Review and Prospect of Research on the Application of VR Technology in Education and Teaching Analysis based on citespace knowledge graphs

Ximu Zhang [1*] , Yue Liu [2]
[1,2] Geely University of China, Chengdu, Sichuan,China

Article Information

Received: 21-11-2024
Revised: 28-11-2024
Published: 05-12-2024

Keywords
Citespace;visualization and analysis; virtual reality; education and teaching; applied research ; artificial intelligence

Correspondence Email:
1628959092@qq.com

Abstract
This paper analyzes 863 China Knowledge Network (CNN) source documents using CiteSpaceV6.3.R1 software, and sorts out the current research status and development trend of VR technology in education and teaching by mapping the relevant knowledge map of keywords, issuing authors, and issuing institutions. It is found that the research on VR technology in education and teaching has experienced a slow growth from its start in 1996 to 2015, and then a significant growth after 2017 with interdisciplinary characteristics. In terms of authors and institutions, as the cooperation on this related topic is still small and very scattered, but there are some research teams cooperating with each other, and the research hotspots cover virtual reality, information technology, vr technology, education and teaching, and teaching tools. In the future, research in this field should show the following trends: deepen interdisciplinary integration and expand VR education applications; strengthen empirical research and verify the effectiveness of the technology; pay attention to ethical privacy and build a responsible education ecology.

1. Introduction

With the rapid development of information technology, VR technology gradually penetrates into various fields. As the cornerstone of national development, education is of great significance to the application of VR technology. This paper summarizes the status quo of the application of VR technology in education and teaching, the development trend, and the challenges faced through the quantitative analysis and visual presentation of the literature, which also helps to understand the historical research and application of VR technology in China, and it also helps to provide reference for the reform of China's education and teaching in terms of the application of artificial intelligence, and to promote the integration of educational innovation.

The data of this study were obtained from the database of China Knowledge Network (CNKI). Through the advanced search function in the webpage of China Knowledge Network (CNKI), searching for the subject term "VR technology education and teaching", a large amount of literature was obtained, the types of which included academic journals, dissertations, conferences, newspapers, books, and achievements, etc., and the **ty**pes of journals included Beida Core, CSSCI, AMI, WJCI, CSCD and other source journals, and obtained 863 search results.

1.1 Literature Review

By analyzing the number of publications on "VR technology, education and teaching" at a specific time, it can reflect the research status of the field of "VR technology, education and teaching" at a specific time, which can help to predict the future research trends and research dynamics. Statistics from 1994 to 2024 in the China Knowledge Network of the number of journals on VR technology, education and teaching literature, to get the period of time distribution of articles on artificial intelligence, education and teaching in the domestic distribution of line graphs. As shown in Figure 1, the earliest domestic literature related to VR technology, education and teaching appeared in 1953. According to the line graph of the number of publications, the development stage of "VR technology, education and teaching" can be divided as follows:

- Early years of research (1953-1992) Academic infancy At this stage, domestic research on the combination of virtual reality (VR) technology and education and teaching is still in its infancy. The amount of literature issued is relatively small, and the number of documents issued each year is basically maintained between 1-4, with overall fluctuations being very small and fluctuating changes negligible.1953 marked the beginning of research in the field of VR technology and education and teaching, and since then, the amount of relevant literature issued has increased, but the growth rate has been extremely slow, presenting a line tending to the horizontal line.
- Growth phase (1992-2019) Research in the field of VR technology and education and teaching is beginning to show significant growth. Especially in 2019, the number of publications reached a historical peak, with a total of 122 documents published. This growth trend shows that the application of VR technology in the field of education has received attention and attention from academics, and it also represents that modern scientific and technological achievements have reached a certain level of effectiveness, which allows for the realization of scientific research experiments and results related to "VR technology education and teaching".
- Fluctuating exploration phase (2019-2024) The research results on VR technology and education and teaching show a declining trend, with the number of publications experiencing several ups and downs, but still showing a descending triangle shape. Notably, small peaks in the number of publications occurred in 2021 and 2023, although these peaks did not exceed the number of publications recorded in 2019. This phase of research shows that the application of VR technology in education and teaching is still being explored and attempted, and the overall level of research remains within a relatively stable range.

From 1953 to 2024, research on VR technology in education and teaching has gone through a process of germination, growth, and fluctuating exploration, demonstrating continued academic interest and deepening research efforts in this area.

