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PAPER

Artificial Intelligence in Mobile-Interactive EFL Learning Environments: A Bibliometric Analysis

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ABSTRACT

In the past five years, artificial intelligence (AI) has become increasingly embedded in technology-enhanced and mobile-interactive English as a foreign language (EFL) learning environments. However, the overall structure of knowledge production in this domain remains poorly understood. This study therefore conducts a bibliometric analysis to map publication patterns on AI-mediated EFL learning environments. Peer-reviewed SSCI-indexed journal articles published between 2021 and 2025 were retrieved from the Web of Science (WoS) Core Collection; 311 eligible articles were analyzed. Descriptive performance indicators, citation-based mapping, and network analysis were applied to identify influential documents, authors, institutions, journals, and countries. The findings show an exponential rise in publications and citations, but this growth is uneven. Knowledge production is overwhelmingly concentrated in East Asia, particularly Mainland China and Hong Kong, while research is dominated by chatbot-mediated and mobile-interactive AI applications published in a small cluster of technology-enhanced and interactive learning journals. The field is expanding rapidly but remains conceptually narrow and geographically concentrated. This study provides a structural baseline for future inquiry and highlights the need to widen AI modalities, strengthen theory-linked constructs, and advance cross-regional comparative designs to support cumulative knowledge development in mobile-interactive EFL learning contexts.

KEYWORDS

artificial intelligence (AI), English as a foreign language (EFL) learning, interactive mobile technologies, interactive learning environments, bibliometric analysis

1 INTRODUCTION

In recent years, the rapid diffusion of generative artificial intelligence (AI) has reshaped the ways in which English as a foreign language (EFL) learning is conceptualized, practiced, and evaluated. Intelligent technologies have been incorporated at multiple levels of language education, ranging from text generation and feedback provision to conversational practice and analytics-driven instructional support.

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Recent studies have reported several pedagogical advantages of AI-based tools. These tools have been found to improve academic writing [1], strengthen learners' speaking performance and willingness to communicate [2], enhance motivation and self-regulation [3], and sustain engagement through chatbot-mediated learning activities [4]. Empirical evidence also suggests that the integration of conversational agents as classroom participants, rather than peripheral technologies, alters how learners interact and construct meaning [5]. Collectively, these findings indicate that AI is becoming an essential component of EFL education rather than merely serving as an auxiliary instructional aid [6], [7].

However, there is still a lack of theoretical integration and structural coherence in this area. Existing empirical work spans multiple skill domains, contexts, technological configurations, and learner populations; yet, the field lacks a structural overview of who produces knowledge, where intellectual influence is concentrated, and which publication channels anchor research dissemination. Many studies focus on specific use-case interventions or isolated classroom implementations, producing a scattered evidence base that makes it difficult to identify dominant knowledge clusters or developmental trajectories that can cumulatively advance theory and guide future research innovation.

Against this background, this study performs a bibliometric analysis of peer-reviewed journal articles indexed in the Web of Science (WoS) Core Collection between 2021 and 2025. The aim is to provide a structural map of publication patterns on AI-mediated EFL education, identify key knowledge producers and publication venues, and reveal conceptual concentrations that currently structure this emerging domain. Such synthesis is necessary to diagnose where influence is located, where blind spots remain, and how future research may move beyond tool-centered experimentation toward sustained theoretical consolidation and SDG-4-aligned pedagogical development. Building on this aim, this study addresses the following research questions:

RQ1: What are the descriptive characteristics of publications on AI in EFL retrieved from the WoS Core Collection?
RQ2: What publication trends can be observed across countries, institutions, and authors?
RQ3: Which journals and publications show the greatest output and citation impact in AI-related EFL research?

2 LITERATURE REVIEW

In recent years, AI has been progressively integrated into English language education, shaping a wide range of skills, including speaking, writing, reading, and translation. Recent research has examined how it has been applied pedagogically in oral communication [8], academic writing [9], reading comprehension [10], and translation-oriented teaching [11]. Of these domains, academic writing support represents a key focus within AI-related EFL research. Empirical studies indicate that generative AI helps refine rhetorical accuracy, textual cohesion, and linguistic sophistication in academic writing [12]. When used as a writing scaffold, it also appears to foster motivation and ease writing-related anxiety [13]. From the instructional perspective, teachers view generative AI as a helpful tool for providing more timely and detailed feedback [14]. Although this research stream shows the strongest and most immediate pedagogical value, these studies are predominantly built around chatbot-mediated text generation or feedback enhancement, which means that AI is currently

being operationalized mainly as a tool for textual production and feedback support. This reveals a developmental bias toward highly specific performance tasks and provides limited insight into how AI can support other forms of language development.

