

Research Article

A Bibliometric Analysis of Artificial Intelligence Chatbots in Language Education

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Abstract: Chatbots in language education demonstrate promising potential. This study identifies their developmental paths, recent designs, and primary application contexts through a bibliometric and visualization analysis. We find that artificial intelligence chatbots in language education have gained avid interest in recent years due to technological advancements and growing social attention. Research demonstrates an interdisciplinary trend, and integrating various technologies has improved chatbot effectiveness in education. This study identifies popular research issues on chatbots in language education, such as students' perceptions, effectiveness evaluation, and technological upgrades. Additionally, we find various roles and functions of chatbots in specific language education domains characterized by learning content, strategies, and contexts. This study establishes its significance by summarizing and discussing the effects of artificial intelligence chatbots from a language education perspective. We propose a model for chatbot applications and research in language education that connects technological and pedagogical aspects, which can be extended and validated to broaden future research empirically.

Keywords: bibliometric analysis, chatbot, artificial intelligence, language education, visualization

1. Introduction

With the increasing popularity of technologies, educational stakeholders show growing interest in artificial intelligence (AI)-based chatbots (Deng & Yu, 2023; Wu & Yu, 2023). Chatbots are computer programs created to simulate personal conversations with their users (Chopra et al., 2016). The history of chatbots can be traced back to the 1950s when Alan Turing (1950) formulated his tentative question, "Can machines think?", published in *Mind*. This has sparked blossoming research on AI chatbots. Weizenbaum's (1966) publication discussed the first chatbot named ELIZA and how it interacted with users. The advancements of AI chatbots have led to empirical studies examining their use. These studies focused on the effectiveness and acceptance of chatbots in various educational contexts. For example, Wardat et al. (2023) indicated that ChatGPT was a valuable educational aid in mathematics and emphasized the necessity for establishing guidelines to ensure its safe usage. Besides, previous literature has established that chatbots applied to language education is a dominant direction from a general educational perspective (Lin & Yu, 2023), and that the effectiveness is significantly positive (Wu & Yu, 2023).

Language education has been assisted by various educational technologies, especially when AI demonstrates its strong potential in facilitating educational practice. With technological advancements, reforms in language education

are active. AI plays an increasingly important role in language education. Studies on AI-enhanced language education have increased over the past two decades (2000-2019) (Huang et al., 2023). AI chatbots catch language educators' and researchers' attention, and chatbots as educational aids gain popularity in language learning because they can interact with learners in their target languages instantly and realistically (Fryer et al., 2020). Chatbots showcase the potential to enhance language learning by providing valuable language inputs and fostering communicative competence (Kim et al., 2019). They fulfill roles as language practice tutors and self-guided learning tools (Haristiani, 2019). A typical example is that ChatGPT presents significant possibilities for educators and institutions to enhance the effectiveness of second or foreign language teaching (Hong, 2023). However, inconsistent findings and concerns about AI in education exist. For one aspect, learners indicated that cultural, humorous, and empathetic elements could be poorly perceived and understood by AI chatbots (Zhai & Wibowo, 2022). The plagiarism in academic writing aided by chatbots emerged also a major concern (Jarrah et al., 2023). Besides, integrating chatbots into language education could lead to unforeseen outcomes, like the disruption of conventional language learning methods, technological limitations, the novelty effect, and cognitive load. (Farrokhnia et al., 2023; Huang et al., 2022). Even when language teachers are aware of the latest chatbots, successful implementations require pedagogical guidance and training for teachers to use such technologies to complement traditional instruction (Klimová & Seraj, 2023).

Confronted with limitations and the educational potential, few studies have specifically concentrated on chatbot applications in language education. Our study aims to contribute to this less-investigated topic by identifying the developmental paths, recent designs, and primary application contexts of AI chatbots in language education. We first review the existing literature on chatbot applications in language education. Then, we describe the methods used for searching and visualizing the literature. We use VOSviewer to visualize the related publications in order to find recent designs and primary application contexts of chatbots. We also use CitNetExplorer to cluster the literature and conduct citation analysis to address the development of chatbots in language education. Finally, we draw implications for future research based on a proposed model through this study. We intend to analyze current chatbot applications, enable further developments in diverse language learning contexts, and provide guidance for researchers and designers to meet learners' educational needs better.

2. Literature review

2.1 Previous reviews

Reviews with diverse methods and themes have examined the effectiveness of AI chatbot applications in education, as Table 1 demonstrates. Meta-analytical approaches could only reveal the effectiveness of chatbots (Deng & Yu, 2023; Wu & Yu, 2023; Zhang et al., 2023), causing the issue that technological and theoretical developments were seldom examined in these reviews. Others adopted systematic review approaches (Huang et al., 2022; Kuhail et al., 2022). Few studies adopted bibliometric analysis approaches to display a full picture of the literature on AI chatbots in language education. Compared with systematic reviews, meta-analyses, and studies on specific and diverse contexts, this bibliometric analysis with visualization and citation network analysis would provide insight into various educational contexts and connections between existing literature. As similar visualization analysis reviewed various educational technologies, such methods could vividly and automatically explore the relationships through citations between a large size of literature, especially helping researchers identify research directions, popular issues, and applications in this area (e.g., Lin & Yu, 2023; Wu & Yu, 2023).

Chatbots were reviewed from educational perspectives, while few studies focused on language education. Reviews from a general perspective of education might leave limited implications for language education researchers and instructors (e.g., Deng & Yu, 2023). Learning contexts of chatbot applications were reviewed, but insufficient attention was paid to the learning content and strategies (e.g., Lin & Yu, 2023). Some reviews focused on the different kinds of educational chatbot approaches (Kuhail et al., 2022), while an excessive emphasis on technological advancements could be difficult to practice. Scholars have conducted reviews on language education applications, for example, English as a foreign language (Klimová & Seraj, 2023) and second language acquisition (Zhai & Wibowo, 2022). Nonetheless, their findings were site-specific and failed to provide an overview of language education. Among a large body of literature, the applications of AI chatbots from a specific perspective of language education were yet to be investigated if we

considered language learning content, strategies, and contexts particularly.

