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RESEARCH ARTICLE

A bibliometric analysis of artificial intelligence in L2 teaching and applied linguistics between 1995 and 2022

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Abstract

This study offers a comprehensive bibliometric analysis of artificial intelligence (AI) applications in the field of second language (L2) teaching and applied linguistics, spanning from the early developments in 1995 to 2022. It aims to uncover current trends, prominent themes, and influential authors, documents, and sources. A total of 185 relevant articles published in Social Sciences Citation Index (SSCI) indexed journals were analyzed using the VOSviewer bibliometric software tool. Our investigation reveals a highly multidisciplinary and interconnected field, with four main clusters identified: AI, natural language processing (NLP), robot-assisted language learning, and chatbots. Notable themes include the increasing use of intelligent tutoring systems, the importance of syntactic complexity and vocabulary in L2 learning, and the exploration of robots and gamification in language education. The study also highlights the potential of NLP and AI technologies to enhance personalized feedback and instruction for language learners. The findings emphasize the growing interest in AI applications in L2 teaching and applied linguistics, as well as the need for continued research to advance the field and improve language instruction and assessment. By providing a quantitative and rigorous overview of the literature, this study contributes valuable insights into the current state of research in AI-assisted L2 teaching and applied linguistics and identifies key areas for future exploration and development.

Keywords: artificial intelligence (AI); L2; applied linguistics; bibliometric analysis; co-citation analysis

1. Introduction

The transformative role of artificial intelligence (AI) in language teaching, particularly in second language (L2) acquisition, is a burgeoning field in applied linguistics. With advancements in natural language processing (NLP) and machine learning (ML), AI is revolutionizing language education, moving from traditional methods to personalized and engaging learning experiences (Pokrivcakova, 2019). A pivotal element in this transformation is AI-driven chatbots, providing immersive language practice opportunities (Dokukina & Gumanova, 2020; Huang, Zou, Cheng, Chen & Xie, 2023). They offer simulated conversations that enhance language proficiency, as shown by studies like that of de la Vall and Araya (2023) and Alm and Nkomo (2020). Moreover, personalized feedback in chatbot interactions is essential for an enriched learning experience (Tsivitanidou & Ioannou, 2021).

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Schulze (2008) discusses the imminent impact of AI in computer-assisted language learning (CALL), challenging the notion of its inflated status in the field. His insights align with the broad applications of AI in L2 teaching, where NLP and ML algorithms play critical roles in enhancing language understanding and personalizing learning experiences (McHugh *et al.*, 2020). Tschichold and Schulze (2016) further underscore the significance of intelligent technologies in facilitating language learning. Schulze and Heift (2013), in their comprehensive review, illustrate the evolution and potential of intelligent CALL, emphasizing its multifaceted applications in language education. These include robot-assisted language learning (RALL) for dynamic learning environments (Lee & Lee, 2022), and intelligent tutoring systems (ITS) for adaptive content delivery (Kumar, Singh & Jyothi Ahuja, 2017). The integration of gamification and virtual reality (VR) in language learning, exemplified by Dhimolea, Kaplan-Rakowski and Lin (2022), demonstrates the innovative use of AI in creating immersive experiences.

Adaptive learning systems, as outlined by Chen, Zou, Xie and Cheng (2021), demonstrate AI's capability in tailoring learning to individual styles. The use of AI for precise language assessment and automated grading is a significant advancement (McHugh *et al.*, 2020). Also, the combination of AI with gamification creates engaging learning experiences (Bouchrika *et al.*, 2021). ITS and NLP tools provide real-time correction and feedback, essential for language learning (Wang, Choi, Xu & Yang, 2021).

The increasing interest in AI's role in language education is reflected in the surge of review papers in this area. Xu, Wijekumar, Ramirez, Hu and Irey (2019) and Oliva *et al.* (2021) offer comprehensive analyses of technology's role in language learning. Bibliometric studies by Huang, Hew and Fryer (2022) and Liang, Hwang, Chen and Darmawansah (2023) map the trends in AI applications in language education. However, as highlighted by Yang and Kyun (2022) and Ali (2020), further holistic syntheses are needed.

Our study aims to fill this gap with a comprehensive bibliometric analysis of AI in language education, addressing key research topics, trends, authors, documents, and sources. This aligns with the framework established by van Eck and Waltman (2017). We aim to illuminate the potential and challenges in AI-assisted L2 teaching and contribute to the development of effective language teaching methodologies. The research questions guiding the current study are:

1. What are the prevailing themes and trends in AI-assisted L2 teaching and applied linguistics research?
2. What are the key authors, documents, and sources that have contributed significantly to AI-assisted L2 teaching and applied linguistics research?
3. What are the most promising avenues for future research in the field of AI in L2 teaching and applied linguistics?

2. Method

The present research employs a bibliometric analysis to investigate developments in the domain of AI in language education, with a particular emphasis on its applications in the fields of L2 teaching and applied linguistics. The data were collected from the Web of Science (WoS) database and subsequently processed and scrutinized to yield a detailed depiction of the scholarly production in this field.

2.1 Data collection

In this study, bibliometric data were gathered meticulously from the WoS database, an authoritative source for scholarly content (Roemer & Borchardt, 2015). The data collection followed a structured approach, beginning with an advanced search using comprehensive