Building on these text-oriented applications, a second line of research has expanded AI-assisted learning into multimodal and immersive contexts. In particular, multimodal and immersive designs that integrate AI with virtual reality (VR) environments have demonstrated clear benefits for experiential language engagement. For example, AI-integrated VR environments have been shown to enhance vocabulary learning and learner motivation [15], while also improving speaking performance and willingness to communicate [16]. Apart from immersive interaction, empirical reviews suggest that studies on chatbot-assisted language learning remain methodologically diverse and insufficiently theorized [17]. At the same time, a growing body of research has started to treat AI as a diagnostic and evaluative tool—for instance, in dynamic assessment of second language vocabulary learning [18]. VR-based interventions are discussed here because their pedagogical strengths—embodiment, presence, and multimodal interaction—are increasingly being integrated with AI-based analytics and adaptive learning support. As a whole, this emerging stream suggests that AI can function not only as a conversational interlocutor but also as an engine for multimodal input, formative analytics, and adaptive assessment. Even so, complex applications of this kind are still rare, which shows that research on AI-mediated language learning is only at an early exploratory phase.

Beyond functional scaffolding and multimodal designs, a third trajectory foregrounds affect and learner experience. This strand focuses on affective, motivational, and behavioral dynamics in AI-mediated learning. Research indicates that AI-supported teaching affects both learners' emotional responses and their engagement in learning [19]. Findings from EFL research indicate that speaking activities supported by AI have a notable impact on learners' enjoyment, anxiety, and willingness to communicate [20]. Additional studies point out that learning environments incorporating AI tend to elicit a variety of emotional reactions, such as excitement, uncertainty, and short-term anxiety [21]. According to experimental evidence, interaction that incorporates AI tends to reduce speaking anxiety while enhancing oral performance [22]. Other research indicates that learners' engagement trajectories with AI-powered vocabulary learning systems are shaped by behavioral intention and perceived value [23]. This suggests that AI is not merely a technological intervention but an affective and socio-cognitive stimulus that reshapes how learners regulate, sustain, and invest effort in EFL learning. These affect-centered studies further reveal that affective processes may become a decisive dimension determining how AI eventually translates into meaningful language development. Overall, these three strands show how AI research in EFL is diversifying in both pedagogical purpose and technological form, which sets the conceptual background for the bibliometric mapping that follows.

3 METHOD

3.1 Bibliometric approach

Bibliometric analysis is a quantitative approach that regards publications as measurable data and uses statistical techniques to explore publication output, citation patterns, and production structures across time, sources, and contributing actors such as authors, institutions, and countries [24], [25]. Rather than interpreting theoretical arguments, bibliometrics aggregates indicators such as documents,

citations, keywords, and source venues to reveal who produces knowledge, how knowledge circulates, and where intellectual influence is concentrated within a field [26]. By doing so, it enables researchers to identify existing patterns, developmental trajectories, and cross-field associations within a selected time frame. To carry out such quantitative mapping, a clearly defined and structured dataset must be established prior to analysis [27].

3.2 Data collection

All bibliographic data used in this study came from the WoS Core Collection. This database was chosen because of its extensive coverage, standardized indexing practices, and well-established citation network [28], [29], which make it a reliable source for bibliometric work in education and applied linguistics. The search was limited to peer-reviewed journal articles published between 2021 and 2025 that explore how AI is applied in EFL education. The search query was formulated using Boolean operators as follows:

TS = (("artificial intelligence" OR "AI" OR "Generative AI") AND ("English as a Foreign Language" OR "EFL"))

Based on these criteria, the dataset was collected in 2025. The data collection criteria is summarized in Table 1. Using WoS provides a well-indexed and consistently structured dataset with a mature citation network, which supports transparent and replicable bibliometric mapping. However, as with any single database, WoS coverage is selective and may reflect database- and language-related biases; moreover, records from 2025 should be interpreted cautiously because indexing for that year was still ongoing at the time of data retrieval.

Table 1. Inclusion criteria for bibliometric analysis

WoS Database	Core Collection
Time period	2021 to 2025
Search field	TS
Search keywords	("artificial intelligence" OR "AI" OR "Generative AI") AND ("English as a Foreign Language" OR "EFL")
Document type	Article
Language	English
WoS Index	SSCI

3.3 Screening process

The screening and selection procedure followed the PRISMA approach. Figure 1 presents the PRISMA screening flow. A total of 561 records were initially retrieved from the WoS Core Collection (n = 516). After the year range (2021–2025) was applied, 18 items were excluded from the dataset (n = 18). The remaining 543 records were screened by document type (n = 543), leading to the exclusion of 47 non–peer-reviewed sources (n = 47; e.g., editorials, book reviews, conference proceedings). Of the 496 full texts assessed (n = 496), 185 were excluded (n = 185): 184 were not indexed in SSCI

(n = 184), and 1 was not published in English (n = 1). Finally, 311 studies met all inclusion criteria and were retained for bibliometric analysis (n = 311).

