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Virtual Reality in Language Learning: A Bibliometric Analysis from 2003 to 2023

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Abstract: Virtual reality (VR), as a computer-generated immersive environment that provides a highly interactive and simulated learning experience, has attracted great attention in the last decades. This author entered "virtual reality" and "language learning" as core keywords in the Web of Science academic paper database, limiting the search to articles published between 2003 and 2023 and English as the publication language, and obtained 430 articles. Subsequently, the author conducted a bibliometric analysis of these 430 relevant papers using the CiteSpace software. The results show that: (1) China has the largest output of literature on VR-based language learning, followed by the United States; (2) the main contributing institutions include National Taiwan Normal University, National Taiwan University of Science and Technology, and University of London; (3) the literature is mainly distributed in the fields of linguistics, education, and computer science; (4) the main keywords discussed include "immersive learning", "virtual environment", and "interactive experience", and (5) the VR-based language learning is expected to be combined with artificial intelligence (AI) in the future in order to promote English language learning. By systematizing the literature on VR-based language learning, this paper provides a useful overview for scholars or educators who want to further investigate this field.

Keywords: Virtual Reality (VR); Language Learning; Bibliometric Analysis; CiteSpace.

1. Introduction

Virtual Reality (VR) is a computer-generated environment that allows users to interact with the virtual world through various senses such as vision, hearing, and touch. It has advanced quickly since its inception in the 1960s, and today's VR tools are far more advanced and interactive than the early two-dimensional (2D) text-based online virtual environments. In recent years, VR has emerged as a powerful tool in education, particularly in language learning. VR offers users a 3D virtual world that immerses them in an environment without constraints of time and space. This immersive experience is essential for creating authentic and engaging learning environments, as highlighted by Parmaxi and Peixoto in their studies on technology-enhanced language learning. With virtual scenarios, learners can engage in language practice as if they were in real-life situations, having conversations with virtual characters and simulating real-world contexts. Additionally, VR can provide a personalized learning experience by adjusting the learning content according to the learners' needs.

However, VR is not yet mature enough to be used in language learning. To gain a deeper understanding of the development trends and research hotspots in the field of

VR-based language learning, this paper used the CiteSpace to conduct a bibliometric analysis of relevant literature from 2003 to 2023. Bibliometric analysis is a data-based research method which is capable of performing quantitative statistical analysis on a sizable number of papers. Additionally, the visualizing network analysis may be used to pinpoint the primary clusters of the research that are now in existence as well as the major themes found in the publications. Thus, we can better understand the current state of research in VR-based language learning and provide suggestions for future studies and applications.

This study aims to answer the following research questions: 1) What is the overall development of VR-based language learning over the past 20 year? 2) What are the hot topics and publications distribution of VR-based language learning? 3) What are the future trends and directions of VR-based language learning?

2. Methodology

2.1. Research design

In order to explore the dynamics and evolution of the overall development of VR-based language learning, this paper screened and exported the data from Web of Science in the past 20 years, and utilized CiteSpace to conduct bibliometric analysis in four aspects, including temporal distribution of published papers, space distribution of published papers, keyword distribution of published papers, and fields distribution of published papers. Through information integration and data mining, we summarize the characteristics of the development of VR-based language learning research, and gain a deeper understanding of the dynamics and hot topics in this field.

2.2. Data collection

All the data for this study were obtained from Web of Science, because WoS have received enduring acknowledgment as the most credible and respected indexing tool for scientific and technological literature, providing insight into the most critical relevant research. The keywords entered were "virtual reality" and "language learning". A total of 1999 records were retrieved. Utilizing the Web of Science filtering function, setting the time span as 2003 to 2023 and only selecting articles from SCI-Expanded (Science Citation Index Expanded) and SSCI (Social Sciences Citation Index), a total of 498 records were retrieved. The 498 data were exported to the "input" folder as plain text, and the duplicates were screened out by CiteSpace, and the final 430 data in the folder "output" were put into the folder "data", and then the data collection was completed.