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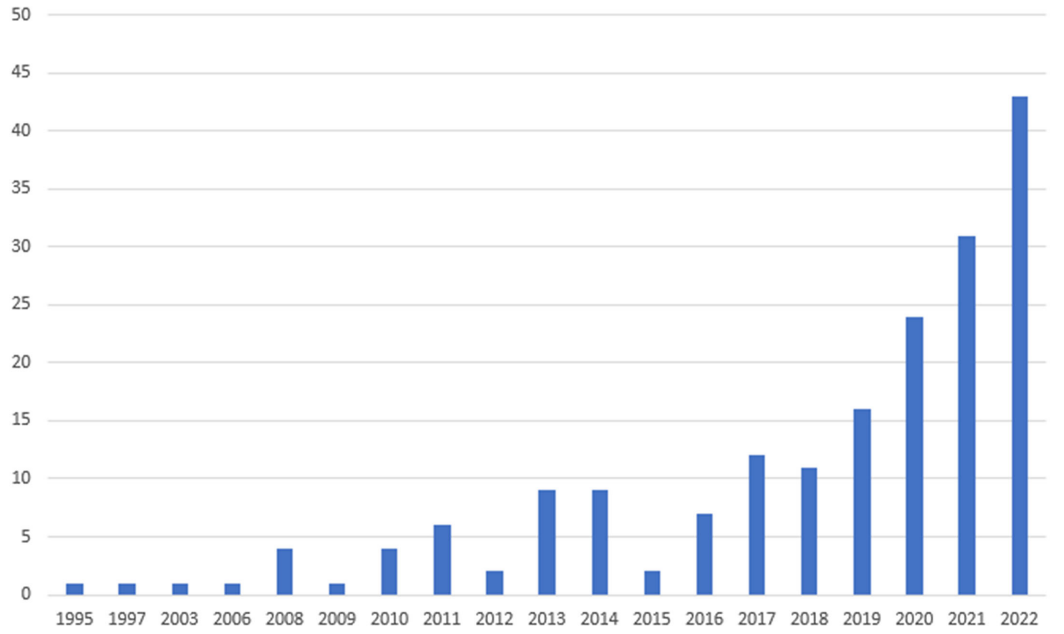


Figure 1. Distribution of selected papers across years

keywords. These terms were chosen to encapsulate the study's focus: [ALL = ("artificial intelligence*" OR "machine intelligence*" OR "artificial neural network*" OR "machine learning" OR "deep learning*" OR "natural language processing*" OR "robotics*" OR "thinking computer systems*" OR "evolutionary computation" OR "hybrid intelligent systems*") AND ALL = ("second language learning" OR "second language teaching" OR "foreign language learning" OR "foreign language teaching" OR "additional language" OR "third language" OR "ELF" OR "EFL" OR "ESL" OR "ELT" OR "L2" OR "second languages*" OR "foreign languages*" OR "applied linguistics" OR "TESOL" OR "TEFL" OR "L3")]. This initial search yielded 4,858 articles.

To ensure the relevance and specificity of the data, several filters were applied. Articles published from 2023 onwards were excluded, resulting in the removal of 42 publications. The focus was then narrowed to peer-reviewed articles, which brought the count down to 2,703. Further refinement was made by selecting articles from five WoS categories pertinent to the research subject: Education Educational Research, Language Linguistics, Linguistics, Education Scientific Disciplines, and Psychology Educational. The selection of these categories reduced the pool to 364 articles. The emphasis on English language articles further narrowed the selection to 345. Lastly, including only articles indexed in the Social Sciences Citation Index (SSCI) yielded 222 relevant publications.

To verify the accuracy and pertinence of the selected articles, a rigorous manual screening was conducted. This entailed a detailed review of each article's title, abstract, and research questions/hypotheses, focusing on their relevance to AI L2 pedagogy and applied linguistics. Articles with ambiguous relevance underwent a thorough reading, and in cases of uncertainty, the insights of a researcher colleague were sought. Additionally, to further bolster the robustness of this screening, a random 10% subset of the articles was independently reviewed by a third party for topical relevance, ensuring an additional layer of verification. This meticulous process ultimately identified 185 articles (Supplementary Material Table A) as fitting for the study's purpose, spanning a range of 71 journals indexed in the SSCI. The chronological distribution of the articles, published between 1995 and 2022, is visualized in Figure 1.

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This visualization highlights the evolution in the field, emphasizing a surge in research activity in recent years, and a notable scarcity of papers from 1995 to 2008. Figure A (Supplementary Material Figure A) complements this temporal analysis by showcasing the distribution of articles across the top 15 journals in the domain of English language teaching and AI from 1995 to 2022, offering insights into the academic platforms driving this research field.

2.2 Data analysis

Data underwent a detailed cleaning process to ensure accuracy and consistency. This included creating thesaurus files for integration into VOSviewer, a bibliometric software tool used for this study. Terms like "natural language processing" were standardized to "NLP," and variations such as "Computer-assisted language learning" and "Computer assist lan learn" were uniformly coded as "CALL." The analysis also involved conducting an author keyword analysis to identify prevailing themes and trends in the field. Author keywords are instrumental in demonstrating the major research directions and trends in a given field (Wang, Dong, Qu, Lin & Liu, 2024). Using VOSviewer, the study analyzed the cleaned data to uncover key research topics, trends, and patterns in AI-assisted L2 teaching, learning, and applied linguistics. The tool's capabilities in generating co-word maps and network diagrams were pivotal in visualizing the relationships between different concepts in the literature. This included creating a co-word map to depict connections between various keywords and concepts. Additionally, VOSviewer aided in identifying influential authors, institutions, and journals, and revealed collaboration patterns among them, thereby providing a comprehensive overview of the current state of research in AI in language teaching and learning (Zou, Yue & Le Vu, 2018).

3. Findings and discussion

This section presents the findings structured around the research questions. It offers a summary of key themes and trends, highlights influential authors, documents, and sources, and outlines promising directions for future research. Additionally, it discusses emerging questions and challenges in AI-assisted L2 teaching and applied linguistics, providing insights into the field's current state and areas ripe for further investigation.

3.1 Evolution of AI in L2 teaching and applied linguistics research: Trends and significant changes

Our analysis yielded four primary clusters, namely artificial intelligence, NLP, robot-assisted language learning, and chatbots. Figure 2 visually depicts the emerging themes and trends in the field.