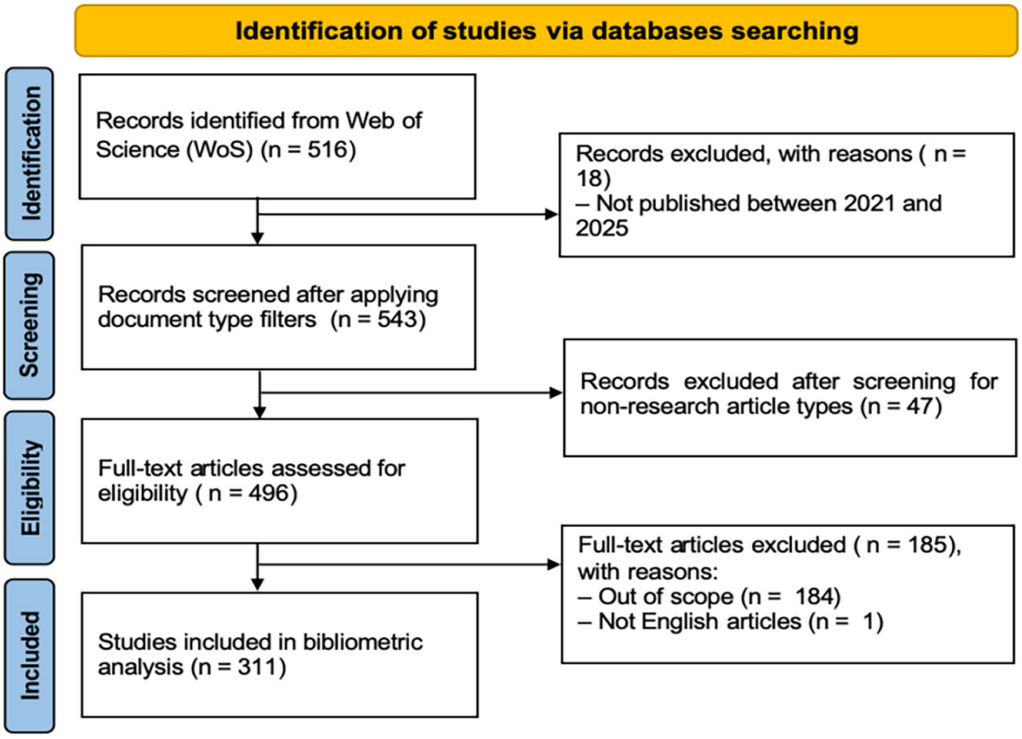

Fig. 1. PRISMA flowchart

3.4 Data analysis

The final dataset was exported from WoS in both plain text (.txt) and Excel (.csv) formats. The .txt files were imported into VOSviewer (version 1.6.20) to generate author- and institution-based co-authorship network visualizations, while the .csv files were processed in Microsoft Excel to clean the dataset and derive performance indicators by extracting, ranking, and aggregating document counts, citation counts, and total link strength. In addition, Datawrapper was used to construct geographical maps to visualize national contributions. This combination of spreadsheet-based processing and specialized mapping tools ensured analytical transparency and facilitated structural interpretation of performance outcomes. The performance analysis then focused on publication output and citation impact in AI-related EFL studies, drawing on key indicators such as annual publication trends, total citations, and h-index scores [30]. Five major aspects were analyzed, including highly cited papers, productive journals, influential authors, active institutions, and countries with the largest contribution.

4 RESULTS

4.1 Descriptive overview of the field

As depicted in Figure 2, research on the application of AI in EFL has experienced a steady upward trajectory during the past five years. The annual publication output

increased from 14 records in 2021 (n = 14) to 120 records in 2025 (n = 120). A similar progressive trend is observed in citation impact, which increased year on year across the five-year window and reached its highest point at approximately 800 citations in 2025. These descriptive trends suggest that AI in English language education has moved beyond its initial exploratory stage and is gradually consolidating into a more stable and recognized research domain, with increasing scholarly visibility and academic impact.