Table 1. Previous reviews on chatbots in education and their research themes

Authors (Years)	Methods (Included studies)	Research themes
Deng and Yu (2023)	Meta-analysis and systematic review (N = 32)	The effects of chatbots in sustainable education
Huang et al. (2022)	Systematic review (N = 25)	Chatbot-supported language learning, especially on technological, pedagogical, and social affordances
Hwang and Chang (2021)	Systematic review (N = 29)	Trends of chatbots in education studies
Jeon et al. (2023)	Systematic review (N = 32)	Speech-recognition chatbots for language learning
Klimová et al. (2023)	Systematic review (N = 7)	Chatbots' potential in practicing and integrating the existing theories and concepts used in English as a foreign language teaching and learning
Kuhail et al. (2022)	Systematic review (N = 36)	Evidence-based chatbot-learner interaction design techniques applied in education
Lin and Yu (2023)	Bibliometric analysis (N = 384)	AI chatbots in educational contexts
Wu and Yu (2023)	Meta-analysis (N = 24)	AI chatbots on student learning outcomes
Zhang et al. (2023)	Meta-analysis (N = 18)	The effects of chatbots-assisted language learning
Zhai and Wibowo (2022)	Systematic review (N = 48)	AI second language chatbots and the development of empathetic strategies for enhancing learners' learning outcomes

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2.2 Theoretical frameworks of technological integration and their adapted models to chatbots in language education

Several theoretical frameworks were proposed to extend AI chatbot applications in education. Aparicio et al. (2016) suggested a comprehensive theoretical model for examining educational technology applications and studies, identifying three key elements of technology-enhanced learning: the individuals involved in e-learning systems, the activities that they could perform, and the technologies used. Lin and Yu (2023) extended Aparicio et al.'s (2016) conceptual framework for an analytical purpose to specify factors influencing technology-enhanced education. The three important dimensions of an e-learning system were "people, technologies, and services", and their framework helped to assess AI chatbot applications in educational contexts (Lin & Yu, 2023). Hwang and Tu (2021) considered six dimensions for reviewing AI in mathematics education research. In their original model, they took application domains, sample groups, research methods, roles of AI, algorithms, and research issues into account. Although the above two frameworks were instructive in structuring educational technology research, they were from a general perspective of education and needed to be further focused to fit into language education contexts.

Through combining those two frameworks, we proposed a framework more specifically for chatbot research and applications in language education, as Figure 1 demonstrates. Relying on visualizing techniques, this study would reveal the publication trends, elaborating on popular research issues on chatbot applications in language education through clustering analyses of keyword items and publications. Digging into the clustering results would allow us to find primary application contexts characterized by learning content, educational levels, learning strategies, and learning modes. Functions, roles, and models behind chatbot designs were closely associated with technological foundations. Research methods could also be revealed in this review through a close examination of representative and critical publications on this topic. Following this framework, the subsequent sections would specify our research questions according to this review framework.

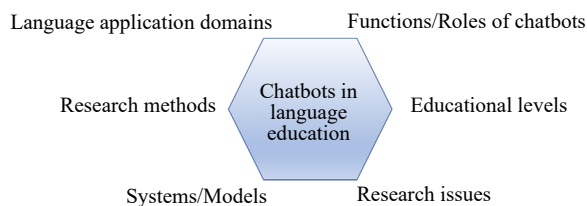


Figure 1. A proposed review framework of chatbots in language education adapted from Hwang and Tu (2021) and Lin and Yu (2023)
Source: Originally created by the authors

2.3 Contributions to AI chatbot research in language education

Many researchers have investigated chatbot applications and their contributions to language education. The progress in AI technologies led researchers to exploring machine learning and natural language processing technologies in developing chatbots, forming a new area of academic research in education (Følstad et al., 2018). These technologies enabled chatbots to become intelligent teaching assistants, and teachers were recommended to incorporate AI-based chatbots into classroom activities (Smutny & Schreiberova, 2020). The affordances of chatbots could be supported by the significant role of interaction in learning, emphasizing language learners' collaborative efforts to interact and communicate (Li, 2018). Fryer and Carpenter's (2006) study pioneered investigations into chatbot applications in language learning, indicating students' positive experience conversing with a chatbot. Fryer et al. (2017) evaluated language learning effectiveness, comparing chatbot and peer interactions and suggesting huge potential for chatbot applications in language education. Additionally, some students preferred chatting with chatbots to interacting with students or teachers (Fryer et al., 2019). With increasing applications, critical bibliometric data would be needed to facilitate future researchers in this area. Based on the related literature on this topic, we would identify the publication trends and top research contributors by the following research questions (RQs):

RQ1: What is the year-based publication trends?

RQ2: What are the top keyword items, authors, organizations, and countries in the studies on AI chatbots in language learning?

2.4 Application domains of chatbots in language education

Empirical studies investigated various aspects of language education, including learning content, strategies, and contexts. Except for English, learning other languages could also be assisted by chatbots, such as Arabic (Shao et al., 2022) and Japanese (Haristiani et al., 2022). Chatbots could enhance students' basic grammar and terminology learning (Haristiani et al., 2022). Regarding learning strategies, chatbots could allow interactive learning and improve self-learning practice (Fryer & Carpenter, 2006). Interactive roleplay, storytelling, and simulated text messaging provided by chatbots could offer opportunities for second language writing practice, helping students overcome writing challenges (Bailey, 2019). Regarding the learning contexts, university students' learning outcomes and motivation could be enhanced with a speech-mission-based digital learning theater supported by chatbots (Cai et al., 2020). Chatbots employed in classrooms could develop learners' different language skills, such as, speaking, reading, listening, and writing (Gayed et al., 2022). Chatbots integrated into collaborative learning and online learning were effective and represented new possibilities for chatbot practice (Neto & Fernandes, 2019). The contexts of chatbot applications were diverse, which might confound efficient explorations and teaching practice in the future. To solve this issue, we would summarize popular research issues by RQ3 and the specific functions by RQ4 from diverse contexts of chatbots in language education:

RQ3: What are the popular research issues in the studies on AI chatbots in language education?

RQ4: What roles can chatbots play in specific application domains of language education?

4a) How can chatbots be combined with different language learning content?

4b) How can chatbots be combined with different language learning strategies?

4c) How can chatbots be combined with different language learning contexts?

3. Methods

3.1 Literature search and result analysis in SCOPUS

First, we searched the related literature from the SCOPUS database. SCOPUS was a representative literature database, containing an extensive body of journal articles, conference papers, book chapters, and other sources, which was conducive to bibliometric analysis and visualization techniques. Compared with numerous studies based on Web of Science (e.g., López-Belmonte et al., 2023), this database was infrequently used but might extend the existing knowledge and reveal valuable insights. The following search strategy was adopted: Chatbot* (TITLE-ABS-KEY) and Language learn* (TITLE-ABS-KEY). The keywords corresponded to our research topic while including related studies with relatively loose matches. Such a search allowed us to analyze the relationships between the educational technology practice and its backgrounds, i.e., publications beyond educational research. The “Analyze Results” function in the database enabled us to study publication trends based on years, research areas, and journal titles. We collected basic bibliometric data such as a year-based publication trend, the most published research categories, and the most published journals. These items would provide information about publication trends and the research areas related to the topic.