Co-occurrence of author keywords analysis revealed that the field is highly multidisciplinary and characterized by a range of approaches and techniques, with strong interconnections among many of the topics. The most prominent clusters included "intelligent tutoring systems," which emphasized the increasing use of these systems in L2 teaching and learning research and their potential to provide personalized feedback (Amaral, Meurers & Ziai, 2011) and instruction to individual learners. Other notable clusters, such as "syntactic complexity" and "vocabulary," highlighted the importance of understanding the role of syntactic complexity and vocabulary in L2 learning and the potential for AI technologies to facilitate vocabulary acquisition (Lei, 2022). Moreover, the cluster of "educational robots" revealed a growing interest in exploring the use of robots in L2 teaching and learning (Leoste *et al*., 2022), suggesting a need for further research in this area and the potential for robots to enhance the learning experience of L2 learners (Khalifa, Kato & Yamamoto, 2017). Additionally, clusters such as "gamification" and "computational linguistics" reflected a trend in exploring game-based approaches and competition in L2 teaching

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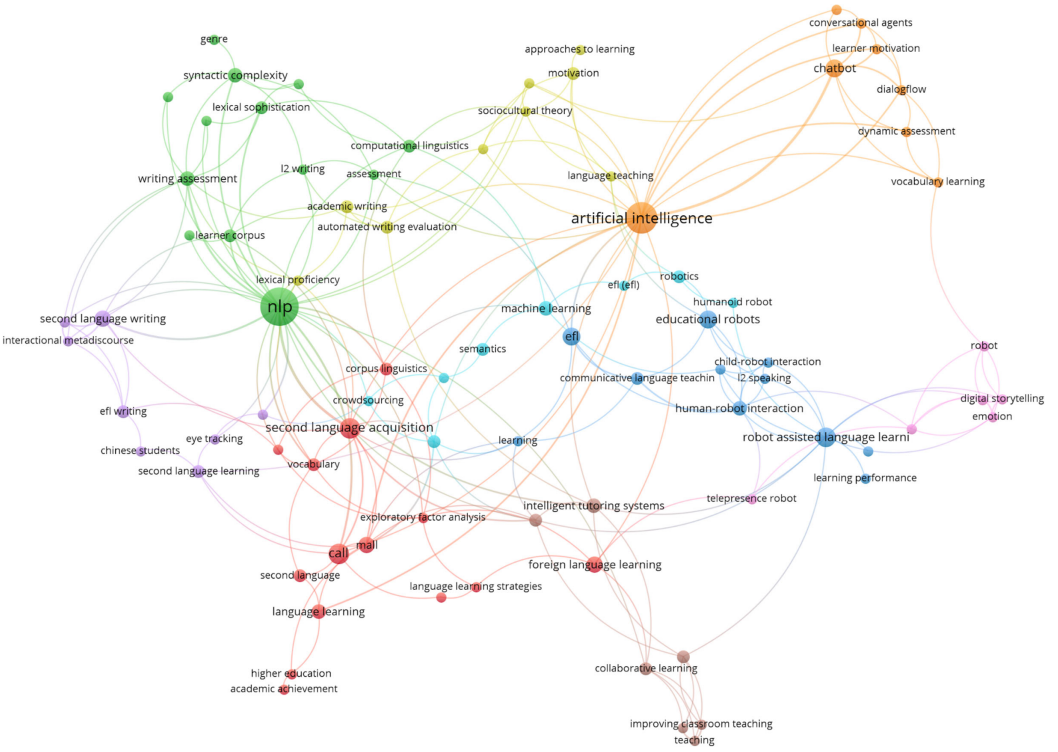


Figure 2. Analysis of emerging themes and trends: Co-occurrence of author keywords

and learning research. Overall, these outstanding clusters demonstrate the increasing interest and potential of AI technologies in language learning and teaching, as supported by the relevant literature (Yang & Kyun, 2022). These ideas are further supported by the identification of the "artificial intelligence" cluster in Figure 3, which highlights the growing interest and potential of AI technologies in language learning and teaching, as well as its multidisciplinary nature. While some items in the identified clusters overlap, we prioritized those with the strongest interconnections, as illustrated in the figure.

Based on the co-occurrence of author keywords, we identified four main clusters, one of which focuses on "artificial intelligence." This cluster highlights the growing interest and potential of AI technologies and contains a total link strength of 34, with 23 links among the items in the cluster. The presence of keywords such as "vocabulary learning," "task design," and "sociocultural theory" suggests that the field is a complex and multidisciplinary one, with connections to various areas of linguistics, psychology, and education (Hamal & El Faddouli, 2022). Specific topics within the cluster include the use of conversational agents and chatbots to simulate authentic language interactions, as well as the use of dynamic assessments and automated writing evaluation tools to provide personalized feedback to language learners (Huang *et al.*, 2022). By exploring the links and relationships among these topics, researchers and practitioners can gain a better understanding of the interrelatedness of these areas and identify new avenues for research and development. The outstanding cluster on "artificial intelligence" reflects the significant and growing interest in AI technologies and their potential to improve language instruction and assessment. In our analysis, we observed an outstanding cluster around "artificial intelligence." AI's adaptability facilitates personalized learning experiences that cater to individual student needs. It can provide real-time, detailed feedback, a crucial aspect of effective language learning. Furthermore, AI's ability to handle extensive language data enables complex linguistic analyses.

