

# A Bibliometric Analysis of Recent Trends in VR-Assisted Language Learning Research from 1991 to 2023

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This study conducts a comprehensive bibliometric analysis on Virtual Reality-Assisted Language Learning (VRALL) using 2,286 documents from the Web of Science Core Collection, spanning from 1991 to 2023. Employing the bibliometrix R package and VOSviewer, this research maps the academic terrain of VRALL to uncover prevailing themes and the evolving research trajectories that could potentially dictate future developments in VR-assisted language education. Our findings illuminate significant growth in research output, particularly highlighted by a surge starting in 2016, coinciding with major technological advancements in VR hardware. The analysis reveals key thematic areas such as cognitive processing and language acquisition, showcasing VR's profound impact on reducing communicative apprehension and enhancing learner engagement and language proficiency. The study also highlights extensive collaborative networks and geographical diversity in contributions, with notable inputs from the United States, China, and European countries. This macroscopic view of VRALL's evolution not only emphasizes the field's interdisciplinary nature but also stresses the role of immersive VR environments in fostering effective language learning paradigms.

*Keywords:* virtual reality-assisted language learning, bibliometric analysis, interdisciplinary research, collaborative networks, immersive learning environments

In the rapidly evolving domain of educational technology, Virtual Reality (VR) has emerged as a transformative tool, reshaping how languages are taught and learned (Lan, 2021; Li & Lan, 2022; Nobrega & Rozenfeld, 2019). The integration of VR into language education, referred to as Virtual Reality-Assisted Language Learning (VRALL), offers immersive experiences that significantly enhance linguistic and cultural competencies (Lan, 2015; Sharma et al., 2023; Shih, 2015; Tai et al., 2022). This integration not only facilitates engaging and interactive learning environments but also allows for the simulation of realistic interactions and contextual scenarios, making the abstract aspects of language learning tangibly accessible and interactive (Peixoto et al., 2023). Recent advancements in VR technology, particularly the accessibility

and sophistication of VR headsets like the Oculus Rift and HTC VIVE, are likely to have promoted research productivity within the field of VRALL. Nevertheless, the academic exploration into VRALL remains scattered across various disciplines (e.g., educational technology, linguistics, cognitive science, computer science and cultural studies), making it challenging to grasp the full scope of its development and impact. A bibliometric analysis serves as a strategic approach to synthesize this expansive body of research, providing a structured overview of the field's evolutionary trends, key contributors, and prevailing research themes.

By employing the bibliometrix R package and VOSviewer tools, this study aims to map the academic terrain of VRALL, examining scholarly outputs sourced from the Web of Science Core Collection. The objectives of this study are twofold. First, to identify and analyze the key research themes and methodological approaches that have shaped VRALL, highlighting how technological advancements and scholarly interest have evolved over time. Second, to investigate the collaborative networks and geographical distribution of research contributions, offering insights into the intellectual structure and dynamics of the field. Through this analysis, the study endeavors to furnish educators, technologists,

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and policymakers with a comprehensive understanding of VRALL, aiding in the strategic development of future educational technologies and methodologies that align with modern learning needs and environments.

### An Overview of Related Studies

Virtual reality environments are characterized by their imaginativeness, immersiveness, and interactivity, effectively addressing the inherent deficiencies of traditional language classroom teaching, such as the lack of context and interaction. Additionally, they allow for precise experimental variable control (Peeters, 2019), paving new pathways for foreign language teaching and research (Li & Lan, 2022; Peixoto et al., 2023; Pinto et al., 2021). Specifically, there are abundant platforms that support VR-assisted language, such as EduVenture and Google Expeditions. These immersive learning environment helps to increase students' interest and motivation in learning (Berns & Reyes-Sánchez, 2021; Chen, Wang, & Wang, 2022; Chen & Hwang, 2022; Chu et al., 2023; Lin et al., 2023).

Related studies date back to the 1990s, with empirical research encompassing various levels of immersive technology such as desktop-based (Berns et al., 2013; Liou, 2012), spherical video (Chen, Li, et al., 2022; Ebadijalal & Yousofi, 2022; Huang et al, 2020), CAVE systems (Macedonia et al., 2023), and head-mounted virtual reality (Tai et al., 2022). Previous studies have examined the advantages of VR learning environments compared to traditional teaching methods, such as reducing learning anxiety (Lindner et al., 2019), enhancing engagement (Li et al., 2022), boosting learning motivation (Lin & Wang, 2021), improving specific language skills (Chen, Wang, & Wang, 2022), and deepening cultural understanding (Gao et al., 2021). For instance, Kang et al. (2019) compared public speaking training in front of an imaginary versus a virtual audience, assessing the effectiveness and psychological impacts of VR training. Chen et al. (2021) studied how a VR-supported environment could shape learners' self-concept in Chinese descriptive writing. Lin et al. (2023) explored the use of scenery-based VR to support dyadic learning of English for tourism purposes, emphasizing the immersive experience's impact on learning effectiveness.