2. Research Methods

In order to comprehensively parse the relevant information in the retrieved materials, this study first used the visual analysis tools provided by the Knowledge Platform to create a series of statistical charts. Subsequently, the required literature was selected and the literature data were exported in RefWorks format and further analyzed using CiteSpace V6.3.R1 (64-bit Basic Edition), a visual analysis software. In the analysis process, we set the time range as 1996 to 2024. Then the number of analyzed literature is 860 in total, and then the time slice is set to 1 year, k value is 14, and other parameters are defaulted to the preset values of the software, which draws out the relevant knowledge maps such as author collaboration, institutional release, keyword co-occurrence, and so on, so as to show the basic situation of the current research, as well as the focus, hotspot, and future development trend of the research.

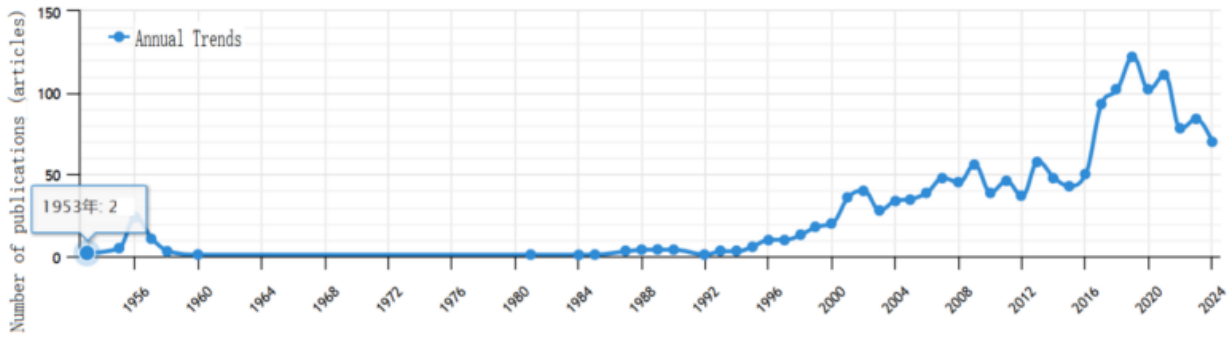

Fig. 1 Changes in the number of articles published in domestic research related to VR technology and education and teaching, 1953-2024

From the perspective of subject areas, the number of articles involving the discipline of "Education Theory and Management" is the largest, with 488 articles, accounting for 20.84%, followed by the discipline of "Vocational Education" with 451 articles, accounting for 19.26%, and the discipline of "Computer Software and Computer Applications" with 431 articles, accounting for 18.40%. 19.26%, again, "Computer Software and Computer Applications" has the third largest number of articles with 431 articles, accounting for 18.40%, while "Primary Education", "Secondary Education", "Higher Education", "Secondary Education" and "Higher Education" have the largest number of articles with 488 articles, accounting for 20.84%, followed by "Vocational Education" with 451 articles, accounting for 20.84%. In addition, "Primary Education", "Secondary Education", "Higher Education" and other subject areas also have 109-332 articles. The relatively high attention of these subject areas reflects the fact that the research on VR technology and education and teaching is interdisciplinary.

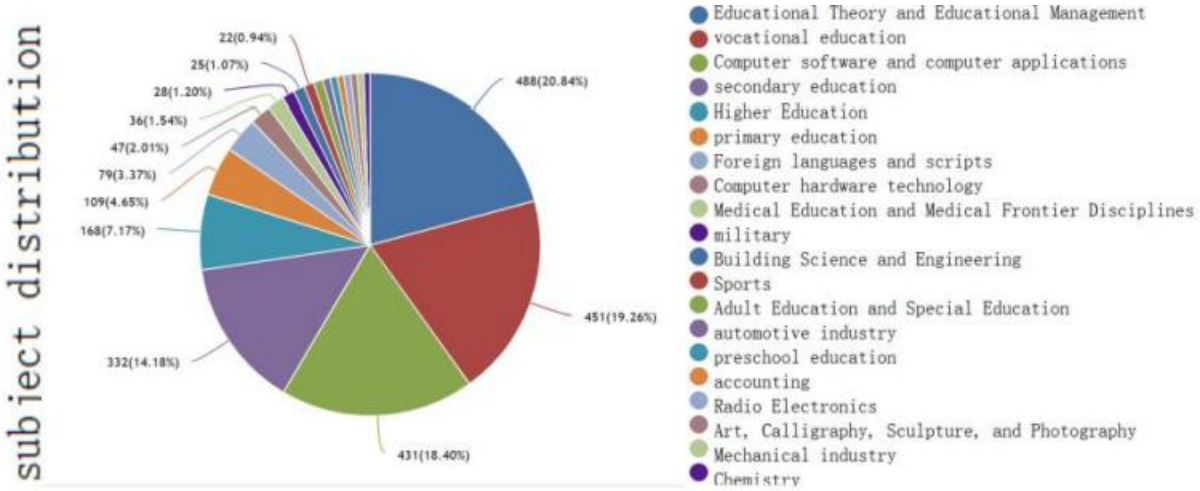

Fig. 2 Discipline distribution of research papers issued on VR technology and education and teaching related research in China, 1953-2024