Table 1. Summary of Data Source and Parameters

Data source	Web of Science Core Collection
Searching period	Jan. 2003 to Dec. 2023
Searching keywords	"virtual reality" AND "language learning"
Language	English
Sample size	430

2.3. Data analysis

This paper mapped out the collected 430 data in the CiteSpace software. Firstly, we mapped the temporal distribution to explore the overall trend of publications in VR-based language learning over the past 20 years. Secondly, we mapped the space distribution to explore the contribution of different institutions or countries and regions to the research and the collaboration between them. Meanwhile, the fields of main contributing journals of VR-based language learning were analyzed. Finally, the co-occurrence network of all the keywords was mapped, and the cluster view was used to explore the research hot topics in VR-based language learning and the term burst was analyzed to search for the future development trend.

3. Results and Discussion

3.1. Temporal Distribution of Published Papers

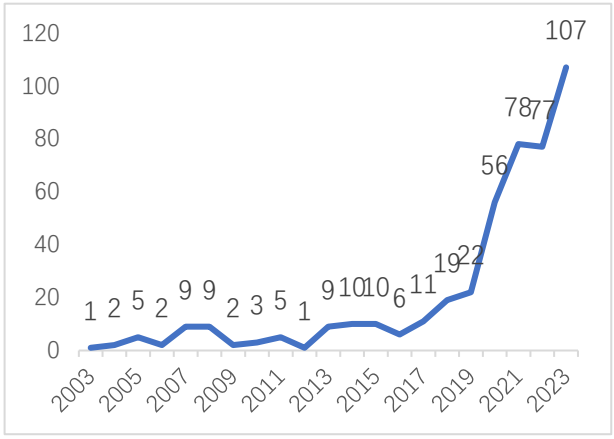

Figure 1. Temporal distribution of the published papers

Figure 1 shows the number of papers published on the development of VR-based language learning during 2003 to 2023. The number of publications from 2003 to 2015 was relatively low and fluctuated little, basically remaining below 10. Starting in 2015, the number of papers published shows an upward trend, especially from 2019 onwards, the growth rate is significantly accelerated. The sharp increase between 2019 and 2022 suggests that certain factors during this period may have driven the increase in research activity. For example, this increase may be related to the COVID-19 pandemic and the global quarantine, there is an urgent demand for VR-assisted language learning. since then, a large number of empirical research on the application of VR technology in language learning have been carried out. More notably, 2023 saw the highest number of publications, exceeding 100. This growth reflects, on one hand, the continuous development and innovation of technology, such as reduced costs and more portable devices, driving academic research into VR applications across various fields. On the other hand, there is the deep integration of VR with artificial intelligence (AI). For example, large language models (LLMs) play a crucial role in providing a more virtual and immersive environment for VR-based language learning. Overall, this figure shows a developmental trend of the application of VR in language learning from a macro perspective.