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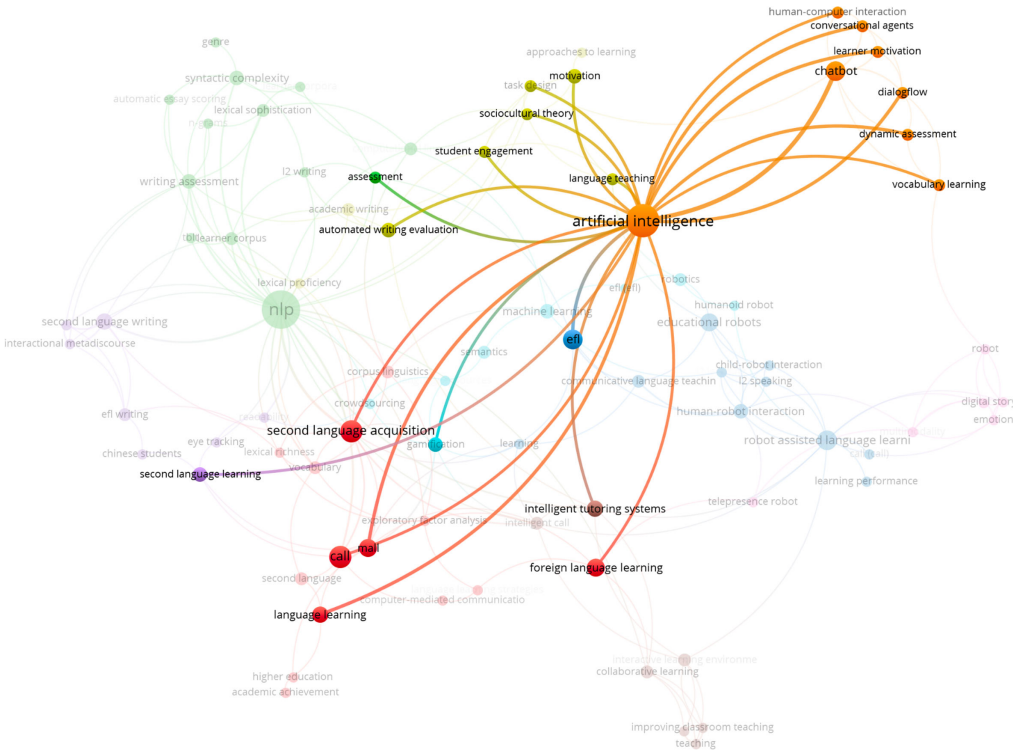


Figure 3. First main cluster: Artificial intelligence

The second cluster (Figure 4), identified through co-occurrence of author keywords, focuses on NLP in the context of AI-assisted L2 teaching and applied linguistics research. The cluster has a total link strength of 45, with 28 links among the items in the cluster. This cluster highlights the NLP and computational linguistics to improve language instruction and assessment. The specific topics within the cluster, such as automatic essay scoring, learner corpus analysis, and syntactic complexity, showcase the potential of NLP technologies to provide objective and accurate feedback to language learners. The effectiveness of NLP in providing feedback has been widely recognized in L2 teaching (Meurers, 2013).

The multidisciplinary nature of this field is evident from the presence of keywords such as "task design" and "sociocultural theory" within this cluster. This implies that the application of NLP is a complex and multifaceted field, with connections to various areas of linguistics, psychology, and education. The term "complex" is used to refer to systems or phenomena that consist of multiple interconnected parts and variables, where changes in one part can lead to nonlinear and unpredictable changes in the whole system. "Multifaceted," on the other hand, denotes a subject or problem having many different aspects or features that must be considered to grasp its full nature. NLP technologies can enhance the development of more effective language instruction and assessment approaches and deepen our understanding of the social and cultural contexts of language learning (Rustan, 2022). The strong linkages among the items in the cluster suggest that these topics are highly interrelated and significant. Continued exploration and development of NLP tools and techniques are essential to advancing the field. Figure 5 displays the third main cluster, which is robot assisted language learning.

The third outstanding cluster identified through co-occurrence of author keywords is focused on "robot assisted language learning." The cluster comprises a total link strength of 13, with 13 links among the items in the cluster. This cluster emphasizes the growing interest in the use of

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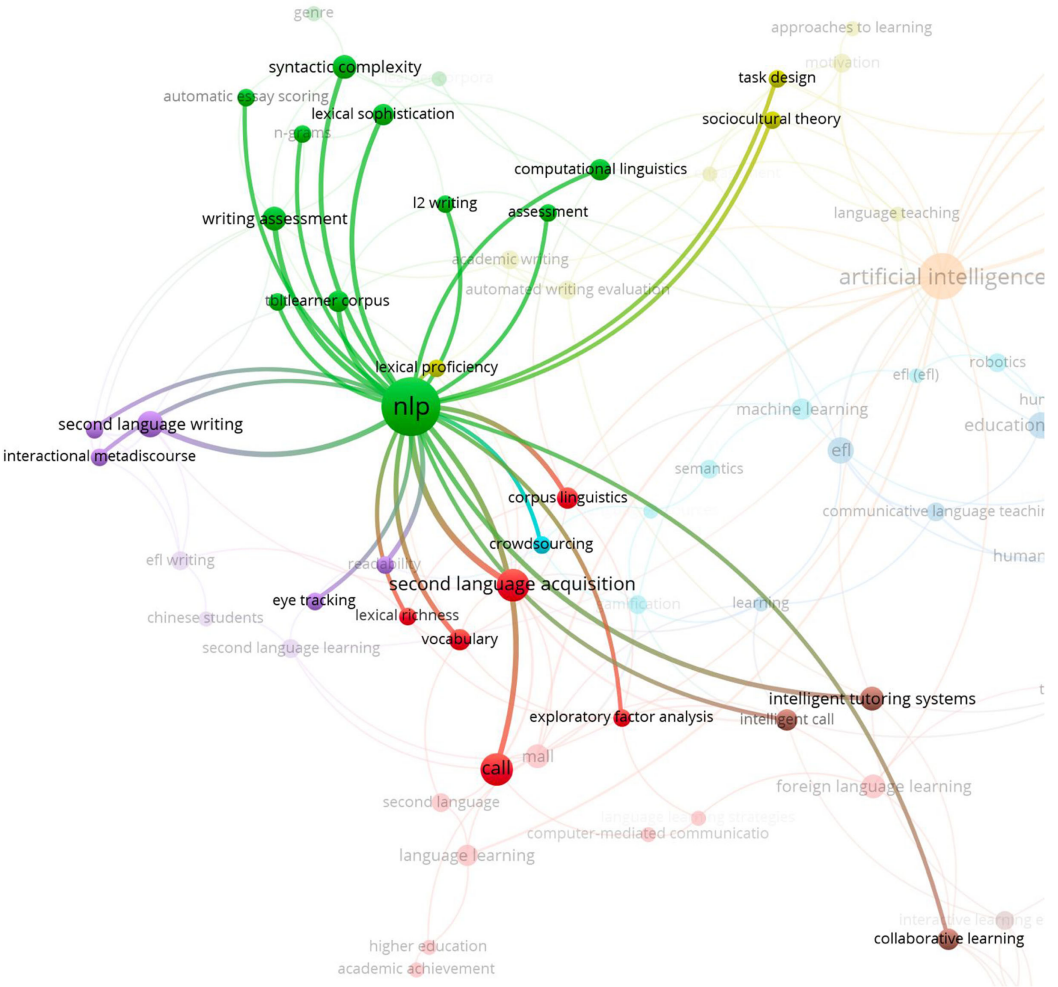