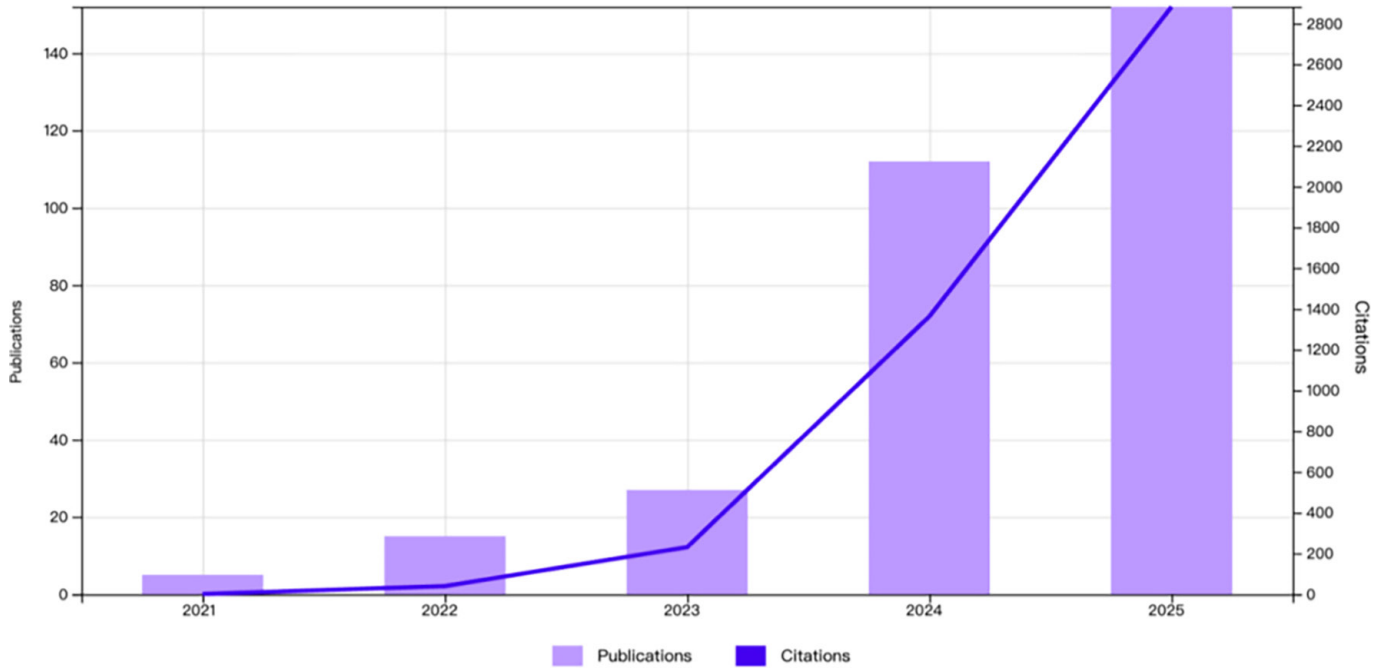

Fig. 2. Annual publications and citations

Source: WoS database.

Table 2 shows the key bibliometric indicators of the dataset extracted from the WoS Core Collection. The 311 publications examined (n = 311) accumulated 4,519 citations from 2,164 citing articles. Even after excluding self-citations, citation impact remained substantial, with 3,438 citations derived from 1,943 citing articles. The mean citation rate was 14.53 citations per item, and the H-index of 35 indicates the presence of multiple well-cited publications within the dataset. These indicators are reported to describe the basic citation profile of the dataset and to provide a quantitative context for subsequent network-based analyses.

Table 2. General bibliometric indicators from WoS

Metric	Value (2021 to 2025)
Total Publications	311 (n = 311)
Total Citing Articles	2,164 (1,943 excluding self-citations)
Total Citations	4,519 (3,438 excluding self-citations)
Average Citations per Item	14.53
H-Index	35

4.2 Leading documents shaping the field

Table 3 summarizes the ten most cited publications on AI applications in EFL education. The three most influential papers are Liu & Ma, Song & Song, and Mohamed, each receiving more than 150 citations, indicating that highly cited work has emerged only very recently. Across these top-ranked publications, a clear thematic convergence is visible: almost all examine ChatGPT or chatbot-mediated learning, and most target core EFL learning outcomes such as academic writing, speaking performance, engagement, motivation, and willingness to communicate. Notably, several 2024 studies—such as [4], [6], and [31], [32]—occupy leading positions in both citation counts and total link strength, suggesting that the intellectual center of this domain is shifting towards ChatGPT-driven pedagogical interventions. This concentration of highly cited work around chatbot-assisted learning points to a rapidly consolidating research niche that is gaining structural influence within the network.

Table 3. Top 10 most cited documents on AI in EFL

Authors	Year	Title	Citations	Total Link Strength
Liu & Ma	2024	Measuring EFL learners' use of ChatGPT in informal digital learning of English based on the technology acceptance model	213	70
Song & Song	2023	Enhancing academic writing skills and motivation: assessing the efficacy of ChatGPT in AI-assisted language learning for EFL students	160	104
Mohamed	2024	Exploring the potential of an AI-based Chatbot (ChatGPT) in enhancing English as a Foreign Language (EFL) teaching: perceptions of EFL Faculty Members	159	57
Jeon	2024	Exploring AI chatbot affordances in the EFL classroom: young learners' experiences and perspectives	157	83
Fathi et al.	2024	Improving EFL learners' speaking skills and willingness to communicate via artificial intelligence-mediated interactions	115	150
Wang & Xue	2024	Using AI-driven chatbots to foster Chinese EFL students' academic engagement: An intervention study	112	99
Wang et al.	2023	What matters in AI-supported learning: A study of human-AI interactions in language learning using cluster analysis and epistemic network analysis	106	37
Wei	2023	Artificial intelligence in language instruction: impact on English learning achievement, L2 motivation, and self-regulated learning	104	124
Yang et al.	2022	Implementation of an AI chatbot as an English conversation partner in EFL speaking classes	103	31
Guo et al.	2022	Using chatbots to scaffold EFL students' argumentative writing	100	28