3.2. Space Distribution of Published Papers

3.2.1. Institutions distribution of published papers

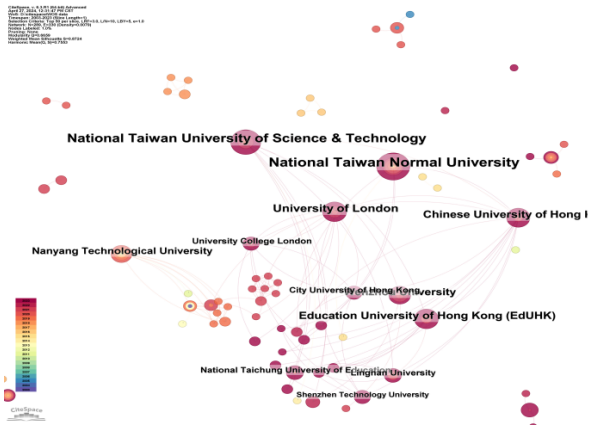

Figure 2. Institution distribution map of published papers

Figure 2 shows the institution distribution of published papers. According to the publication frequency provided, the institution with the highest frequency is National Taiwan Normal University, which published 17 related papers in 2015. National Taiwan University of Science and Technology follows closely, publishing 15 papers in 2014. This indicates that Taiwanese academic institutions are very active in the field of VR-based language learning, but there's less collaboration between the two institutions. University of London also published 10 papers in 2015, indicating that European academia's interest in this field is also growing. Meanwhile, Education University of Hong Kong and Chinese University of Hong Kong published 9 papers in 2021 and 2020, respectively. The figure also shows that Hong Kong institutions have strong connections with other institutions, reflecting Hong Kong's contribution to VR-based language learning research. The University of California System in the United States published 8 papers in 2017, indicating that American educational institutions have an interest in researching VR in this field. However, American universities and research institutions don't collaborate closely with other institutions, relying primarily on internal resources for independent research. Wenzhou University in China also published 8 papers in 2021, showing that academic institutions in mainland China are increasingly participating in VR-based language learning research. Lastly, Nanyang Technological University published 7 papers in 2011. This further demonstrates the growing interest in VR-based language learning research in Asia.

Overall, the publication frequency of these institutions reflects the global increase in research interest and participation in VR-based language learning.

3.2.2. Countries/Regions distribution of published papers

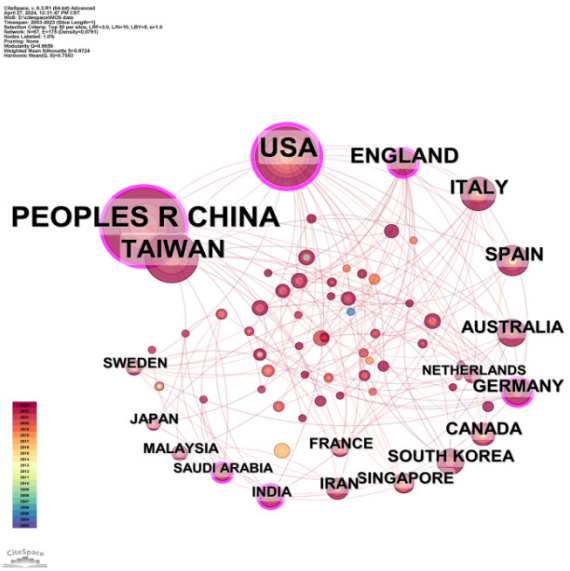

Figure 3. Countries/ Regions distribution map of the published papers

Figure 3 shows the countries or regions distribution of published papers. The main participating countries include China, the United States, the United Kingdom, Singapore, Germany, Italy, and Canada. The larger node for China suggests a relatively high number of published papers in the field of VR-based language learning. The United States has the second-highest number of publications, but its highest centrality (0.46) indicates its significant role in VR-based language learning research. Importantly, figure 3 shows that research in VR-based language learning is exhibiting a trend of global collaboration, especially between the Asia-Pacific and Western regions.

3.3. Research Area Distribution of the Published Papers

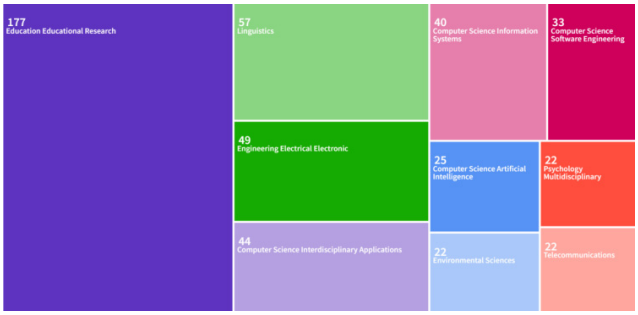

Figure 4. Research area distribution of published papers

Figure 4 lists the main research areas of published papers related to VR-based language learning. It is clear that VR-based language learning research is closely related to the areas such as education, linguistics, computer science, and artificial intelligence. In terms of the number of publications, "Education Educational Research" leads with 177 articles. Others with high publication counts include "Linguistics" (57), "Engineering, Electrical Electronic" (49), Computer Science Interdisciplinary Application (44), Computer Science Information Systems (40), Computer Science Software Engineering (33), Computer Science Artificial Intelligence (25), Environmental Science (22), Psychology Multidisciplinary (22) and Telecommunication (22). The concentration in education and linguistics is expected. However, the prevalence of engineering and computer science shows the technological foundation of VR. It is worth noting that some papers focus on psychological aspects, so we can infer that there is a promising future of VR in treating language-related disorders.