Figure 4. Second main cluster: NLP

humanoid and telepresence robots. Furthermore, digital storytelling (Nair & Yunus, 2021) and emotion (Zhang, 2022) are regarded as essential factors in effective language instruction. The presence of keywords such as "learning performance" and "interactive learning environments" suggests that the use of RALL is a complex and multidisciplinary field, with connections to various areas of education and psychology. The strong linkages among the items in the cluster underscore the significance of these topics and their interrelatedness. Continued research and development of RALL tools and techniques are essential to advancing the field regarding instruction and assessment. The remarkable cluster on "robot assisted language learning" reflects the growing interest and potential of utilizing robotic technologies to improve language learning and teaching (Khalifa, Kato & Yamamoto, 2019). The strong linkages among the items in the cluster indicate the importance of exploring these topics and undertaking further research in these areas to advance the field. Figure 6 shows the fourth cluster.

Through analyzing the co-occurrence of author keywords, we have identified four main clusters that are relevant to AI-assisted L2 teaching and applied linguistics research. The fourth cluster that we have identified centers around the topic of "chatbot" and consists of 15 links, eight of which occur within the cluster. The chatbot cluster underscores the growing interest in utilizing

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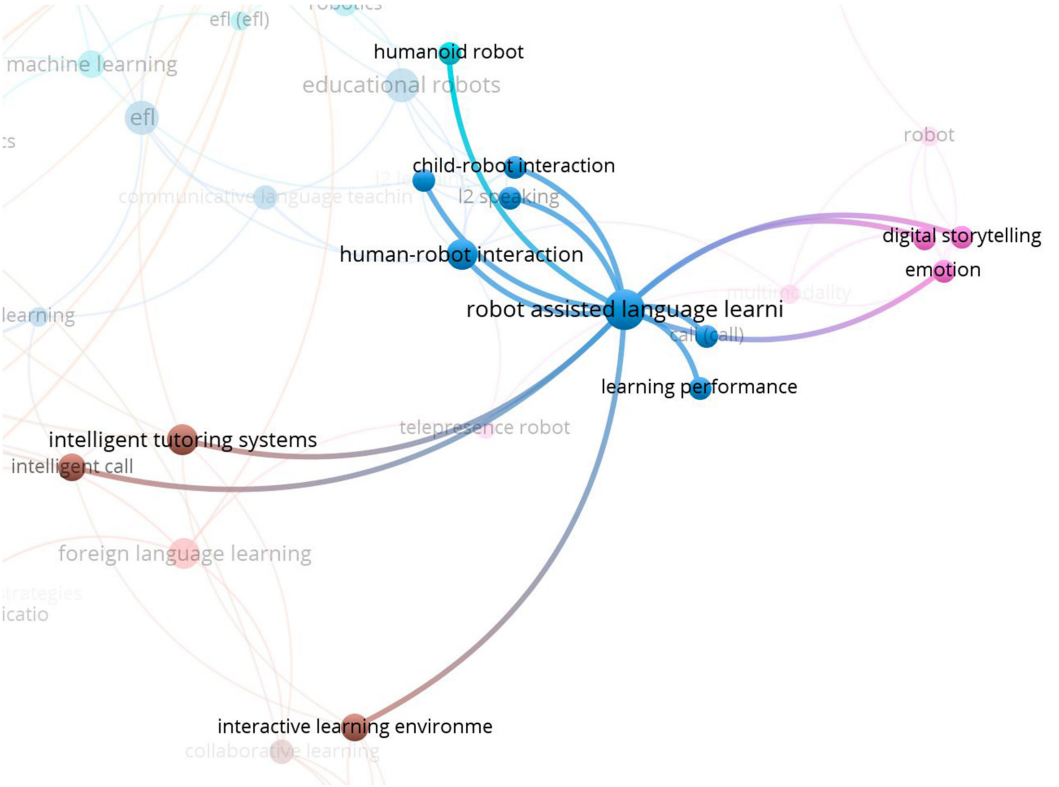