4.3 Key journals serving as primary publication outlets

Figure 3 shows that the highest-impact publications on AI applications in EFL education are clearly concentrated in mainstream technology-enhanced language learning journals. *Education and Information Technologies* (n = 28; 526 citations) and *Computer Assisted Language Learning* (n = 26; 459 citations) dominate both in output and citation impact, and together with System (n = 21; 406 citations) they constitute the densest structural hubs in the network. Although general education and psychology journals such as the *European Journal of Education* (n = 28; 413 citations; TLS = 293) and *Frontiers in Psychology* (n = 11; 333 citations), also attract substantial citation counts, their network connectivity is weaker, indicating that their influence is more citation-based than structurally embedded. By contrast, outlets such as the *British Educational Research Journal* (n = 12; 5 citations) and *Learning and Motivation* (n = 9; 30 citations) remain peripheral nodes. Overall, this pattern confirms that the consolidation of AI research in English language education is being driven from within TEL and applied linguistics venues rather than imported from domain-external sources.

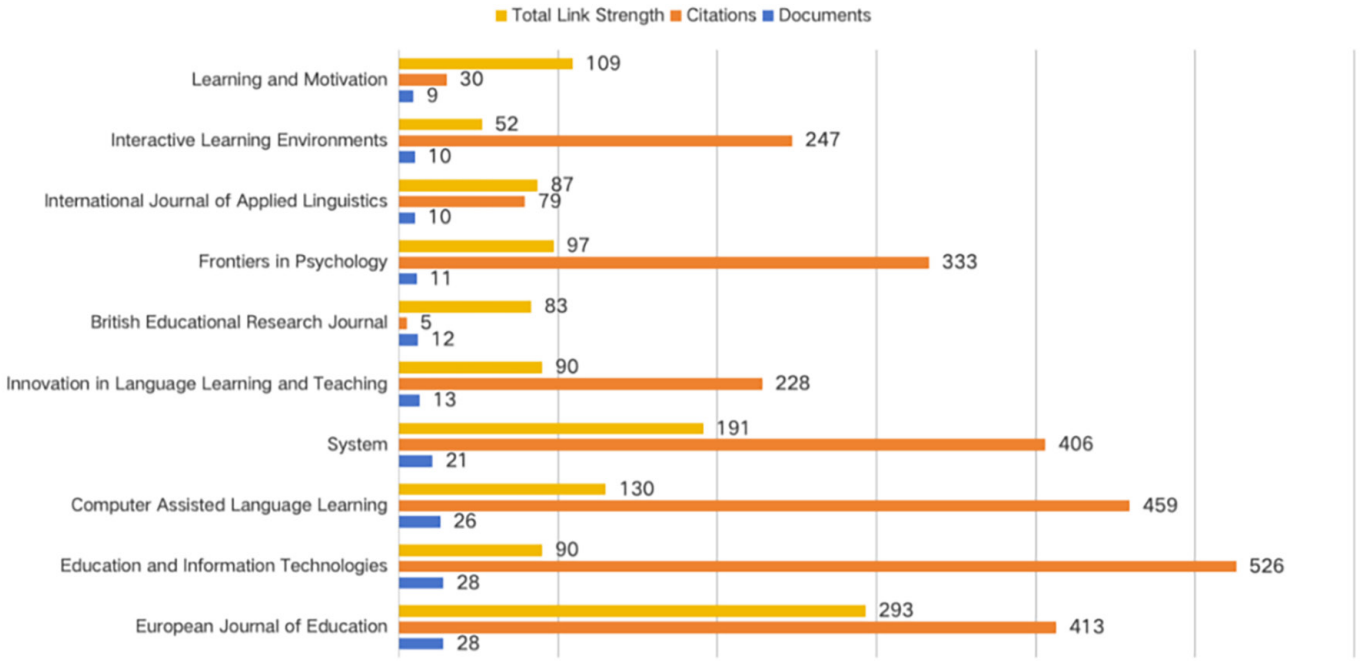

Fig. 3. Top 10 most influential journals

4.4 Core authors driving the research agenda

Table 4 shows that several authors stand out as major contributors. Wang Yongliang (n = 6; 341 citations) and Jeon Jaeho (n = 4; 292 citations) are among the most highly cited authors in the field, while Guo Kai (n = 12; 220 citations; TLS = 17) and Zou Bin (n = 11; 186 citations; TLS = 12) combine high productivity with stronger structural linkage. Figure 4 further shows that these authors do not operate in isolation: the co-authorship network forms several tightly connected clusters. Guo Kai's group constitutes the densest collaboration hub, whereas a separate cluster led by Hwang Gwo-Jen reflects a more educational technology-oriented trajectory

that links AI-assisted language learning to broader TEL innovation. Overall, both performance indicators and network structure suggest that the field is shaped not by a single "star author" but by overlapping author groups that jointly drive methodological and conceptual developments.