Employing bibliometric analysis, the present study aims to discern the development, trends, and interconnections in VR-assisted foreign language education. The popularity of

bibliometric analysis can be attributed to the advancements, availability, and accessibility of bibliometric software (Donthu et al., 2021). The following are our research questions:

1. What are the major developmental trends and thematic focuses in VR-assisted language learning research from 1991 to 2023?
2. Who are the leading contributors, and what is the nature of the collaborative networks in the VRALL domain?
3. How do geographical and institutional contributions shape the global landscape of VRALL research?

### Methods

This study aims to thoroughly explore the landscape of VR-assisted language learning research, leveraging advanced data visualization tools to decipher patterns and insights within the field effectively.

#### Bibliometric Analysis Framework

Bibliometrics is a quantitative approach in information science that utilizes statistical methods to analyze scholarly literature, such as articles, reviews, and books. This technique is instrumental in assessing the influence and dissemination of research outputs, determining research productivity, and identifying key contributors and trends across various academic disciplines (Borgman & Furner, 2002; Ninkov et al., 2022). For this study, the Bibliometrix R package, equipped with its graphical user interface Biblioshiny, was employed to perform a detailed and systematic analysis (Aria & Cuccurullo, 2017). Additionally, the VOSviewer software (version 1.6.20) was used for creating network visualizations, which is well-regarded for its efficacy in bibliometric visualizations (Van Eck & Waltman, 2010).

#### Data Collection and Processing

The data for this study were sourced from the Web of Science Core Collection, renowned for its comprehensive and reliable indexing of scholarly documents. An advanced search was conducted in December 2023 using the following query:

*(TS=(“VR” OR “virtual reality” OR “virtual environment” OR “virtual world” )) AND (TS=(“second language” OR “L2” OR “foreign language” OR “EFL” OR “language acquisition” OR “language learning” OR “listening” OR “speaking” OR “reading” OR “Writing” OR “Vocabulary”))*

After refining the selection to exclude non-English works,

a total of 2,286 documents were finalized for analysis. These documents were then examined using Biblioshiny and VOSviewer to facilitate a robust bibliometric evaluation and visualization.

## Results

### Academic Performance Analyses

Figure 1 shows the annual publication trend spanning from 1991 to 2023, reflecting the dynamic fluctuations of research productivity. The initial period between 1991 to 2015 witnessed a slow but stable increase in scholarly output. The number of publications began to surge in 2016, indicating a growing interest and investment in this research field. Note that 2016 is considered as the “Virtual Reality’s Breakthrough Year,” marking the transition of virtual reality from a niche innovation to mainstream acceptance. Major virtual reality headsets like the Oculus Rift and HTC Vive, released this year, significantly boosted the market for VR technologies, which seemingly contributing to the rapid advancements of VR-assisted language learning research. Notably, a slight decrease in scholarly output occurred in 2019, suggesting a temporary deviation from the otherwise exponential growth pattern observed in preceding years. This could arguably be attributed to the initial disruptions in academic activities caused by the COVID-19 pandemic. However, the number of annual publications resumed its drastic increase in 2020 and peaked at 287 in 2023. It is anticipated that this number will continue to increase in the subsequent years due to the rapid emergence of a nascent research domain: *VR-Assisted Language Learning*.

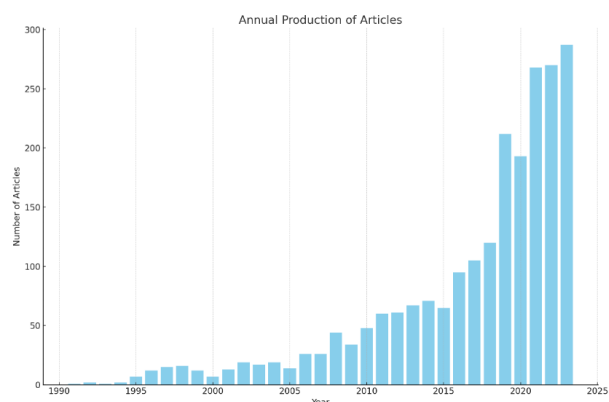


Figure 1. Annual Scientific Production

Figure 2 illustrates the distribution of the most relevant

publication sources contributing to the field of VR-assisted language learning. *Frontiers in Psychology* is the foremost contributor with 31 publications, closely followed by *Interactive Learning Environments* (29 publications) and *Applied Sciences-Basel* (26 publications). *Computers & Education*, *Computer Assisted Language and Education* and *Information Technologies*, and *Sustainability* each contributes approximately 20 documents. At the lower end, *Frontiers in Virtual Reality*, *Virtual Reality*, and *RECALL* adds approximately 15 documents. This figure encapsulates the influential sources shaping the scholarly narrative of this research field.