3.4. Keyword Distribution of Published Papers

3.4.1. Co-occurrence network

Keyword analysis is used to identify hot topics in the current research and future directions, as well as to obtain a deeper understanding of one research field. Overall, the high-frequency keywords generally align with those with higher centrality rankings, indicating that the higher the frequency, the more central the term becomes, suggesting that centrality can somewhat capture the hotspots and key turning points in VR-based language learning.

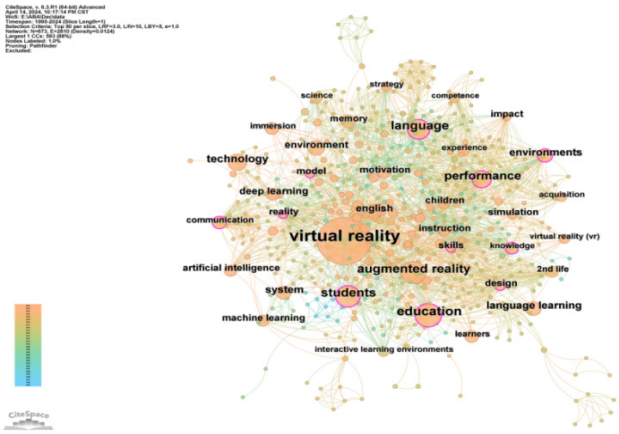

Figure 5. Co-occurrence network of keywords

The most frequent term in figure 5 is "Virtual Reality" (214), and around this core term are "education" (52), "language" (48), "augmented reality" (47), "students" (42), "performance" (39), "technology" (26), "environment" (24), "system" (24), "language learning" (23), "children" (21), and "English" (20). It's worth noting that some less frequent keywords exhibit higher centrality, such as "individual difference" (0.07), "competences" (0.05), and "disorder" (0.04), indicating that the research focus in VR-based language learning is continually expanding.

3.4.2. Cluster view

To further integrate separate keywords" it is useful to define a cluster, signifying a distinctive domain or a concentration of topics. The highest ranked noun phrases were chosen to be the cluster labels. Notably, Q values ranging from 0.4 to 0.8 are reasonable, and an S value larger than 0.6 means the clusters are successful.

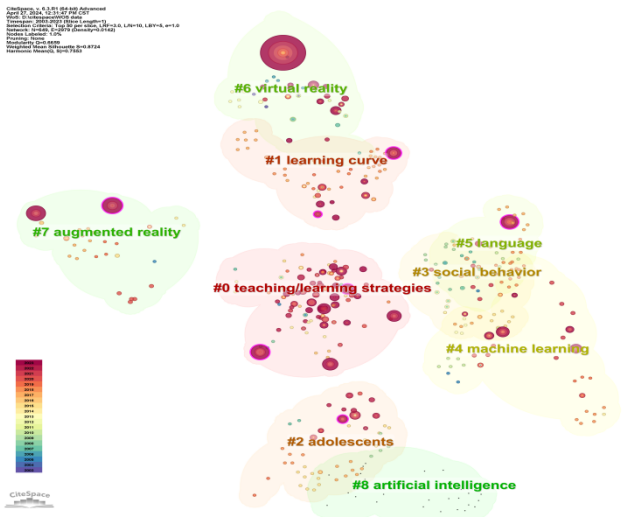

Figure 6. Cluster view of keywords

Considering that research in VR-based language learning is still in its infancy, to further explore its potential, the number of the maximum clusters selected is nine. Based on the related literature, these nine clusters can be grouped into several main themes.

The first theme encompasses cluster 4 (machine learning), cluster 7 (augmented reality) and cluster 8 (artificial intelligence), focusing on the effective ways of applying VR in language learning. Cluster 4 (machine learning) is followed by machine learning, gesture recognition, leap motion, data mining, and three-dimensional displays. Cluster 7 (augmented reality) is followed by immersion and cluster 8 (artificial intelligence) is followed by virtual environments, serious games, empirical evidence, and games-based learning. This suggests that integration between VR and artificial intelligence (AI) is currently an effective approach for incorporating VR into language learning. Previous studies have tried to optimize VR design through artificial intelligence (AI) to enhance interactivity in learning environments or systems. Especially, the emergence of large language models and the application of serious games improve intelligence and interactivity in virtual learning environment.