3.2 Visualization and citation network analysis

The full records text file was processed using VOSviewer (Van Eck & Waltman, 2010) and CitNetExplorer (Van Eck & Waltman, 2014). This plain text file from SCOPUS could be processed directly by VOSviewer but not CitNetExplorer. We used the “Scopus2CitNet” package with Rstudio based on R 4.3.0 to transform the records exported from the SCOPUS database to a plain text file that could be read by CitNetExplorer (Boireau, 2017). VOSviewer was used to visualize connections between keyword items, and the top contributors with the highest frequencies were identified, including authors, countries, and organizations. CitNetExplorer allowed clustering analysis, displaying studies closely connected. The software could analyze citation networks and retrieve the longest paths. This would show how one study was cited by later researchers, forming a citation network that passed on original ideas to newer studies through multiple citations. This function identified the theoretical foundations and advancements in the field. However, citation paths could be shorter than three, generating little meaning; in that case, the most cited and recent publications should be analyzed for advancements in the research topics (e.g., Kusumastuti et al., 2016). These two programs were combined in many studies to obtain significant item- and publication-level findings to provide a comprehensive understanding of a certain topic (Lin & Yu, 2023; Yu & Yu, 2023).

4. Results

4.1 Publication trends (RQ1)

We searched for the related publications on SCOPUS (<https://www.scopus.com/search/form.uri?display=basic#basic>) on April 18, 2023 and found 1,013 publications. The publication trends of the search results were demonstrated in Figure 2. There were few studies before 2017, while research on this topic has experienced a sharp increase in number since 2018. During 2019-2022, over 100 articles were published each year. The largest quantity of publications was recorded in 2022 (N = 288). Such a year-based trend seems to suggest that artificial intelligence chatbot applications required instructors and researchers to closely follow technical updates, such as, the emergence of generative, pre-trained, and conversational chatbots based on large language models in 2022. Future technological changes would infinitely and increasingly influence the applications of such educational technologies. We analyzed the disciplines in the SCOPUS to which these findings were assigned. The top ten published categories were Computer Science (N = 845, 78.751%), Engineering (N = 345, 34.057%), Mathematics (N = 219, 21.619%), Decision Sciences (N = 159, 15.696%), Social Sciences (N = 153, 15.104%), Medicine (N = 95, 9.378%), Physics and Astronomy (N = 79, 7.799%), Arts and Humanities (N = 47, 4.640%), Business, Management and Accounting (N = 46, 4.541%), and Energy (N = 39, 3.850%).

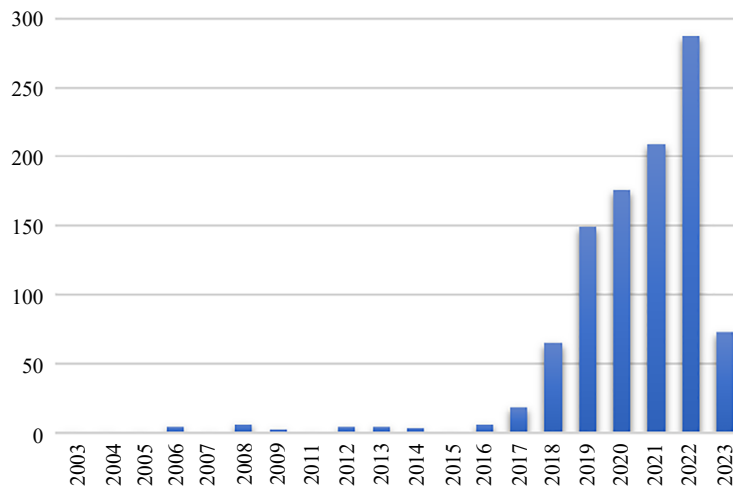


Figure 2. A year-based publication trend of studies on chatbots in language education
Source: Originally created by the authors

Top nine journals and conferences where the publications were released were as follows: *Association for Computing Machinery (ACM) International Conference Proceeding Series* (N = 42, 4.146%), *Communications in Computer and Information Science* (N = 27, 2.655%), *Central Europe Workshop Proceedings* (N = 25, 2.468%), *Advances in Intelligent Systems and Computing* (N = 22, 2.172%), *Journal of Physics: Conference Series* (N = 13, 1.283%), *IEEE Access* (N = 11, 1.086%), *Procedia Computer Science* (N = 8, 0.790%), *Applied Sciences (Switzerland)* (N = 7, 0.691%), and *International Journal of Advanced Computer Science and Applications* (N = 7, 0.691%). Based on publication types, the top five were “Conference Paper” (N = 588, 58.045%), “Article” (N = 270, 26.654%), “Conference Review” (N = 74, 7.305%), “Book Chapter” (N = 40, 3.949%), and “Review” (N = 31, 3.060%). The outcomes indicated that the studies were extensively disseminated across journal publications and conferences. Conferences were the primary outlets of the publications due to their relatively short time for publication. Publications on this topic were highly associated with computer sciences, where more conference articles represented the most recent updates at the frontiers.

4.2 Literature visualization

4.2.1 Keywords and top contributors (RQ2)

VOSviewer visualized 351 keyword items (the matched items when minimum occurrence was set at five) from the search results. The top 15 keywords were listed in a descending order of occurrences as follows: chatbot (occurrences = 807, link strength = 6,276), natural language processing (occurrences = 806, link strength = 7,282), machine learning (occurrences = 250, link strength = 2,154), artificial intelligence (occurrences = 232, link strength = 1,740), deep learning (occurrences = 217, link strength = 1,907), natural languages (occurrences = 174, link strength = 1,613), learning systems (occurrences = 173, link strength = 1,570), learning algorithms (occurrences = 167, link strength = 1,795), conversational strength (occurrences = 119, link strength = 1,034), students (occurrences = 93, link strength = 780), language processing (occurrences = 91, link strength = 1,002), e-learning (occurrences = 76, link strength = 622), machine-learning (occurrences = 74, link strength = 817), natural language understanding (occurrences = 63, link strength = 507), and computational linguistics (occurrences = 50, link strength = 414).

The keyword items were grouped into eight clusters (Figure 3). The largest nodes in the central part indicated that these keywords occurred in the search results most frequently; they included “chatbot(s)”, “natural language processing (system)”, “artificial intelligence”, “deep learning”, and “machine learning”. Cluster 1 had the most items (N = 77). It was about deep learning models, mainly including “deep learning”, “computational linguistics”, and “deep/recurrent neural networks”. Cluster 2 (62 items) was about chatbots in learning, such as “chatbot”, “students”, and “language learning”. Cluster 4 (45 items) was about various applications of AI, such as “ChatGPT”, “language”, and “health care”. Cluster 5 (42 items) was characterized by “machine learning”, and “learning algorithms”. Cluster 6 (32 items)

was identified by “natural language processing”, “social networking (online)”, and “search engines”. Cluster 3 (56 items), Cluster 7 (26 items), and Cluster 8 (11 items) had small nodes, which were respectively represented by “virtual assistants”, “natural language understanding”, and “e-commerce”.