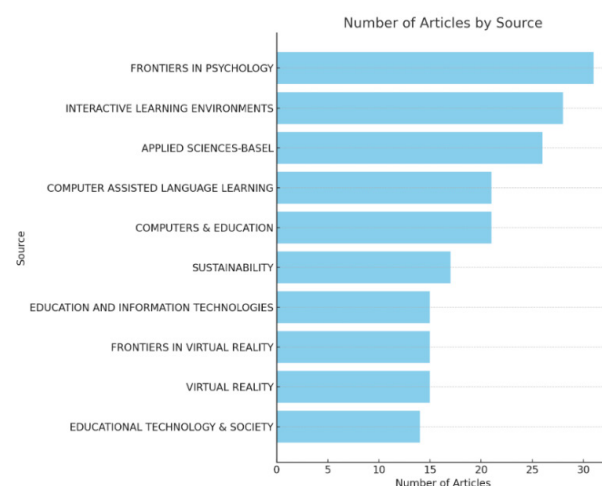


Figure 2. Most Relevant Sources

Figure 3 showcases the principal authors within the field of VR-assisted language learning, highlighting individual contributions. Lan leads with 15 publications, followed by Hwang who has authored 13 documents. Brinkman holds the third position with 12 documents, followed closely by Anderson, who has contributed 11 publications to this scholarly discourse. Jong and Blater have each produced 10 documents; Li and Pavani, 9 each; and Lindner and Murtaugh, 8 each. These authors have collectively enriched the research landscape in this domain.

Figure 4 demonstrates the most influential authors’ production over time. Lan’s scholarly output varied significantly between 2013 and 2023, with 2015 marking the peak in both publications and citations. Except for 2016 and 2019, when no papers were published, Lan consistently contributed to the field annually. Hwang, who entered the field in 2020, quickly established a consistent publication rate of 2 to 8 papers per year, with his citations per year ranging from 20 to 40, indicating significant academic influence. Jong and Pavani, who also started publishing in 2020, followed a

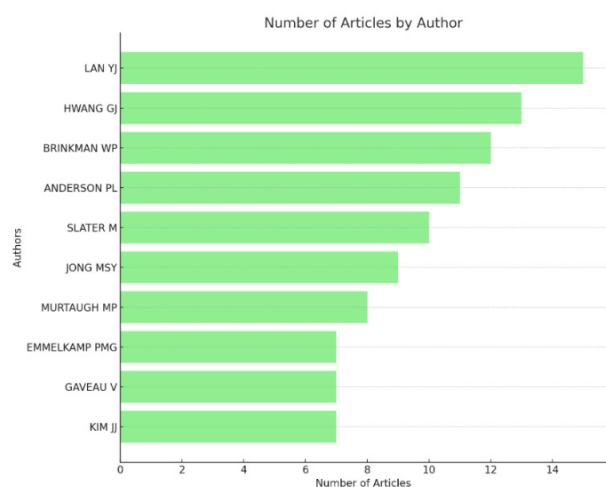


Figure 3. Most Relevant Authors

similar pattern, maintaining a steady output with substantial citation impacts. Slater has established a distinguished publishing record that extends over two decades, from 1999 to 2022, producing 2 to 4 papers every 2 to 4 years. Finally, Murtaugh, one of the pioneering figures in this field, began his publication efforts in 1995 and concluded in 2011. His significant contributions include four publications in 1999, which collectively received 30 citations, affirming his status as a key influence in the domain's formative years.

### Scientific Mapping

Figure 5 shows the collaborative network of the most active scholars in this research field. In light of the academic contributions of individual authors and their collaborative network, interesting patterns emerge. For instance, while Lan has an impressive publication record (15 articles and 521 citations), her work is predominantly authored independently, with a relatively lower total link strength of 3. Contrastively, Hwang has also made a significant contribution with 13 documents and 344 citations. As a core author in the field, Hwang has collaborated extensively across various research clusters. Hwang's ability to work effectively with diverse research teams shows his competence in conducting pertinent research with varying perspectives and methodologies. Hwang's work also shows deep engagement with the research landscape, as evidenced by the interconnectivity of his publications within the academic network. Overall, this analysis highlights the diverse and substantial contributions of authors to the field, revealing varying degrees of collaboration and engagement within this academic discourse.

Figure 6 displays the co-citation network among authors in the research domain, where authors are represented as nodes and links between nodes as co-citations in scholarly articles. The density and frequency of these links reflect the extent of co-citations and suggest a correlation among the authors' works. Highly interconnected nodes indicate significant alignment in research interests. This figure identifies six