Table 4. Top 10 most cited authors

Rank	Authors	Documents	Citations	Total Link Strength
1	Wang, Yongliang	6	341	2
2	Jeon, Jaeho	4	292	1
3	Derakhshan, Ali	7	264	3
4	Guo, Kai	12	220	17
5	Zou, Bin	11	186	12
6	Hwang, Gwo-Jen	6	168	4
7	Tu, Yun-Fang	3	131	5
8	Wan, Youmei	3	131	5
9	Zhang, Lawrence Jun	5	98	4
10	Liu, Meilu	3	98	3

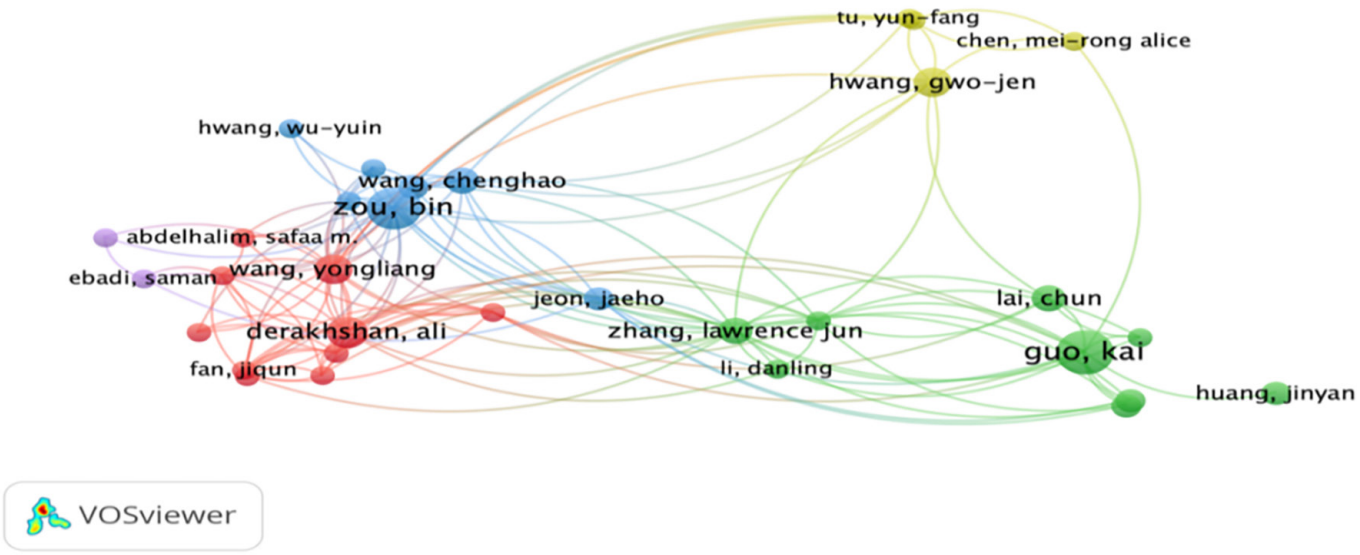

Fig. 4. Co-authorship network of core authors (VOSviewer)

4.5 Institutions acting as central research hubs

Table 5 and Figure 5 show that institutional influence in this domain is centered in East Asia. Universities in Hong Kong hold a leading position in the field. The University of Hong Kong (n = 17; 225 citations) and the Education University of Hong Kong (n = 13; 177 citations) record high publication volumes and occupy core positions in the collaboration network. Universities in Mainland China also form strong clusters, with North China University of Water Resources and Electric Power showing high structural connectivity (TLS = 87) despite only eight publications.

Outside East Asia, a smaller cluster led by Gulf-region and Iranian universities (e.g., Golestan University, TLS = 93) indicates an emerging collaboration niche. Overall, the institutional landscape is characterized by multiple interconnected regional hubs, with Hong Kong institutions acting as cross-regional brokers while Mainland groups form dense intra-regional subnetworks.

Table 5. Top 10 most cited institutions

Rank	Institutions	Documents	Citations	Total Link Strength
1	The University of Hong Kong	17	225	40
2	The Education University of Hong Kong	13	177	44
3	The Chinese University of Hong Kong	11	456	66
4	Xi' an Jiaotong-Liverpool University	11	186	61
5	North China University of Water Resources and Electric Power	8	379	87
6	Nanjing Normal University	8	192	57
7	National Taiwan University of Science and Technology	8	240	14
8	Golestan University	7	264	93
9	Wenzhou University	7	151	21
10	Shanghai International Studies University	6	52	45

Fig. 5. Institutional collaboration network (VOSviewer)

4.6 Countries contributing dominant scholarly influence

Figure 6 shows that national influence in this domain is highly geographically asymmetric. China overwhelmingly dominates (n = 183; 2,552 citations), indicating that the center of gravity for AI-mediated EFL research has decisively shifted into East Asia. South Korea (n = 17; 453 citations) and Saudi Arabia (n = 17; 230 citations)

also occupy strong positions, suggesting that AI-supported language learning has become an active research agenda across both East Asian and Gulf-region systems. English-speaking Western systems, such as the USA (n = 16; 89 citations) and the UK (n = 14; 112 citations), contribute less both in volume and total citation impact, implying that AI in EFL is being shaped less by legacy Anglophone TESOL academic centers and more by national contexts where EFL is a core educational priority. Overall, the global publication landscape reveals a pronounced relocation of epistemic leadership toward Asia, with China at the epicenter, and emerging secondary poles in South Korea and Gulf-region contexts.