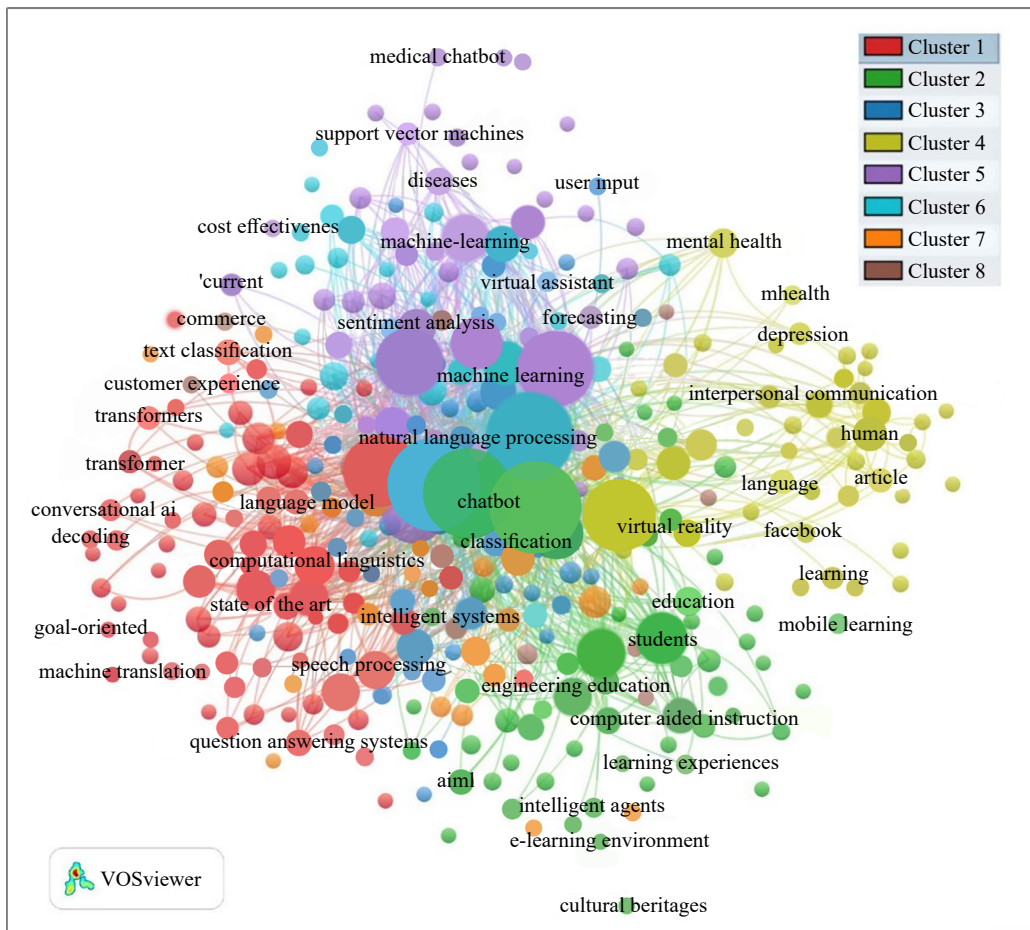


Figure 3. A keyword visualization map by VOSviewer
 Source: Originally created by the authors. https://app.vosviewer.com/?json=https://drive.google.com/uc?id=1sm9-J5Ks_1Z4r8SLefB6egC9NO4FButQ

The top ten contributing authors of the literature search records were as follows: Jiwei Li (documents = 2, citations = 490), Luke K. Fryer (documents = 3, citations = 375), Andrew Thompson (documents = 2, citations = 234), Muhammad Abdul-Mageed (documents = 1, citations = 219), Alice Kerly (documents = 3, citations = 195), Pavel Smutny (documents = 1, citations = 180), Aggeliki Androutsopoulou (documents = 1, citations = 176), Alaa A. Abdalrazaq (documents = 2, citations = 143), James A. Nichols (documents = 1, citations = 135), and Dorottya Demszky (documents = 1, citations = 109). Due to the technical setting of VOSviewer, total link strengths were not calculated for records exported from SCOPUS.

The top ten contributing organizations to chatbot research in language education were listed as follows. Stanford University (documents = 3, citations = 498, link strength = 5), Microsoft Research (documents = 2, citations = 495, link strength = 4), Ohio State University (documents = 1, citations = 489, link strength = 2), School of Library, Archival and Information Studies, University of British Columbia (documents = 1, citations = 219, link strength = 0), Electronic, Electrical and Computer Engineering, University of Birmingham (documents = 3, citations = 195, link strength = 2), University of Patras (documents = 1, citations = 176, link strength = 1), University of the Aegean (documents = 1, citations = 176, link strength = 1), Jabberwacky.com (documents = 1, citations = 141, link strength = 1), Ksyshu

Sangyo University (documents = 1, citations = 141, link strength = 1), and Centenary Institute, and The University of Sydney (documents = 3, citations = 135, link strength = 3). Among these affiliations, Jabberwacky.com was a website for an online chatbot called Jabberwacky. It was an early attempt at creating an AI through human interaction.

The top ten contributing countries to chatbot research in language education were United States (documents = 120, citations = 1,504, link strength = 50), India (documents = 2,323, citations = 1,143, link strength = 25), United Kingdom (documents = 49, citations = 936, link strength = 41), China (documents = 68, citations = 567, link strength = 46), Australia (documents = 19, citations = 567, link strength = 19), Canada (documents = 26, citations = 499, link strength = 17), China Hong Kong (documents = 26, citations = 481, link strength = 10), Japan (documents = 16, citations = 438, link strength = 14), Jordan (documents = 8, citations = 318, link strength = 4), and Greece (documents = 12, citations = 311, link strength = 9).