Figure 4. Authors' Production over Time

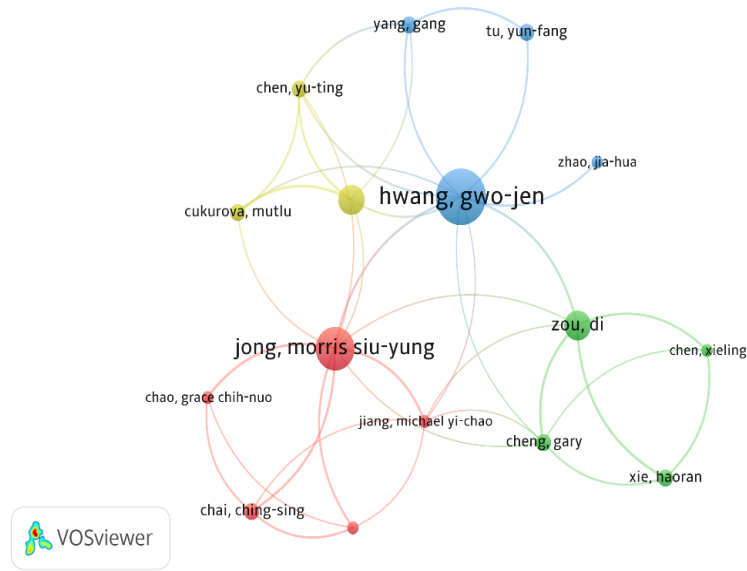


Figure 5. Authors' Collaboration Network

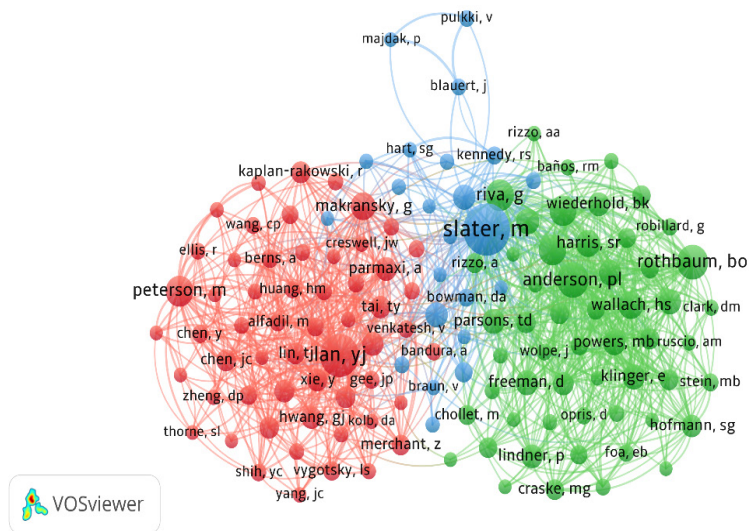


Figure 6. Authors' Co-Citation Network

distinct clusters labeled with different colors. Prominent nodes within these clusters include Slater, Lan, and Meulenberg, exhibiting an extensive citation pattern and indicating central roles in the network.

Figure 7 provides a comprehensive analysis of global academic contributions to VR-assisted language learning research, drawing on data from 77 countries. The United States leads the field with 534 publications and a notable 12,150 citations, indicating its dominant position. Following closely, China has a significant presence with 302 publications, although its relatively lower citation count

of 2,871 suggests room for greater recognition within the scholarly community. Note that Taiwan, as a part of China, makes substantial contributions with 126 publications and 2,195 citations, reflecting its active and impactful participation in this research area. In Europe, Germany distinguishes itself with 137 publications and 1,447 citations, closely followed by the United Kingdom, which boasts 136 publications and 2,807 citations. Spain and France also show strong research outputs with 113 and 100 publications, and 1,285 and 1,021 citations, respectively. These figures highlight the robust research productivity and influence of these European countries in

Country Scientific Production

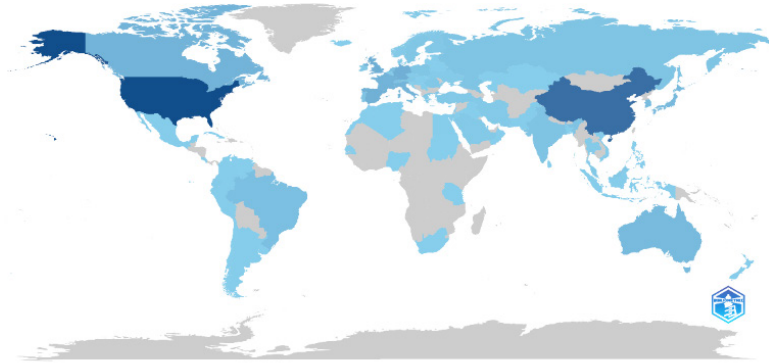


Figure 7. Country Scientific Production

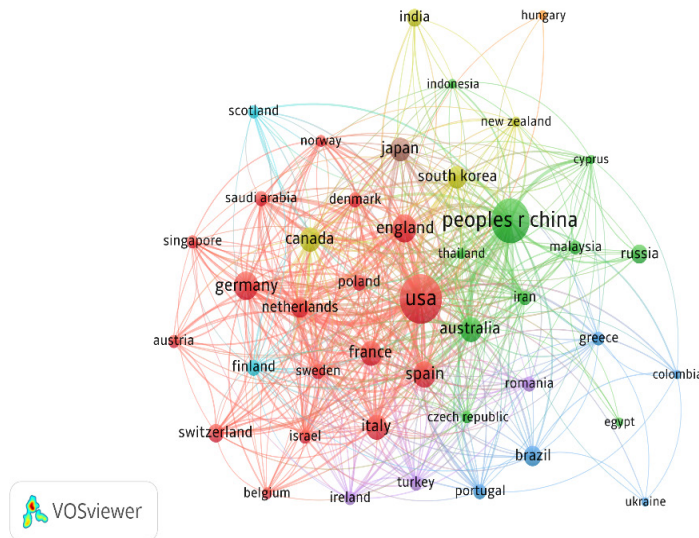


Figure 8. National Collaboration Network

advancing VR-assisted language learning research. This summary not only demonstrates the extensive involvement of these nations but also underlines the significant geographical diversity and academic interest in this evolving field.