Figure 5. Third main cluster: Robot assisted language learning

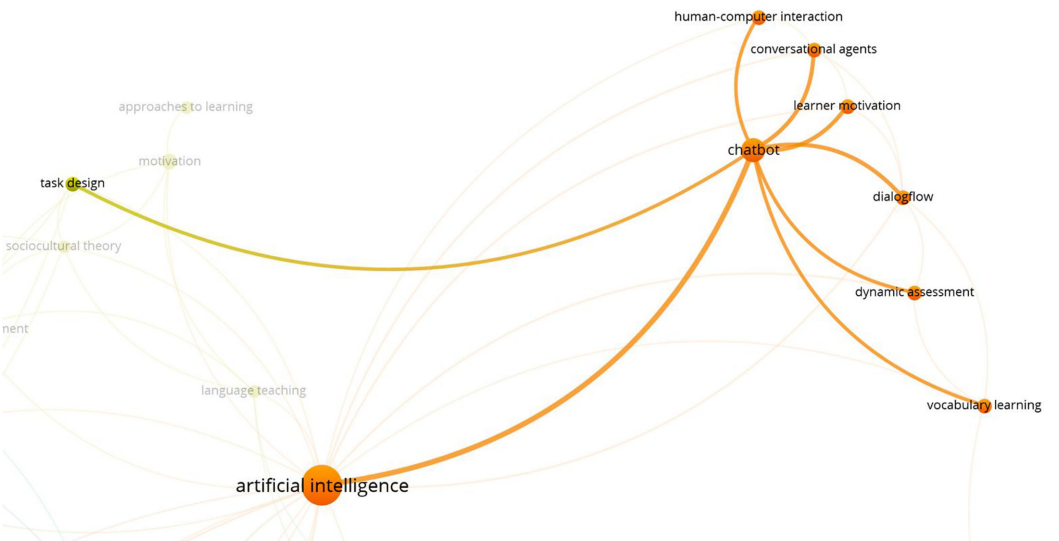


Figure 6. Fourth main cluster: Chatbot

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conversational agents, such as chatbots, to simulate natural language interactions and to provide customized language learning experiences. Specific topics within the cluster include the design of task-based chatbot interactions, the use of dynamic assessments to evaluate language proficiency, and the role of chatbots in fostering learner motivation and engagement. It is noteworthy that keywords such as "vocabulary learning" and "task design" signal that chatbot-assisted language learning is an interdisciplinary field with connections to various areas of linguistics, psychology, and education. A review of the use of chatbots on language learning by Huang *et al.* (2022) supports these findings on chatbots. By examining the links and relationships among these items, scholars and practitioners can acquire a better comprehension of the interconnectedness of these topics and identify fresh prospects for research and development.

The cluster on "chatbot" in AI-assisted L2 teaching and applied linguistics research is indicative of the rising interest and potential of conversational agents in language learning and teaching (Huang *et al.*, 2022). The strong linkages among the items in the cluster highlight that these topics are highly related and significant. Continued research and exploration in these areas is crucial for advancing the field of L2 teaching and applied linguistics. One promising avenue for future research is the examination of chatbot-based language assessments, which could offer a more personalized and efficient approach to measuring language proficiency (Kuhail, Alturki, Alramlawi & Alhejori, 2023). Further investigation into the role of chatbots in promoting learner motivation and engagement could also help optimize their use in language learning contexts. The findings from this cluster suggest that chatbot-assisted language learning is a dynamic and rapidly evolving area of research with significant potential for improving language instruction and assessment.

The four identified clusters reveal a significant progression in the field of AI-assisted L2 teaching and applied linguistics, aligning with the advancements in AI technologies like ChatGPT in 2023. The progression from foundational AI principles to specific applications in NLP, RALL, and chatbot technology reflects an increasing sophistication and practicality in language learning tools. The most notable developments include the integration of conversational AI like ChatGPT, which provides highly interactive, responsive, and personalized language learning experiences. This trend signifies a shift towards more naturalistic and user-centric approaches in language education. The advancement in AI-driven language assessment tools, particularly in chatbot technology, highlights a move towards more efficient, accurate, and learner-friendly evaluation methods. These developments represent a paradigm shift in language learning, where technology not only supplements but also actively shapes and enhances the educational experience, making it more adaptive and engaging for learners. The increasing interconnectivity of these clusters underscores a future where AI's role in language education is not just supportive but also transformative, leading to innovative approaches and methodologies in language teaching and learning.

3.2 Citation analysis of impact and co-citation analysis: Influential authors

A total of 446 unique authors contributed to the articles published in the dataset. S. A. Crossley contributed 18 articles. He is followed by K. Kyle, having 10 articles. N. S. Chen, D. S. McNamara, J. H. Lee, and D. Meurers are among the top six, with article counts of 7, 6, 4, and 4, respectively. Figure B (Supplementary Material Figure B) shows the citation analysis of the authors. The citation analysis yielded four clusters, with a minimum of one document and 15 citations. The resulting clusters contained a total of 190 links and a total link strength of 226. Of note, the analysis revealed a strong link among authors conducting research on RALL, underscoring the growing interest in this area. The presence of a link related to robot-assisted language teaching suggests a significant number of researchers working in this field, which demands advanced technologies and laboratory support. This finding reflects the increasing investment in the development of innovative technologies to improve language education and highlights the

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importance of continued research and development in this area to advance the field of language education. It is evident in the literature that RALL is a rapidly developing field, and there is increasing attention to the use of robots for language teaching and learning (Khalifa *et al*., 2019). RALL is a promising application for employing social robots to help both children and adults acquire a language and is an increasingly widely studied area of child–robot interaction (Molenaar, Soliño Fernández, Polimeno, Barakova & Chen, 2021).

In addition to the impact-based citation analysis, we also conducted co-citation analysis of the authors (as depicted in Supplementary Material Figure C). Co-citation analysis differs from impact-based citation analysis in that it evaluates the documents cited in the reference lists of articles. This approach expands the scope of analysis beyond the limited bibliometric dataset and captures a much broader literature (Hallinger & Kovačević, 2019). Through this methodology, we aimed to gain a more comprehensive understanding of the relationships and connections among the articles and authors in the field of AI-assisted L2 teaching and applied linguistics research.

The co-citation analysis (Figure C) resulted in the identification of 27 authors with a minimum of 15 citations, clustered into three groups based on their co-citation patterns. The total link strength among these authors is 2,565, and the total number of links is 238. Cluster 1 includes the most co-cited authors. These authors are known for their research on topics such as learner autonomy, task-based language learning, and language testing. Notably, M. Alemi (link strength = 69) and Z. Dornyei (link strength = 101) have the highest individual link strengths in this cluster, indicating their influence in the field. Cluster 2 includes authors whose research focuses on computational linguistics, NLP, and educational technology. S. A. Crossley (link strength = 781), K. Kyle (link strength = 427), and D. S. McNamara (link strength = 304) are the most co-cited authors in this cluster. Their research is likely to be highly relevant in today's digital world, where technology is increasingly being integrated into language learning and teaching. This finding is also a result of joint papers by Crossley, Kyle, and McNamara (and Salsbury). Cluster 3 includes authors whose research is centered on corpus linguistics, genre analysis, and cognitive linguistics. Biber (link strength = 464) and Ellis (link strength = 365) are the most co-cited authors in this cluster. Their work is likely to be influential in shaping our understanding of language structure and use, as well as how language is learned and taught. This co-citation analysis sheds light on the different research areas and subfields within the broader field of language learning and teaching. The findings highlight the contributions of highly cited authors and their impact on the field, as well as the areas of research that are most salient today. These insights are likely to be valuable for researchers, practitioners, and policymakers in shaping their work and advancing the field further.