4.2.2 Literature clustering

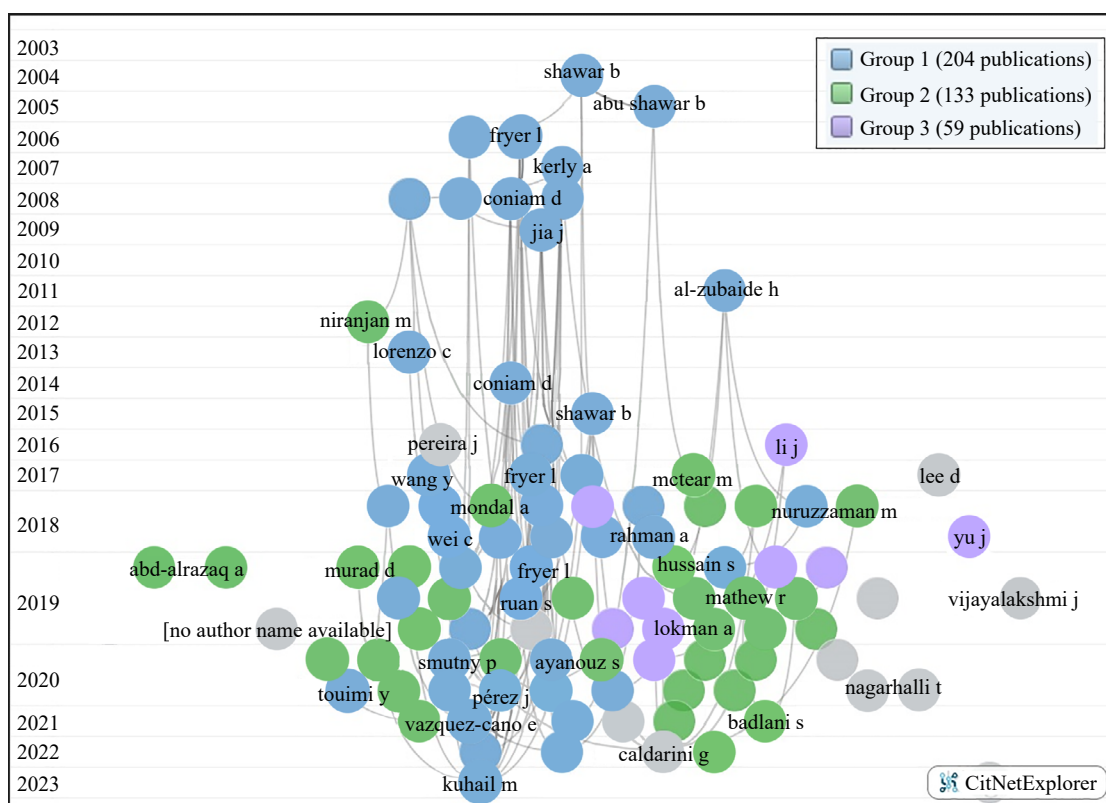


Figure 4. Literature clustering results by CitNetExplorer

Source: Originally created by the authors

We clustered the exported literature with CitNetExplorer’s automatic algorithms based on the citation relationships between the literature search results, grouping 384 publications and their references into three clusters (Figure 4). As the minimum cluster size was set as 25, and 555 publications were not closely related to other publications and were not assigned to any cluster. The visualized publications revealed a potential common focus on academic research, while publications with weak relations to them may not contribute to a discussion on popular issues. Therefore, the subsequent review would be based on these articles selected by the program. To overcome a flaw of visualization analysis which could only present rough information of a large literature, we were suggested to review the clustering results by reading the titles and abstracts (Lin & Yu, 2023). This method encouraged us to apply literature coding approaches to titles and abstracts based on literature clustering results and draw findings and implications from thematic discussions on chatbot

applications in language education. In this way, we could identify different research themes among the three groups. The three clusters were not completely independent, as connections could be found. The rest of this section would explain the focus of each cluster.

Cluster 1 concentrated on chatbots in language education. Figure 5 demonstrates the longest paths between a pioneering and a recent study, i.e., Kerly et al. (2007) and Belda-Medina and Calvo-Ferrer (2022). Kerly et al. (2007) suggested that combining chatbots and intelligent tutoring systems could develop negotiation strategies for chatbots and optimize the open learner model well-suited for educational applications. Kerly et al. (2008) subsequently developed CALMsystem to improve users' self-assessment accuracy; trials of the system showed that chatbots could enhance self-assessment skills. Suleman et al. (2016) further presented a framework, evaluating their automatic context-aware dialogue-generating system (NDLtutor) and Kerly et al.'s (2008) CALMsystem. Suleman et al.'s (2016) framework demonstrated that a reflective dialogue could effectively involve learners in evaluating and analyzing their knowledge and revealed interaction patterns in learners' categories. Mageira et al. (2022) tested an educational AI chatbot delivering cultural and linguistic knowledge in high school, supporting its suitability for interactive information and communication technologies-based learning. Belda-Medina and Calvo-Ferrer (2022) yielded positive results when integrating conversational agents into language learning. Their study revealed that participants had favorable views toward ease of use and attitudes, although the behavioral intention was moderate (Belda-Medina & Calvo-Ferrer, 2022).

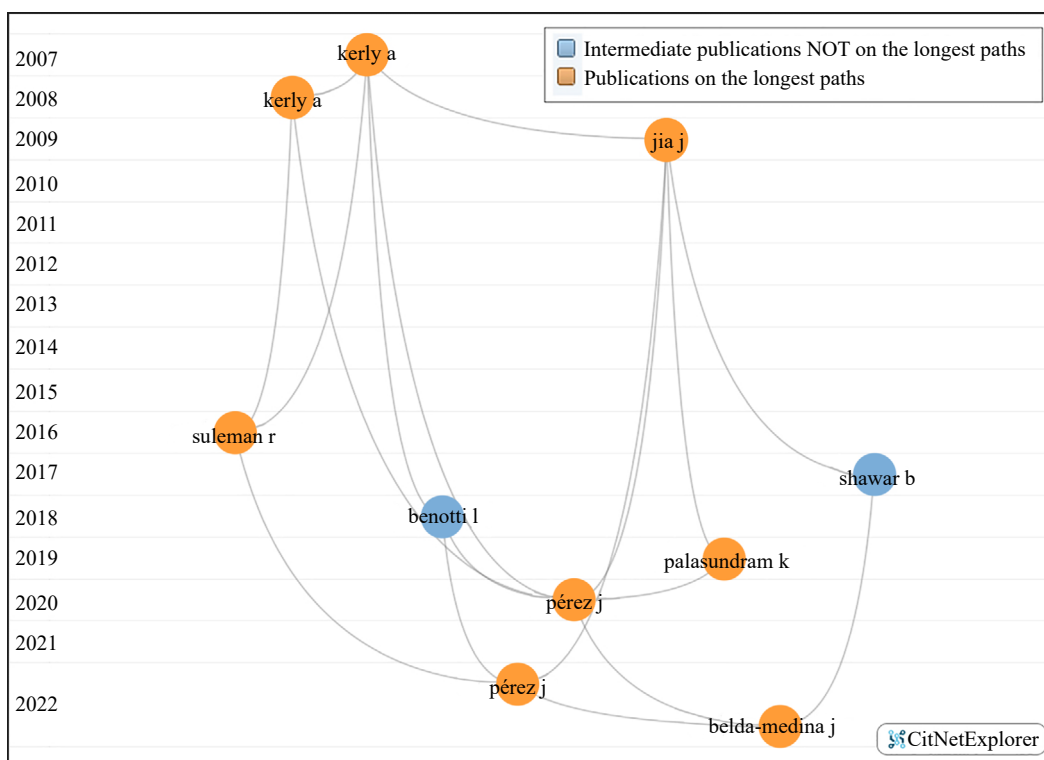


Figure 5. Longest citation paths in Cluster 1

Source: Originally created by the authors

Studies on the above paths also revealed the underlying technologies of chatbots. Following Jia's early work mentioned in the literature review (2004), he (2009) developed the Computer Simulation in Educational Communication system and the underlying mechanism. This system proposed "a naïve method of logical reasoning and inference directly through syntactical and semantic analysis of textual knowledge" (Jia, 2009, p.249). Among techniques supporting AI chatbots, the sequence-to-sequence (Seq2Seq) model had been commonly used and developed for implementing AI chatbots since 2014. Palasundram et al. (2019) assessed the effectiveness of Seq2Seq, guiding dataset

creation and question crafting for training and testing a question-answering model. With natural language processing, chatbots have been introduced into education as teaching assistants (Jia, 2009). Pérez et al. (2020) systematically reviewed education-oriented chatbots, suggesting that chatbots could aid learning in comparable ways to human tutors and exploring effectiveness evaluation approaches for chatbots (Pérez et al., 2020). The longest paths in Cluster 1 demonstrated that the analysis of chatbots' developmental paths in language education included technological foundations, initial functions, and recent practices of chatbots in language education.