Figure 8 illustrates the national collaboration network in this research field, highlighting extensive academic exchanges between countries. The United States appears as a central node, reflecting its extensive collaborations with numerous countries and stressing its leadership in this domain. Following the United States, China and Australia also demonstrate significant collaborative networks. Notably, there exists a dense network of collaborations within Europe, involving countries like France, Germany, Italy, and the United Kingdom. The intricate interconnections among these European nations suggest a high level of collaborative activity,

which is closely correlated with their collective publication output. Overall, this network map provides insights into the dynamics of international academic collaborations, indicating that larger networks often denote higher engagement and cooperative efforts across nations.

As shown in Figure 9, institutions worldwide are actively engaged in research on VR-assisted language learning. Among these, National Taiwan Normal University (NTNU) stands out with 23 publications and 735 citations, affirming its leadership in integrating virtual reality with language acquisition. Close behind, University College London (UCL) has also made significant contributions with 22 publications and 752 citations, exploring the innovative use of virtual reality in language education. The National Taiwan University of Science and Technology (NTUST) demonstrates

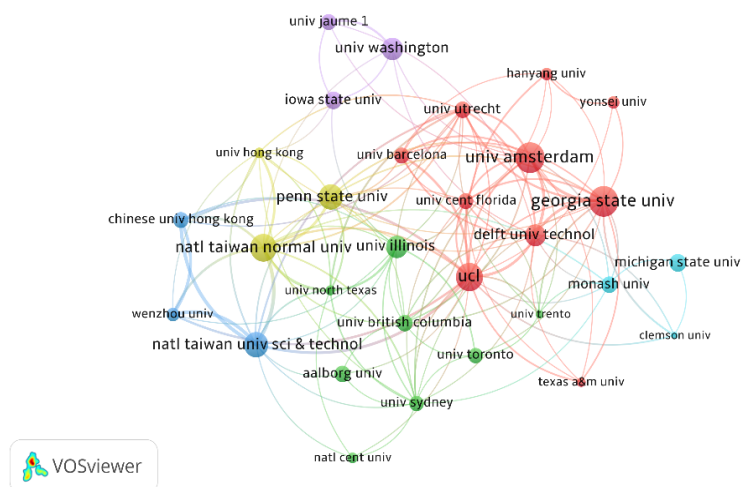


Figure 9. Institutional Collaboration Network

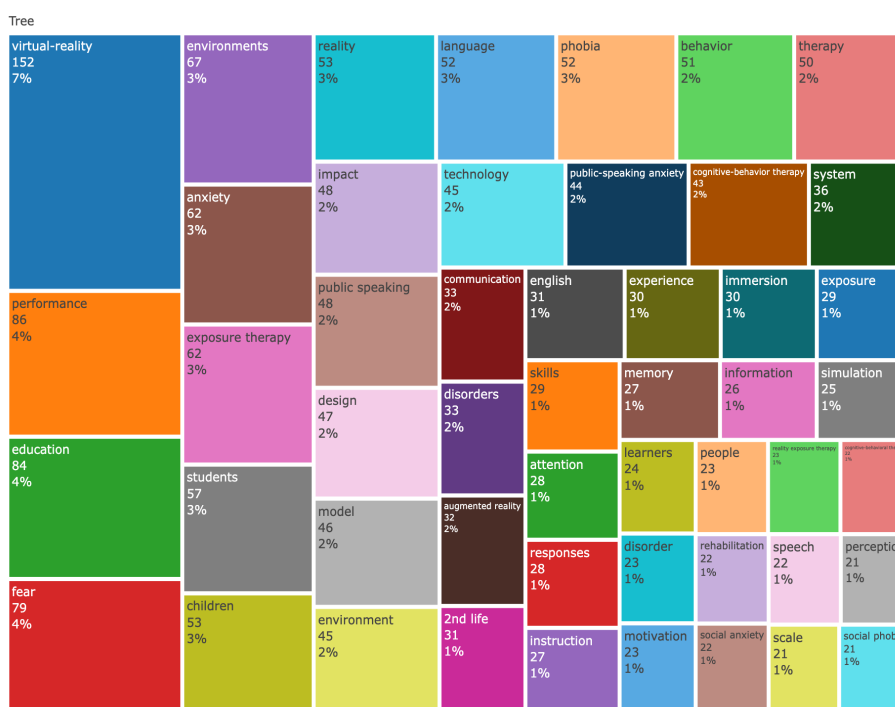


Figure 10. Keyword Tree Map

robust involvement with 21 publications and 599 citations. The University of Sydney (USYD), though having fewer publications at 16, has nonetheless achieved a substantial citation impact with 218, suggesting the recognition of its research quality. Similarly, the University of Illinois (UI) and the University of Washington (UW) each have published 15 documents. However, UI’s work has drawn more citations (469), reflecting its significant impact, compared to UW’s slightly higher citation count of 479, indicating its strong

influence and academic acceptance. These contributions collectively highlight the intensive and varied research efforts within this research domain, emphasizing the dynamic interplay of interdisciplinary approaches that characterize advancements in this area.