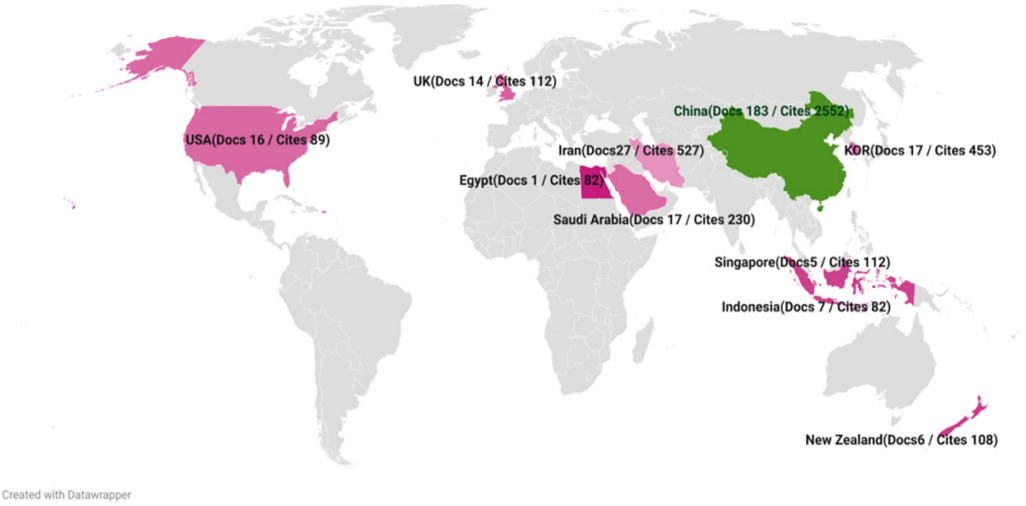

Fig. 6. Top 10 countries by publications and citations (Datawrapper)

5 DISCUSSION

5.1 Topical characteristics of AI-mediated EFL research

This bibliometric investigation mapped publication patterns on AI-enabled EFL education between 2021 and 2025. The results confirm that the field has entered a phase of rapid expansion, but this expansion is highly uneven in topical focus, geographical distribution, and publication ecology [24]. The most visible characteristic of the field is that research has not yet moved into diversified AI ecologies. The top-cited documents overwhelmingly focus on ChatGPT or chatbot-mediated learning [1], which means that the current evidence base is strongly concentrated on a single modality. "AI in EFL" has not yet functioned as a broad methodological category and remains largely limited to chatbot-centered intervention prototypes. At the same time, these studies mainly target academic writing, speaking performance, motivation, engagement, and willingness to communicate [8], suggesting a continued emphasis on task-level performance rather than broader developmental constructs, which constrains theoretical accumulation. On the whole, research in this domain remains dominated by chatbot-centered interventions, while mobile AI applications and MALL-oriented interactive designs are underrepresented. Recent mobile-focused EFL research has shown that AI-supported mobile interaction can positively support speaking development [33], [34].

5.2 Geographical, institutional, and authorship distribution of research output

Another major pattern is that knowledge production is geographically concentrated. China, Hong Kong, and to some extent South Korea and Saudi Arabia collectively dominate publication outputs, citations, and institutional link strength [5], [19]. This indicates that AI in EFL research currently operates mainly within East Asian and Gulf-region ecosystems, where national investment in educational AI is strong and English is a major foreign language. English-speaking Western contexts contribute less to this domain, suggesting that the field is shaped primarily by high-stakes EFL contexts rather than traditional TESOL research centers. The institutional network further confirms this pattern: Hong Kong institutions function as bridging hubs, while Mainland universities form dense intra-regional collaboration clusters. This pattern implies uneven global knowledge flows and a limited representation of diverse pedagogical realities. At the author level, co-authorship networks show that research output is driven by collaborative clusters rather than single "star" authors.

5.3 Journal influence and publication ecology

A third structural tendency is that the publication ecology of this domain is dominated by technology-enhanced learning (TEL) and applied linguistics outlets, especially education and information technologies, computer assisted language learning, and systems [11]. These journals act as the central structural hubs in the network, and their dominance suggests that AI research is being framed primarily as technological innovation and implementation rather than as theory-driven language acquisition research [32]. This implies that the field is still operating mainly at the level of instrument evaluation rather than theoretical generalization.

5.4 Implications for theory

Based on the structural patterns identified above, this study offers several implications for theory development in AI-mediated EFL research. First, AI in EFL has not yet developed into a coherent methodological or theoretical domain, which limits cumulative theory building [17]. Second, the strong emphasis on task-level outcomes, such as writing performance, speaking scores, motivation, and engagement, indicates a preference for short-term performance gains over developmental processes that are central to second language acquisition. Core constructs such as interaction, noticing, and self-regulated learning remain underexplored [3]. This imbalance weakens the explanatory depth and generalizability of existing findings. Third, the concentration of influential studies in East Asian and Gulf-region contexts raises concerns about the contextual dependence of emerging theoretical claims. In the absence of systematic cross-regional comparisons, it is difficult to determine whether current theoretical interpretations can be applied across diverse educational settings [29]. Overall, these patterns highlight the need for future AI-mediated EFL research to move beyond platform-focused evaluations and to more clearly link AI-supported learning processes with established SLA theories.