By looking at Figure 3 (author cooperation network mapping), we can find that the mapping has a total of 295 nodes, the nodes correspond to the authors, the larger the node, the more articles are published and the more influential they are. The graph has 68 connecting lines, the connecting lines represent the cooperation links between authors, the network density is 0.0016, a low value, indicating that the graph as a whole teaches dispersion, the cooperation between authors is not close enough, but there are nodes with small clusters, in which the research cooperation composed of Han Zhaofu, Yang Zhongshu, Wang Chaoyong, Wang Hongtan, etc. has already had a certain scale. The bar chart in Figure 4 helps to understand the contribution of various organizations and individuals in specific research areas. From Figure 4, Li Li has published three relevant literatures, which is by far the largest number of authors who have published relevant research literature in

China. Although there are several authors who have published related literature, the number is not ideal, indicating that there are no researchers in the related field who have specialized in this content. In the future, in the process of promoting the development of the application of VR technology in education and teaching, strengthening communication and cooperation among scholars and constructing a closer academic research network are still important ways to improve the quality and efficiency of research.

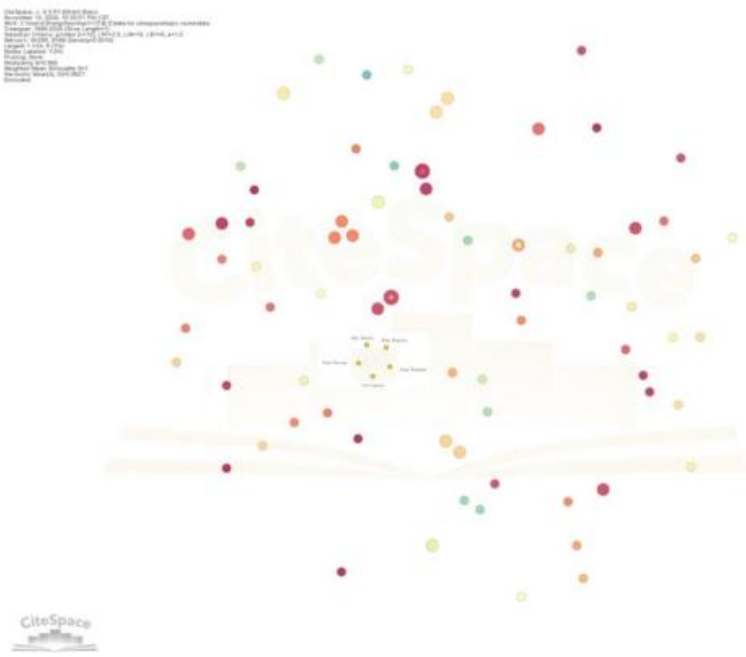

Fig. 3 Mapping of authors' collaborative network of research related to VR technology and education and teaching in China, 1994-2024

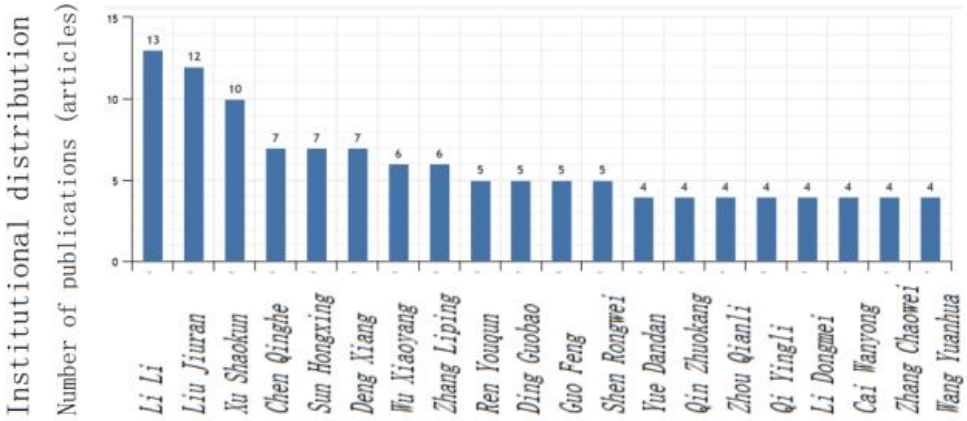

Fig. 4 Distribution of authors of domestic studies related to VR technology and education and teaching, 1953- 2024