Figure 10 reveals the ten predominant keywords in the domain of VR-assisted language learning: “virtual reality,” “education,” “performance,” “fear,” “environment,” “students,” “anxiety,” “exposure therapy,” “language,” and

“children.” These terms highlight the principal research themes, traversing the spheres of technological advancement, educational methodology, learner involvement, and psychological welfare. The data suggest a concentrated scholarly focus on the confluence of VR technology and educational applications. The aspect of student performance is a key investigative concern, with VR providing immersive environments that encapsulate learners in rich, contextual settings. These settings offer varying impacts on language acquisition, underlining the importance of developing, assessing, and researching VR apparatus for educational purposes.

Figure 11 shows the keyword co-occurrence network based on the interconnections identified in the literature. This visualization represents each keyword as a unique node, with connections between keywords depicted by edges. The characteristics of these edges, including their thickness and color, indicate the frequency or intensity of keyword co-occurrence, providing insights into the relationships and thematic linkages across the body of literature. This co-occurrence analysis is instrumental in elucidating the complex research landscape within this research domain.

By grouping keywords into distinct clusters, color-coded as blue and red, the network reveals critical research themes and focal areas. The red cluster, featuring keywords like “virtual reality (VR)” and “second language acquisition,” highlights the synergistic effects of immersive VR technologies on foreign language learning. Research within this cluster explores how VR environments enhance language learning by analyzing factors such as immersion depth, contextual relevance, and learner engagement. It further extends to the cognitive processes involved in language acquisition within

VR settings, offering insights that are pivotal for refining instructional designs and pedagogical strategies. On the other hand, the blue cluster focuses on psychology and examines the dynamic interactions between psychological factors and language-related performance in VR contexts. Keywords such as “anxiety,” “fear,” “public speaking” and “exposure therapy” emphasize the detailed examination of learners’ emotional and cognitive reactions to VR-supported language learning. Studies in this cluster aim to clarify how VR impacts psychological constructs like motivation, self-efficacy, and anxiety levels, thereby guiding the creation of customized interventions and supports to boost learner welfare and effectiveness.

The conceptual structure map (see Figure 12) is a visual representation of a multidimensional scaling (MDS) analysis applied to the field of virtual reality-assisted foreign language learning. The two axes (Dim 1 and Dim 2) represent the two most significant dimensions extracted from the data set. The percentage values indicate how much of the variance in the data each dimension explains. In this map, Dim 1 accounts for 65.6% and Dim 2 for 9.24%. The map is divided into quadrants by the axes. Each quadrant might signify a distinct conceptual area. For example, the top right quadrant could represent studies focusing on the psychological aspects of VR in language learning, like “anxiety” or “phobia,” whereas the top left might represent more practical aspects such as “instruction” and “motivation.”

Key terms such as “learner,” “student,” and “performance” emphasize the centrality of individuals in the language learning process. The focus on “English” and “language” underscores the application aspect, while “technology” and “environment” pertain to the VR interface, reflecting