Cluster 2 reflected chatbots used for general services in diverse social aspects, mostly based on automatic question-answering. No citation paths longer than three publications could be identified, so we reviewed the pioneering, most cited, and most recent studies instead, examining how recent research was grounded on technological and theoretical bases. Niranjan et al. (2012) proposed an inquiry answer system for students that was more interactive than previous systems and made teachers' presence no longer mandatory. Following the pioneering study, Clarizia et al. (2018) developed a system capable of understanding questions and providing answers for students by utilizing natural language processing techniques and domain ontologies. Nuruzzaman and Hussain (2018) introduced a deep recurrent neural network framework with a sequential attention mechanism for creating a self-learning AI chatbot overcoming some constraints in statistical models and implementation mechanisms. Regarding recent studies, we focused on the roles of chatbots and divided educational applications into three main aspects, namely, teaching, advising, and general service/support (Table 2).

Table 2. A classification of chatbot functions in education based on recent publications (2022-2023) in Cluster 2

Function	Theme	Publication
Teaching	Educational assistance	Chempavathy et al. (2022); Martin and Li (2022); Shah and Panchal (2022)
	Translation learning	Aleedy et al., 2022
	Language teaching	Chingmuankim and Jindal (2022)
Advising	Arabic language education	Alhassan et al. (2022); Boussakssou et al. (2022)
	Academic advising	Bilquise et al. (2022)
General service/support	Low-resource language implementation	Perdana et al. (2022)
	College navigation	Sobhana et al. (2022)

Source: Originally created by the authors

Cluster 3 concentrated on technological aspects, including natural language processing, reinforcement learning, and the Seq2Seq model. The longest path was identified between Li et al. (2016) and Bilah et al. (2022) (Figure 6). Li et al. (2016) initiated a neural conversational model allowing chatbots to achieve long-term success in dialogues but was criticized for being cheaply obtained and deterministic (Kandasamy et al., 2017). The ideas presented by Kandasamy et al. (2017) extended chatbots to question answering, generating image descriptions, and machine translation. Palasundram et al.'s (2020) review proposed four broad categories of methods to solve the weaknesses of the Seq2Seq model, i.e., structural modifications, augmented learning, beam search, and complementary mechanisms. Khin and Soe (2020) were inspired to develop a question-answering chatbot in Myanmar languages with the Seq2Seq model providing information about universities in response to user inquiries. However, opportunities to enhance the system's comprehension precision of human language were combined with challenges, for example, a concern about long-term dependence on technology (Bilah et al., 2022).

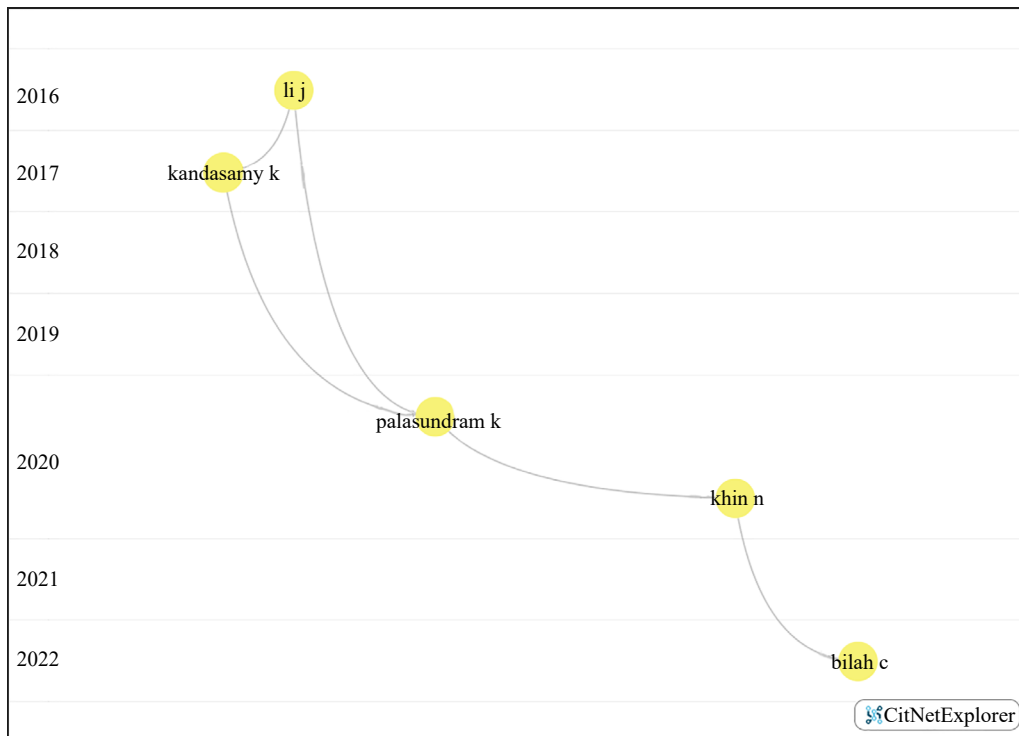


Figure 6. A longest citation path in Cluster 3

Source: Originally created by the authors

5. Discussion

5.1 Publication trends and primary contributors

We find that publications have increased from 2018 to 2022. Chatbots gain increasing attention with technological developments, and theoretical and experimental research on their applications in language education is flourishing (for example, ChatGPT) (Kohnke et al., 2023). Besides, subject distribution reveals a cross-disciplinary research trend, setting high requirements for educational stakeholders' digital literacy. This is consistent with research on teachers' technological, pedagogical, and content knowledge (TPACK, as Mishra and Koehler proposed in 2006). Keyword clustering shows that many technologies have been involved in educational applications and improved chatbot performances. Technological advancements contribute to their applications in education. Among research contributors to AI chatbots in language education, the United States contributes the most to the existing literature. The possible reasons include its early start (for instance, Weizenbaum introduced the first chatbot in 1966), mushrooming of education technology (EdTech) start-ups, and government funding in AI research (Bhutoria, 2022).

5.2 Popular research issues in the studies on AI chatbots in language education (RQ3)

Popular research issues regarding chatbot applications in language education include stakeholders' perceptions, effectiveness evaluation, and advancements in technological designs in chatbot-assisted language education. The research on chatbots in language education frequently combines diverse topics, including "e-learning", "language learning", "virtual assistants", and "semantics", based on the top keyword items and clustering results. These topics can be critical for researchers to extend the related research themes and choose future research directions. Interestingly, despite the growing popularity, some research themes did not appear in the keyword item visualization map, such as personal privacy, artificial intelligence ethics, and user acceptance (Goli et al., 2023; Kooli, 2023; Ye & Li, 2020). A reason why these research questions did not appear is that they have just emerged in academic journals, which does not allow them to reach the threshold of occurrences when we generated the keyword item visualization map.