3.3 The highly influential articles

The articles listed in Table 1 are the most cited ones, taking into account the average number of citations per year instead of total citations, as the publication years of the articles vary. This table presents a comprehensive summary of the highly cited articles arranged in accordance with their average annual citation rate.

Table 1 showcases the influential works and authors shaping current research trends as measured by citation frequency and impact per year. The utilization of network visualization, in addition to the list of articles sorted by average citations per year, serves as a valuable tool for identifying the connections and relationships among the most cited articles in a field. This powerful feature within VOSviewer allows researchers to visualize the network of cited articles as nodes, connected by links that indicate their relationships. This facilitates the identification of key clusters, themes, and trends in the literature, as well as important authors or articles that warrant further investigation. By using network visualization, researchers can also identify patterns of citation behavior, such as which articles tend to be cited together or more frequently than others, leading to a deeper understanding of the research landscape and informing future research

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Table 1. The most cited 10 articles

Article title	Authors	Source title	Total citations	Average per year
Technology and the Future of Language Teaching	Kessler (2018)	*Foreign Language Annals*	91	15.17
Measuring Syntactic Complexity in L2 Writing Using Fine-Grained Clausal and Phrasal Indices	Kyle and Crossley (2018)	*The Modern Language Journal*	82	13.67
DREAM: A Challenge Data Set and Models for Dialogue-Based Reading Comprehension	Sun *et al.* (2019)	*Transactions of the Association for Computational Linguistics*	63	12.6
Exploring the Possibility of Using Humanoid Robots as Instructional Tools for Teaching a Second Language in Primary School	Chang *et al.* (2010)	*Journal of Educational Technology & Society*	163	11.64
The Essential Applications of Educational Robot: Requirement Analysis From the Perspectives of Experts, Researchers and Instructors	Cheng *et al.* (2018)	*Computers & Education*	56	9.33
Predicting Text Comprehension, Processing, and Familiarity in Adult Readers: New Approaches to Readability Formulas	Crossley *et al.* (2017)	*Discourse Processes*	60	8.57
The Relationship Between Lexical Sophistication and Independent and Source-Based Writing	Kyle and Crossley (2018)	*Journal of Second Language Writing*	65	8.13
The Development and Use of Cohesive Devices in L2 Writing and Their Relations to Judgments of Essay Quality	Crossley *et al.* (2016)	*Journal of Second Language Writing*	63	7.88
Conceptions of and Approaches to Learning Through Online Peer Assessment	Yang and Tsai (2010)	*Learning and Instruction*	109	7.79
Task Effects on Linguistic Complexity and Accuracy: A Large-Scale Learner Corpus Analysis Employing Natural Language Processing Techniques	Alexopoulou *et al.* (2017)	*Language Learning*	50	7.14

directions. The network visualization provided in Figure D (Supplementary Material Figure D) displays the most frequently cited articles in the field, with a minimum citation threshold set to four. The network visualization of the most cited articles in the field reveals two main clusters that represent important themes and trends in the literature. These clusters are identified by their distinct colors and consist of articles that share common research interests and methodologies. The yellow main cluster comprises research studies by Chang, Lee, Chao, Wang and Chen (2010), Chen *et al.* (2013), and Sisman, Gunay and Kucuk (2019), which primarily focus on the innovative approach of RALL. The application of RALL in language education is transforming the traditional teaching methodologies, rendering them more accessible and fruitful for learners of all ages and abilities. RALL can offer an engaging and interactive platform to support language learning, enabling learners to receive instantaneous feedback and overcome their learning barriers. Consequently, the incorporation of advanced technology in language education can open new avenues for learners to enhance their cognitive and social skills, as well as their linguistic competence.

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The blue main cluster, which consists of Cheng, Sun and Chen (2018), Cheng, Wang, Yang, Yang and Chen (2020), and Lee *et al.* (2011), is centered around the design and implementation of educational robots for language teaching. These articles showcase the potential of incorporating robotic technology into language education to enhance the learning experience for students. The research indicates that educational robots can provide personalized and interactive language instruction to learners, catering to their unique learning styles and needs. This innovative approach can improve the effectiveness of language teaching, as well as increase student engagement and motivation. The citation networks and links within the cluster highlight the potential of RALL as a promising area of research in the future. The existing literature suggests that RALL can provide a dynamic and engaging learning environment that fosters language acquisition more effectively. As educational robots become increasingly advanced and accessible, it is possible that they will become a ubiquitous tool in language teaching.

The network visualization of the most cited articles in the field provides valuable insights into the research trends and themes in the area of robotic and AI-assisted language learning. The clustering of articles by their common research interests and methodologies facilitates an understanding of the complex interrelationships between topics and enables researchers to identify potential gaps in the literature. These include advanced AI in interactive and communicative language learning, AI application in complex and real-world scenarios, long-term impact of AI and robotics on language acquisition, and effectiveness of AI in diverse cultural and educational contexts. Moreover, this visualization can guide future research and development in the field, highlighting the potential of educational robots and RALL as innovative approaches to language instruction.