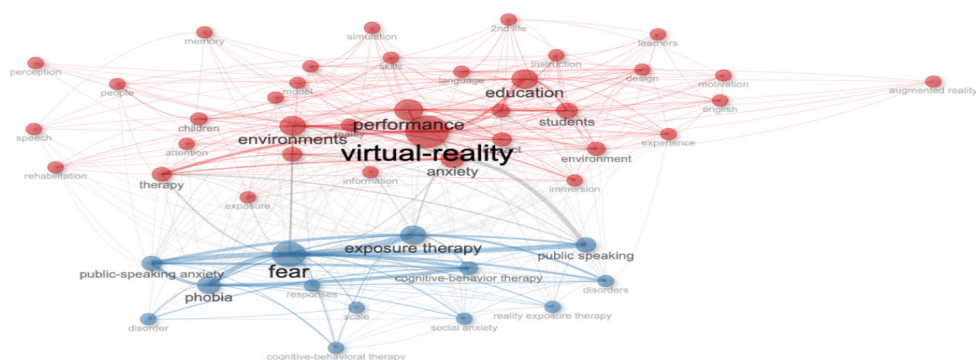


Figure 11. Keyword Co-Occurrence Network



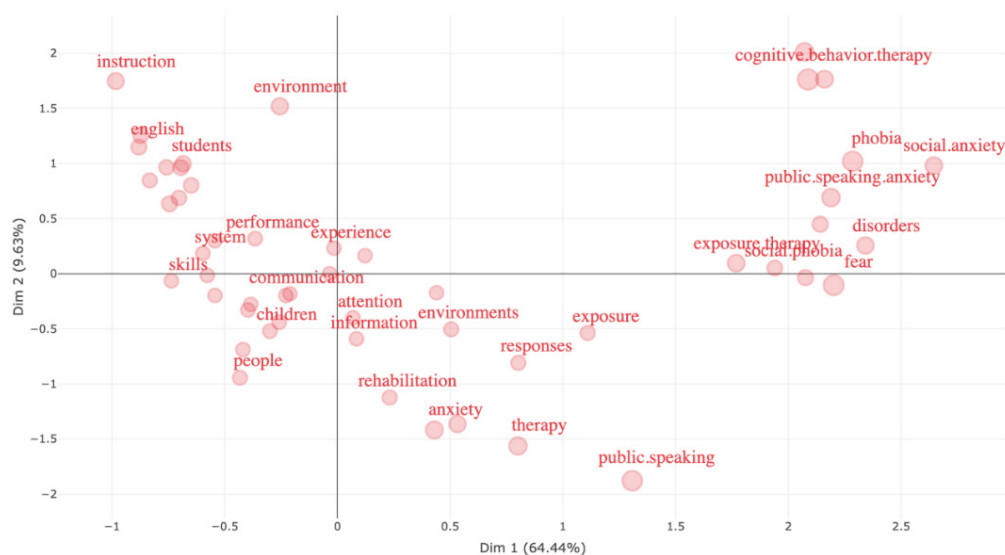


Figure 12. Conceptual Structure Map

a dual consideration of VR's supportive role in language education and the learners' psychological responses. Furthermore, "simulation," "model," "virtual reality," "memory," "perception," and "communication" converge around the nexus of VR and linguistic studies, with an evident predilection for replicating authentic language use scenarios within VR. Attention is also directed towards the influence of VR on memory retention and learner attitudes towards this educational approach. Finally, "prevalence," "cognitive behavior therapy," "exposure therapy," "public speaking anxiety," and "phobia" align more with the psychological dimensions of VR-assisted language learning research (e.g., Anderson et al., 2005; Lindner et al., 2021; Ter Heijden & Brinkman, 2011). This alignment suggests an investigative interest in the extent and mental underpinnings of language learning anxiety, particularly in public speaking and phobia-related scenarios. The inclusion of therapeutic approaches like "cognitive behavior therapy" and "exposure therapy" reflects an investigative trajectory towards therapeutic strategies in alleviating anxiety within VR learning environments.

## Discussion

Our first research question addresses major developmental trends and thematic focuses in VR-assisted language learning between 1991 and 2023. The bibliometric analysis provided in this study highlights a significant growth in the volume of research dedicated to VR-assisted language learning,

especially notable from the year 2016 onwards, coinciding with major technological advancements in VR hardware such as the Oculus Rift and HTC Vive. This surge in scholarly activity suggests a shift from traditional language learning paradigms towards integrating immersive virtual environments with language learning processes, which is increasingly recognized for its potential to enhance linguistic and cultural competency in an engaging manner (Sharma et al., 2023; Tai et al., 2022). Moreover, the analysis of publication sources and output over time indicates that journals like *Frontiers in Psychology* and *Interactive Learning Environments* are at the forefront of publishing cutting-edge research in this field. This suggests a growing interdisciplinary interest that bridges cognitive psychology, educational technology, and language acquisition disciplines. The prominence of these journals also points to a consensus within the academic community about the relevance and efficacy of VR technologies in educational settings. Furthermore, the research has progressively covered essential linguistic competencies—vocabulary (Lan et al., 2015) listening (Levak & Son, 2017), speaking (Xie et al., 2021), reading (Mirault et al., 2021), and writing (Chen et al., 2023)—while incorporating sophisticated thematic elements like cognitive processing and language acquisition. These themes focus on leveraging VR to mitigate communicative apprehension and enhance both learner engagement (Li et al., 2022) and language proficiency (Huang et al., 2021). This transition not only marks a technological evolution but also a methodological shift towards more experiential learning frameworks in language education (Peeters, 2019).

Our second research question concerns leading contributors and collaborative networks in VRALL. The analysis identifies key contributors, such as Lan and Hwang, and outlines the nature of collaborative networks within the VRALL domain. The distribution and impact of their work not only illuminate individual and collective scholarly achievements but also reflect the collaborative nature of this field. Notably, the consistent outputs from key contributors highlight ongoing efforts to innovate and improve VR applications for language learning (Wang et al., 2020). Prominent researchers and institutions, primarily from the United States, China, and Europe countries, have significantly influenced the field's trajectory. The collaborative networks depicted through bibliometric mappings show a robust pattern of inter-institutional and international collaborations (Chen, Wang, & Wang, 2022), suggesting a vibrant academic community that thrives on collective contributions. Such collaborations enhance the interdisciplinary nature of VRALL, integrating insights from cognitive science, computer science, linguistics, and pedagogy, thereby enriching the research output and fostering innovative educational technologies. The robust networks of collaboration among authors and nations are indicative of the complex, multifaceted nature of VR-assisted language learning research. These networks facilitate the exchange of ideas, methodologies, and findings, which are crucial for the iterative improvement of VR applications. Such collaborations are likely to propel forward-thinking educational strategies that can be tailored to diverse learning needs and environments.

Our third research question examines geographical and institutional contributions to VRALL. The geographical and institutional spread of research emphasizes the global interest and diverse approaches taken to integrate VR in language education. The United States and China lead in production, but significant contributions from Europe and other parts of Asia illustrate a wide acknowledgment of the benefits that VR can bring to language education. Such diversity not only enriches the field with a variety of study designs and contextual insights but also promotes a broader understanding and adoption of VR technologies globally. The geographical spread of contributions indicates a strong global interest in VR-assisted language learning, with significant research outputs from North America, Asia, and Europe. This diversity reflects the universal appeal and applicability of VR technologies in language education, transcending cultural and linguistic boundaries. Institutions like the National Taiwan Normal University and University College London

are pioneers in translating VR language learning research into practice, which may inspire others to explore and adopt similar technologies. This trend is critical for the evolution of educational methodologies and the preparation of learners for a digitally interconnected world.