Previous research has been mostly from students' perspectives, including student intents, goal setting, and participation (Tran et al., 2023), while few studies on teaching exist. Technological effectiveness evaluations are also common focuses measured by syntactic complexity, oral fluency, and writing proficiency (Shao et al., 2022). Language education research is often closely linked to "e-learning" and "distance education". This is even more evident in post-pandemic learning, as the COVID-19 urged traditional teaching to transform. The development and incorporation of various technologies have enhanced the efficiency of chatbots in educational settings. As an illustration, applying chatbots in mobile learning improves the academic performance and self-efficacy of nursing students (Chang et al., 2022). Moreover, mobile-assisted chatbots address issues such as a lack of self-motivation for learning, study planning, and opportunities for self-assessment in language learning (Wu et al., 2023). Employing AI chatbots in online learning contexts enhances the achievement of course objectives more effectively compared with traditional methods (Linh et al., 2022). The intention to implement an Augmented Reality (AR)-based chatbot system is anticipated to lead to a noticeable improvement in the educational achievements of students (Chuang et al., 2023). The core impetuses of chatbot applications are technological advancements and interdisciplinary studies. Natural language processing, machine learning, deep learning, and mobile learning are all popular issues due to the developments of artificial intelligence. The rationale behind the highly dispersed research themes can be that chatbots used for language learning purposes are experiencing exponential growth in academic research, and preliminary explorations are active but need systematically organized reviews from various perspectives to provide promising research directions and implications for pedagogical practice. This requires interdisciplinary research perspectives and methods to testify to their applications in educational contexts (Lin & Yu, 2023).

The existing literature focuses on spoken rather than written languages. Spoken language research explores dialogues and conversations. Empirical evidence supports that chatbots improve students' oral proficiency, as the original and primary function of chatbots is to "chat". This is because chatbots can create opportunities to practice oral English through friendly and engaging interactions and access to basic and advanced language learning resources (Gayathri & Viji, 2021). Other reasons include that chatbots relieve students' fear of speaking English and allow spoken English practice at any time (Hsu et al., 2021). Chatbots also accurately evaluate students' performance and advise on improvements (Cai et al., 2020). Research about written language focuses on writing exams, for example, Zhang et al.'s (2023) chatbot-based training on logical fallacies in English argumentative writing. Chatbots may bring more benefits than automated writing evaluation (AWE) systems. They provide immediate feedback throughout the writing process, create a detailed record of the writing process, and can be integrated into instant messaging applications for easy and enjoyable use by students (Guo et al., 2022), although technological reliance may become a concern.

5.3 Roles and functions that chatbots play in specific application domains of language education (RQ4)

5.3.1 Learning content (RQ4a)

Chatbot-assisted language learning content can be characterized by different languages and related skills. Chatbots designed for English learning are popular because developing English language skills can enable people to participate more effectively in the international community, thus opening up more opportunities for them. The English learning platforms assisted by chatbots show advantages in increasing students' self-confidence in learning English (Setiawan et al., 2022). Besides, teaching English as a second language (ESL) is also an important application of chatbots. The reason is that chatbots can make ESL education much easier and more effective (Dokukina & Gumanova, 2020), as chatbots are useful tools for giving feedback, though students may need extra training on how to use them (Chuah & Kabilan, 2021). Moreover, chatbots can be a powerful tool for teaching and learning endangered languages, because they can use synthetic voices to maintain those languages (Chiaráin & Chasaide, 2016). Regarding other languages, many studies focused on Arabic, Chinese, Vietnamese, and Italian (Issa & Hammond, 2023).

5.3.2 Learning strategies (RQ4b)

Many learning strategies can be applied to chatbot-assisted language education, such as self-regulated learning and collaborative learning. Chatbots provide platforms for students' independent language learning because they make self-practice effective due to technological practicality, portability, accessibility, and flexibility (Haristiani et al.,

2022). Learning a new language requires constant practice and interaction. Chatbots act as virtual assistants for self-learning, enabling users to improve their response skills by interacting with the chatbots regularly (Aoyon et al., 2022). Simulative experience can be enhanced because chatbots create interactive language learning environments, generate interest among learners, and encourage them to practice the language more frequently (Jia & Chen, 2008), for example, a chatbot created by Mageira et al. (2022). Chatbots can also support collaborative learning activities by facilitating collaborative dialog and result in more successful language learning (Sato et al., 2018).

5.3.3 Learning contexts (RQ4c)

Chatbots in education can be used in different learning contexts, including different educational levels, learning environments, and media. In higher education, chatbots work more on an academic level to provide professional, fine-tuned language education, such as in university EFL settings (Klímová & Seraj, 2023) and other language courses for university students (Cai et al., 2020). In pre-college education, chatbots are applied because they can arouse young learners' interest in language learning. The interactive nature of chatbots motivates and engages their users (Ruan et al., 2019). Chatbots are implemented in traditional classrooms and online learning contexts. Integrating AI chatbots into language teaching classrooms can improve students' grades significantly (Nghĩ et al., 2019), as it can enhance language teaching and learning experiences and assist teachers in their lessons effectively (Kuddus, 2022). Chatbots can reduce dropout rates, increase educational achievements, and enhance user satisfaction in online learning (Zobel & Meinel, 2022), because those tools bring new opportunities for training through active interaction at a low cost (Li et al., 2022). Mobile-assisted language learning based on chatbots is popular for its convenience and immediacy; chatbots on mobiles can support independent language learning and teaching with instant message services (Haristiani et al., 2019). Chatbots used for contextual and immersive learning can increase learners' sense of presence because chatbots can break geographical barriers (Wang et al., 2017) and enhance learners' internal motivation (Chien et al., 2022).

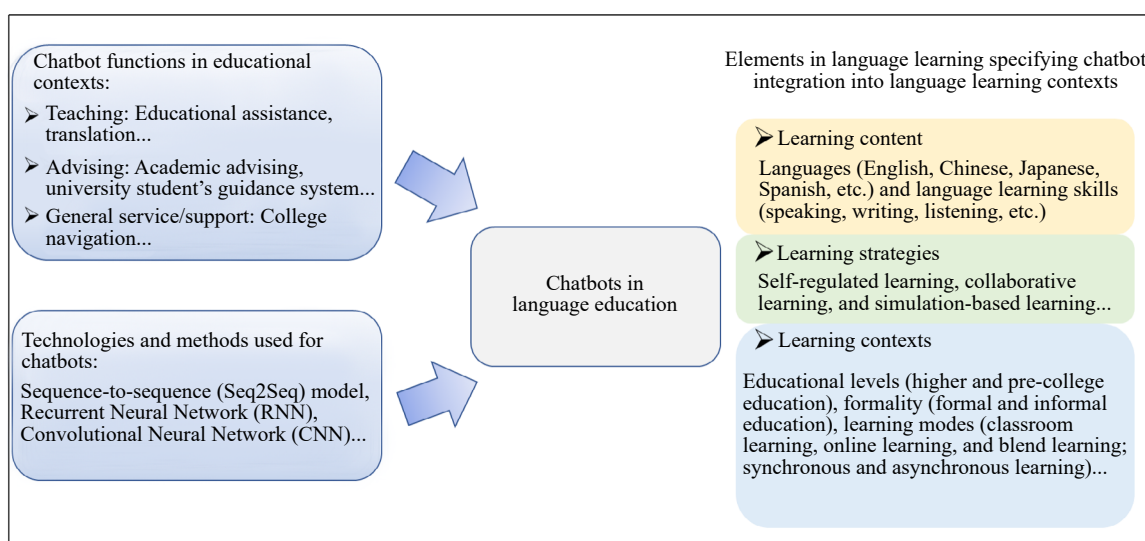


Figure 7. A proposed model of chatbot research in language education combining educational and technological aspects
Source: Originally created by the authors