The second theme includes cluster 0 (teaching or learning strategies), cluster 1 (learning curve), cluster 3 (social behavior), and cluster 5 (language), emphasizing the educational goals of VR-based language learning. Cluster 0 (teaching or learning strategies) is followed by vocabulary learning, writing motivation, motivational support, and social norm. Cluster 1 (learning curve) is followed by attention-deficit hyperactivity disorder, neurocognitive disorders, and intervention. Cluster 3 (social behavior) is followed by cognitive processing, and neuronal networks. Cluster 5 (language) is followed by spatial memory, mnemonic techniques, and individual differences. This indicates that VR has a wide application scope in language learning, from basic memory and language knowledge to language skills, like writing, and further to learning competence and performance. Notably, VR is also gaining attention in the treatment of language-related disorders. For example, Automated Psychological Therapy and VR Exposure Therapy are used for treating Autism.

The third theme is cluster 2 (adolescents), focusing on the users of VR-based language learning. Keywords on cluster 2 are children, youth, adult, and higher education. From the frequency of occurrence, we can infer that the primary groups for VR-based language learning are higher school students, with some literature also mentioning children. Thus, we suggest a trend toward expanding the users for VR-based language learning, but its applicability needs further validation.

3.4.3. Keywords citation bursts

The term burst describes the developmental trend in the value of a variable within a short time span.

Keywords	Year	Strength	Begin	End	2003 - 2023
interactive learning environments	2003	2.5	2003	2013	
learning curve	2016	2.67	2016	2018	
environment	2008	3.01	2020	2023	
instruction	2005	2.9	2020	2021	
english	2013	4.14	2021	2023	
technology	2011	3.12	2021	2023	

Figure 7. Keywords citation bursts

Figure 7 displays the top six keywords with the strongest citation bursts from 2003 to 2023, detailing each keyword's year of origin, burst strength, and burst duration (from start to end). we can divide these keywords into four stages.

At the first stage, "interactive learning environments" had a burst strength of 2.5, with its burst beginning in 2003 and lasting until 2016. This indicates that VR technology initially focused on enhancing the interactivity of learning environments. At the second stage, with a burst strength of 2.67, "learning curve" began its burst in 2016 and ended in 2018, short duration implies that VR technology has yet to be proven in terms of learners' learning curve. At the third stage, "environment" had a high burst strength of 3.01. It began its burst in 2020 and ended in 2023, indicating a notable focus on environment. Similarly, "instruction" had a burst strength of 2.9, with its burst starting in 2020 and ending in 2021, highlighting a relatively recent surge in interest regarding instructional methodologies. At the last stage, with the highest burst strength of 4.14, “English” began its burst in 2021 and lasted until 2023. it mean VR-assistance is gradually emerging in English learning.

Overall, this figure provides insights into the shifts in research interest over the past two decades, highlighting the enduring focus on interactive learning environments and new perspectives on strategy and content.

4. Conclusion

This bibliometric analysis reported that the number of publications on VR-based language learning has been on the rise over the past 20 years, with a continuing trend of growth in the future; the top three high-output research institutions are National Taiwan Normal University, National Taiwan University of Science and Technology, and University of London; the high-yield countries are concentrated in China and the United States, with relatively close collaboration among other countries; and the hot topics discussed include "immersive learning", "virtual environment", and "interactive experience". From the trend of research development, how to effectively combine VR with AI and integrate it into English learning has become a major direction in the future.

Inevitably, this study has its limitations. Bibliometric analysis primarily focuses on the quantitative assessment of results and overlooks the influence of significant factors.

Consequently, future research should incorporate content analysis to provide deeper insights into the latest developments in VR-based language learning. Moreover, this study only considered papers written in English, thereby neglecting research published in other languages. Future analyses should include a diverse range of languages from various academic databases to enrich our understanding of VR-based language learning.

Acknowledgments

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