The red cluster, comprising Kessler (2018), Divekar *et al.* (2022), and Timpe-Laughlin, Sydorenko and Daurio (2022), consists of articles that discuss the impact of AI on language education. In Kessler's review article titled "Technology and the Future of Language Teaching," the author examines the role of AI in L2 research. The cluster of articles related to technology, particularly AI, highlights the increasing interdisciplinarity of collaboration among researchers in search of more effective language education methods. Research articles that explore technological tools and offer insights into future possibilities are of great value to researchers. Divekar *et al.*'s (2022) "Foreign Language Acquisition via Artificial Intelligence and Extended Reality: Design and Evaluation" is an exemplar of AI-based spoken interaction tools. AI tools designed for language teaching have the potential to influence and inspire other researchers. Timpe-Laughlin *et al.*'s (2022) study also centers on dialogue technology, demonstrating that research into the use of AI in improving speaking skills is attracting attention, as also noted by Zou, Guan, Shao and Chen (2023).

3.4 Intellectual development of the field

The integration of AI in language teaching and applied linguistics has become an increasingly important topic of interest and application – that is, the practical use and implementation of AI technologies in the field. The use of AI technology presents new opportunities to improve the efficiency and effectiveness of L2 instruction (Meng-yue, Dan & Jun, 2020; Nushi & Momeni, 2020). As AI technology continues to advance, it is necessary to identify and explore the most promising avenues for future research in the integration of AI in L2 teaching and applied linguistics. The third research question aims to discuss the findings of research conducted in this area and identify the most promising directions for future research. Through this discussion, insights will be provided into the potential benefits and challenges of using AI in L2 instruction, and recommendations will be offered for further investigation and implementation of AI in language teaching and learning.

Figure E (Supplementary Material Figure E) shows the overlay visualization of the field. Overlay visualization is a powerful tool for showing the intellectual development of a

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field (Asher & Hibbard, 2022) and can help researchers to gain a better understanding of the underlying themes and concepts that have emerged over time (Widiasih, Johan, Sipriyadi & Prayekti, 2021). The co-occurrence analysis of author keywords in the field of AI-assisted language learning and applied linguistics has yielded intriguing insights. The analysis of the three periods (as Figure E suggests) reveals an evolution in the field, with different topics and themes emerging in each period. In the first period (purple), spanning from 2016 to 2018, the focus was on ITS and ML, indicating the nascent stages of the use of AI in language teaching and learning. Robotics and intelligent CALL were also prominent areas of exploration during this period (Khalifa *et al*., 2019), suggesting an interest in leveraging technology to augment language learning and teaching. The study of lexical sophistication and learner corpus was also of interest, reflecting researchers' desire to develop AI-based tools for enhancing learners' lexical and grammatical proficiency. In the second period (green), spanning from 2018 to 2020, there was a shift towards specific topics related to writing and academic discourse, such as automated writing evaluation, lexical richness, and academic writing. Researchers also focused on child–robot interaction, student engagement, and EFL writing, indicating an interest in using AI to enhance the learning experiences of particular learner groups. In the most recent period (yellow), spanning from 2020 to 2022, researchers have explored the use of chatbots, conversational agents, and dynamic assessment. There has been increased attention to the use of robots in language learning and teaching, as well as on vocabulary learning, L2 speaking, and gamification. This trend indicates that the field is continuing to experiment with the use of AI in different contexts, with a view to making language learning and teaching more engaging and effective for learners. These findings suggest that the field of AI-assisted language learning and applied linguistics is advancing rapidly, with new topics and themes emerging regularly. Although challenges and unanswered questions remain, such as ensuring the effectiveness and engagement of AI-based tools for learners, the findings suggest that the field is making strides and will likely continue to be a crucial area of research and development in the coming years.

Based on the findings of our analysis and existing literature in the field, we propose several areas for future research. First, we noticed a lack of comparative studies in our analysis. Considering the variety of AI-based tools and methods currently used in language teaching and learning, more comparative studies are needed to better understand their relative effectiveness. Second, as AI becomes more integrated into education, ethical considerations inevitably arise. These include issues related to privacy, bias, and the changing dynamics of the teacher–student relationship. Our review identified a gap in the literature addressing these critical concerns. Third, our findings suggest a need for more context-specific research. While AI is increasingly used in language education, its impact can vary significantly depending on the learner population. In particular, research focusing on young learners, EFL students, and learners with special needs is sparse and deserves further investigation. Finally, as technology continues to advance rapidly, there is a clear opportunity to explore how AI can be integrated with emerging technologies, such as extended reality, blockchain, learner autonomy, and big data. While our review identified some initial explorations in this direction, we believe there is considerable potential for innovative solutions in language education that combine these technologies.

4. Conclusion

The present study provides an insightful overview of the historical development of research in AI-assisted language teaching and applied linguistics. While demonstrating the growing significance of AI-based approaches to language education, our findings also trace the evolutionary path of the field. The early years of our survey period were marked by foundational work in ITS and ML, indicating the nascent stages of AI in language education. Over time, the focus shifted to more specific areas such as automated writing evaluation, lexical richness, and the

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integration of robotics in language learning, reflecting the field's progression and response to evolving educational needs.

In recent years, particularly from 2020 to 2022, the field has witnessed an increased exploration of chatbots, conversational agents, and dynamic assessment. This indicates a trend towards leveraging AI to make language learning more engaging and effective, highlighting the field's ongoing experimentation with AI in diverse contexts. The historical overview provided by our data reveals the substantial shifts in research interests and thematic priorities over time, emphasizing the field's dynamic and rapidly advancing nature.

Despite these insights, our study has limitations, such as its focus on a specific set of journals and the exclusion of non-English language articles, which may have led to an incomplete representation of the field. Future research should aim to address these limitations by expanding the scope of analysis and incorporating a broader range of journals and languages, as well as expert opinions and perspectives. In conclusion, this study not only sheds light on the current state of AI-assisted language teaching but also provides a valuable historical context that underscores the field's significant transformations and the emergence of new themes over the surveyed period.

Supplementary material. To view supplementary material referred to in this article, please visit https://doi.org/10.1017/S0958344024000077

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