5.4 A proposed model of chatbot research in language education

Figure 7 is a proposed model of chatbot research in language education to frame all findings and discussions in the above sections. In response to our proposed review framework, we have tightly integrated multiple aspects that are critical to research on chatbot applications in language education. As analyzed in the Results section, technological details are the foundations of such educational technologies, and primary functions are summarized from the explicit and

educational perspectives through literature clustering. These are two aspects that mainly describe chatbot applications in educational contexts. When chatbots are applied to language education specifically, instructors and students have found some characteristics from the contact of these two fundamental aspects and language education elements. As analyzed above, language education may be specified by learning content (particular languages and language skills), learning strategies (such as collaborative and problem-based learning), and learning contexts (other individual and pedagogical elements). Some aspects above may share commonalities with learning content other than languages, which may benefit educators from diverse backgrounds. In contrast, some findings and discussions may also be unique to language education. Language educators may combine specific teaching objectives with this model, which helps locate their educational technology application and research. Other educators may follow this paradigm to customize their applications of chatbots.

6. Conclusion

6.1 Major findings

This study employs VOSviewer and CitNetExplorer to conduct a bibliometric analysis of chatbots in language education. The study leads us to the following findings through the visualization and citation network analyses on this topic: (1) The number of publications on this topic has increased in the last five years (2018-2022) due to technological advancements and social attention; (2) there is a cross-disciplinary trend in the research, and many technologies have been involved in educational application research and improve chatbot performances; (3) popular research issues are identified, such as students' perceptions of chatbots in language education, effectiveness evaluation of chatbots, and technological upgrades; (4) chatbots play various roles and functions in specific domains of language education, such as language learning content, learning strategies, and learning context; (5) this study proposes some critical dimensions in the theoretical framework to consider the application of AI chatbots to a broader range of language education settings; (6) this study offers guidelines for future language education practice and clarifies directions and avenues for future research.

6.2 Limitations

This research has some limitations, including the use of only SCOPUS for the literature search, the omission of other relevant literature or gray literature, the exclusion of non-English studies, and the lack of expertise in some technological advancements. Unlike systematic reviews and meta-analyses that contain rigorous literature selection based on relevance and quality, this study generated findings from automatic and bibliometric analysis tools, lacking a precise filtration process. However, the study explored the significance of the research topic, identified research trends, and determined primary application contexts and directions for extending the applications of AI chatbots in education from a language educational technology perspective. Besides, established on the previous literature, the proposed model needs to be further examined and tested in practice with greater scrutiny. Furthermore, the study might have resulted in an incomplete grasp of the subject due to our research themes in language education. Further studies from the technological perspectives will provide knowledge related to technological expertise.

6.3 Implications for future studies and teaching practice

Theoretically, we synthesize the technological and pedagogical aspects with some elements unique to language education to propose a research framework for chatbots in language education based on our findings and discussion. It aims to bridge the expertise between technological designers and educational practitioners, which may facilitate chatbots' further developments and applications in diverse subjects. Elaborating on three dimensions, our framework extends the framework proposed by Lin and Yu (2023) in a bibliometric and visualization review. The extended framework and review methodologies can also be adopted for formulating working frameworks in other educational areas considering diverse learning content and learners.

The generalizability of our findings may be justified from the following general perspective of education: Educators in areas other than languages can benefit from similar technological foundations of chatbots in this study and popular

pedagogical and learning strategies listed in this framework, such as collaborative learning and blended learning; instructors in other areas may combine characteristics of chatbots, pedagogical strategies, and teaching objectives. For language educators who may dig into the applications of chatbots, the roles and functions of chatbots in specific language education contexts can be further enriched by different learning content, strategies, and contexts. Technological changes to enable chatbots' new functions may also bring changes; this model can help researchers specify their research directions based on the existing literature. Moreover, it can be extended to systematically evaluate the studies on other language educational technologies regarding the technological foundations and educational domains.

Practically, this study may offer guidelines for using chatbots in specific language teaching practice and inspire implications for language education. Further research is necessary to explore diverse applications and effective designs of chatbots, including emotional intelligence and combining different learning theories with learning strategies. An important function of this model is to dig out less-investigated topics in chatbot applications in education, encouraging more practice and validation. Lin and Mubarak's (2021) study can be considered a good demonstration of its practical value. They combined flipped classroom in English language teaching and mind map-guided AI chatbot approach, yielding the promoted English-speaking achievements and overall English performances. Mageira et al.'s (2022) research also serves as a compelling illustration of practical utility with the integration of content and language integrated learning and AI chatbot based on innovative information and communication technologies.

Research designs and application contexts can be further explored to promote technological advancements to meet specific language educational needs. Researchers in various fields other than language education can combine elements in different dimensions of this model and identify research gaps in the existing literature on chatbot applications. Our contribution of proposing the model is to link the current missing points and clarify future research avenues. With the developments of chatbots and artificial intelligence algorithms, generative artificial intelligence may revolutionize the designs of chatbots and their applications, although concerns also emerge regarding ethical issues in academic and non-academic contexts. Future studies will benefit from this direction and explore the impact of chatbot developments on language education and how these developments ameliorate previous ethical issues or probe novel ones. For one practical direction, incorporating chatbots into prevalent technologies, such as mobile learning, online learning, and augmented reality, may strengthen the adaptivity and effectiveness of AI chatbots in diverse contexts, considering that technologies may rely on different mechanisms and media to promote learning outcomes and complement one another. Chatbots do not form a strictly consistent category of educational technologies, with diverse designs in educational practice which need to be synthesized, evaluated, and equipped with related resources for broader applications. Practical applications will benefit from further explorations of the effectiveness of chatbots in language education through a meta-analysis when the application contexts can be further specified (e.g., Wu & Yu, 2023; Zhang et al., 2023). Profound discussions about the ethical concerns related to generative artificial intelligence-empowered chatbots are also necessary for future technology integration into education (Yu & Yu, 2023).

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Conflict of interest

The authors declare no competing financial interest.

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