligence: a bibliometric analysis. J. Educ. Comput. Res. **62**(8), 1822–1855 (2025). https://doi.org/10.1177/07356331241278636

Zaim, M., Arsyad, S., Waluyo, B., Ardi, H., Al Hafizh, M., Zakiyah, M., et al.: AI-powered EFL pedagogy: integrating generative AI into university teaching preparation through UTAUT and activity theory. Comput. Educ. Artif. Intell. **7**, 100335 (2024). https://doi.org/10.1016/j.caeai.2024.100335

Zakwani, M.A., Binu, P.M.: Exploring student insights on ChatGPT as a resource for learning English and its influence on learner independence. Forum Linguist. Stud. **7**(2), 813–824 (2025). https://doi.org/10.30564/fls.v7i2.7955

Zhang, Y., Dong, C.: Unveiling the dynamic mechanisms of generative AI in English language learning: a hybrid study based on fsQCA and system dynamics. Behav. Sci. (2024a). https://doi.org/10.3390/bs14111015

Zhang, Y., Dong, C.: Exploring the digital transformation of generative AI-assisted foreign language education: a socio-technical systems perspective based on mixed-methods. Systems (2024b). https://doi.org/10.3390/systems12110462

Zhang, W., Li, A.W., Wu, C.: University students' perceptions of using generative AI in translation practices. Instr. Sci. (2025). https://doi.org/10.1007/s11251-025-09705-y

Zhao W, Huang S, Yan L. ChatGPT and the future of translators: overview of the application of interactive AI in English translation teaching. In: International Conference on Computation of Artificial Intelligence, CCAI, pp. 303–307. Institute of Electrical and Electronics Engineers Inc. (2024). https://doi.org/10.1109/CCAI61966.2024.10602989

Zheng, S.: The effects of chatbot use on foreign language reading anxiety and reading performance among Chinese secondary school students. Comput. Educ. (2024). https://doi.org/10.1016/j.caeai.2024.100271

Zheng, Y., Wang, Y., Liu, K.S.-X., Jiang, M.Y.-C.: Examining the moderating effect of motivation on technology acceptance of generative AI for English as a foreign language learning. Educ. Inf. Technol. **29**(17), 23547–23575 (2024). https://doi.org/10.1007/s10639-024-12763-3

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