The keyword and thematic analyses reveal focal research areas such as the impact of VR on language acquisition anxiety (e.g., Anderson et al., 2017), student engagement (e.g., Li et al., 2022), and performance (e.g., Macedonia et al., 2023). The recurring themes across different studies emphasize the role of immersive VR environments in mitigating language learning barriers, enhancing motivation, and providing realistic, context-rich learning scenarios. These findings are important for developing targeted VR curricula that can address specific educational objectives and learner demographics. Moreover, the evolving research landscape, as indicated by recent trends towards integrating artificial intelligence with VR, suggests a promising direction for creating more adaptive and personalized learning experiences. Future studies could explore the potential of AI-driven analytics to refine VR learning environments according to individual learner behaviors and outcomes. Future research should also focus on defining virtual reality immersion, developing standardized metrics, exploring diverse language families and cultures, and deepening our understanding of VRALL's role across linguistic and educational domains. Interdisciplinary collaboration will further elucidate VRALL's interdisciplinary impacts.

In general, research is categorized into two primary dimensions: cognitive processing, grounded in cognitive and behavioral linguistics, emphasizing the relationship between language and behavior, and the affective experiences of learning a new language, including associated fears. The educational process delves into public-speaking anxiety (e.g., Krijn et al., 2004; Kruk, 2021; Ling et al., 2012), social phobia (e.g., Bullinger et al., 1998), and disorders (e.g., Anderson et al., 2013; Kothgassner & Felnhofner, 2021) in conjunction with virtual reality. The second dimension examines progress in second language acquisition (SLA), employing it as a metric for gauging language mastery (Chen, Wang, & Wang, 2022). The study also highlights a need for more cognitive linguistic analysis, indicating potential future research directions. Despite its progress, VRALL's integration into mainstream education remains limited. If VRALL can significantly boost student motivation and interest, it could encourage educators to incorporate digital games into teaching, enhancing learning willingness and effectiveness. The pedagogical advantages

of VR in language education are clear, with its potential to improve learner motivation and proficiency through authentic, interactive environments. Educators may use VRALL findings to design effective language interventions, integrating task-based, collaborative, and experiential learning in VR environments to optimize outcomes.

This study stresses the expansive growth and dynamic nature of VR-assisted language learning research. As VR technologies continue to evolve, their integration into language learning and teaching is poised to transform educational practices, making them more engaging and effective. The insights gained from this bibliometric analysis serve as a valuable resource for educators, technologists, and policymakers, guiding future innovations at the intersection of technology and language education. Future research should continue to explore these trends, focusing on long-term educational outcomes, the scalability of VR applications in diverse educational settings, and the integration of emerging technologies like AI to enhance personalized learning experiences.

The bibliometric analysis also demonstrates the dynamism and rapid expansion of VR-assisted language learning research. As VR technologies become more sophisticated and accessible, their incorporation into language education could profoundly impact how languages are taught and learned. The evidence presented through this study not only validates the effectiveness of VR as a pedagogical tool but also highlights the vibrant scholarly community working to optimize and innovate VR applications for enhanced educational outcomes. This bodes well for future endeavors where technology and pedagogy intersect to foster more inclusive, engaging, and effective language learning paradigms.

Limitations exist, including lack of consensus on VR terminology and learning environment classification, diverse methodologies impacting comparability, and limited data samples focusing on usability rather than quantifiable learning outcomes. Research often concentrates on similar language families, restricting a global understanding of VRALL. Effective VR-based environment design requires attention to application principles, learner needs, and pedagogical objectives, necessitating collaboration among educators, technologists, and instructional designers.

### Conclusion

This study employed a comprehensive bibliometric analysis

using 2,286 documents sourced from the Web of Science Core Collection covering from 1991 to 2023. The analysis utilized the bibliometrix R package and VOSviewer 1.6.19 to depict the contemporary landscape of Virtual Reality-Assisted Language Learning.

The findings illuminate the developmental trajectory of VRALL research, highlighting dynamic trends and interdisciplinary integration involving cognitive science, linguistics, education, and technology. Our analysis identifies a marked increase in research activity beginning in 2016, aligning with significant enhancements in VR technology. It identifies crucial themes like cognitive processing and language acquisition, demonstrating how VR substantially lowers communicative anxiety and boosts both learner engagement and language skills. Additionally, the study reveals robust collaboration and diversity in research contributions, particularly from the United States, China, and European nations. By analyzing publication trends, citation networks, and keyword connections, this research offers insights into the collaborative networks and intellectual framework of VRALL, providing valuable information for educators, technologists, and policymakers involved in the convergence of language learning and virtual reality. Such insights are crucial for understanding the potential of VR technologies in language education and their practical applications. However, the exclusive utilization of a single database, namely the WoS Core Collection, chosen for its extensive metadata coverage, in this study may limit its representation of the scholarly landscape, potentially overlooking contributions from non-indexed sources or networks outside this database's scope. Additionally, the focus on English-language publications might exclude relevant research conducted in other linguistic contexts, thereby narrowing the analytical scope. Future research in VRALL should expand beyond current database limitations to embrace a wider pool of scholarly outputs.

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