5.5 Implications for practice

From a practical perspective, the findings have several implications for teachers, institutions, and policymakers. They suggest that AI use in EFL classrooms risks becoming tool-centered, with insufficient attention to pedagogical integration and long-term learning sustainability [7]. Teachers therefore need clearer guidance on how AI tools can be embedded meaningfully within existing classroom practices, rather than being used as isolated add-ons. Moreover, the strong regional concentration of existing research indicates that reported instructional practices and learning outcomes may not be directly transferable to other educational contexts. Institutions should take local curricular goals, learner characteristics, and technological conditions into account when expanding AI-supported EFL initiatives. At the policy level, the rapid growth of AI-mediated language education highlights the need for clear governance frameworks addressing data protection, ethical use, and teacher workload [21]. Aligning AI-supported EFL practices with broader educational goals, such as SDG-4, is essential to ensure that technological innovation supports inclusive, sustainable, and pedagogically sound language education.

6 LIMITATIONS

This study has several limitations that should be acknowledged. First, the analysis was based on SSCI-indexed journal articles retrieved from the WoS Core Collection and limited to English-language publications. Relevant studies published in other databases or non-English contexts may therefore be underrepresented. Second, although the study aims to map AI-mediated EFL research, the search strategy relied on explicit AI-related terms (e.g., “artificial intelligence,” “AI,” and “Generative AI”). As a result, there is a potential misalignment between the broad conceptual framing and the narrower empirical coverage. Studies framed under adjacent constructs, such as intelligent tutoring systems, adaptive learning systems, or automated feedback, may not have been captured. Third, publications from 2025 should be interpreted with caution, as the dataset reflects only a partial year at the time of data collection, and observed trends may change as indexing continues. Finally, the current literature shows a strong topical concentration, which limits the representation of other AI modalities, such as mobile-based AI applications, immersive VR environments, and adaptive analytics-driven systems.

7 CONCLUSION

On the whole, the bibliometric patterns in this study show that this domain is expanding rapidly, and this expansion is characterized by clear topical, geographical, and publication patterns. The field is not yet developing cumulative theoretical programs, but rather accumulating tool-centered studies within specific educational ecologies [9]. This study provides a baseline map of influence, intellectual concentrations, and structural bottlenecks in the field. The field now stands at a point where it can transition toward broader AI modalities, cross-regional comparison, and tighter alignment with second language acquisition theory [6]. This mapping therefore, contributes not only descriptive metrics but also a structural diagnosis of where the field is currently locked and what levers are needed for

epistemic progression. These structural constraints have important policy and governance implications, especially in terms of aligning AI-supported language education with SDG-4, managing classroom data responsibly, and balancing open data initiatives with privacy protection as the field continues to grow [21], [35].

8 FUTURE RESEARCH DIRECTIONS

Future research should more clearly distinguish between mobile AI-based and other interactive AI modalities in EFL education. While current studies mainly focus on a limited set of AI modalities, other modalities, such as mobile AI applications, immersive VR environments, and adaptive analytics-driven systems, remain underexplored, despite their distinct interaction and access patterns. The field should move toward investigating how multimodal AI, adaptive feedback systems, AI-driven formative analytics, and classroom-embedded AI tools can support authentic language development processes across different skill trajectories [36]. Future studies should also extend to different educational levels—primary, secondary, and tertiary education—to examine whether AI-assisted learning yields consistent outcomes across learners of varying proficiency, age, and learning goals [37].

In parallel, outcomes should be explicitly linked to second language acquisition theory (e.g., interaction, noticing and self-regulation) so that the evidence generated can contribute to cumulative knowledge development rather than platform-specific performance optimization [3]. At the methodological level, embedding AI within existing classroom ecologies needs further verification of its pedagogical sustainability and contextual feasibility. More research is needed to explore how teachers perceive, adopt, and adapt AI tools and to understand how teacher mediation, instructional decisions, and professional agency shape the effectiveness of AI-supported pedagogy [38].

Moreover, future studies should involve larger and more diverse learner groups to test whether the instructional benefits observed so far can be generalized across different regions and educational systems. Drawing on the collaboration patterns identified in the co-authorship and institutional networks, future work should give priority to multi-site comparative studies linking different regional hubs. Future research should further investigate how classroom-based AI tools perform in terms of usability, sustained instructional impact, data protection, and curricular implementation [19], [39]. Finally, establishing shared task repositories, open data and code resources, preregistration practices, and unified reporting standards (e.g., retention, transfer, willingness to communicate, and teacher workload) would help strengthen comparability and reproducibility across different AI frameworks and EFL settings.

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