The research activity of their institutions in the relevant fields was derived by analyzing the histogram of the number of literature publications of the research institutions (Figure 5). East China Normal University (ECNU) topped the list with 13 publications, followed by Jiangxi University of Science and Technology Normal University (JUSTNU) with 12 publications, in addition to Naval Aviation University (NAU) with a relatively high number of 10 publications. This bar chart reflects the influence and contribution of each institution in a particular research area. At the same time, we see that some institutions have relatively fewer publications.

This may be related to the institution's research focus, resource allocation, or research team size. Important information reflecting the performance of different institutions in specific research areas helps us to understand the research strength and development trend of each institution.

By looking at Figure 6 (Institutional Collaboration Network Graph), we can find that there are 274 nodes in this graph, and the nodes correspond to institutions, the larger the nodes, the more articles are issued and the more influential they are. The graph has 25 lines, the lines represent the existence of cooperation between institutions in this field, the network density of this institutional cooperation network graph is 0.0007, a low value, indicating that the graph as a whole is more dispersed, the cooperation between institutions is not close enough, but there are nodes with small clusters. In the future, in the process of promoting the development of the application of VR technology in education and teaching, it is still an important way to enhance the quality and efficiency of research by strengthening the communication and cooperation between institutions and building a closer academic research network.

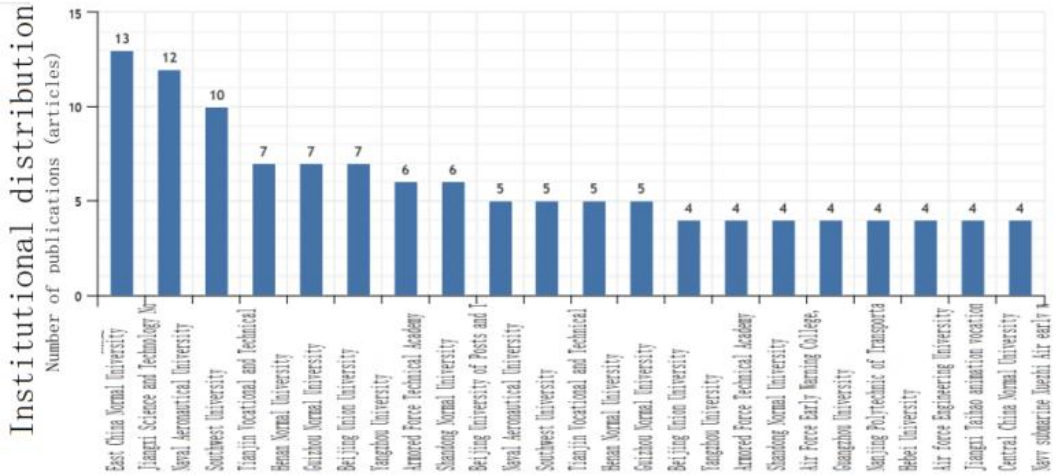

Fig. 5 Distribution of domestic research institutions related to VR technology and education and teaching, 1953-2024

Fig. 6 Network mapping of cooperation between domestic VR technology and educational and pedagogical research institutes, 1996-2024

In this study, with the help of CiteSpace V6.3.R1 (64-bit Basic Edition) visual analysis software, 860 papers from 1996-2024 were analyzed, and keyword co-occurrence mapping, clustering mapping, and timeline mapping were drawn to present current research hotspots in the application of VR technology in education and teaching.

• Keyword co-occurrence analysis

As can be seen through Figure 7 (Keyword co-occurrence mapping), the mapping has 294 nodes, 528 connecting lines, with a network density of 0.0123, and a strong connection between the sample documents. Among the keywords, "virtual reality" "VR technology" "vocational education" "information technology" "education and teaching", "teaching means" and other nodes are large in shape, indicating that they appear more frequently in the literature, and are the focus and hotspot of the current research related to "VR technology education and teaching". The shape of the nodes is large, indicating that they appear more frequently in the literature, which is the focus and hotspot of the current research on "VR technology education and teaching".

3. Results and Discussion

The mean satisfaction ratings for the system were consistently above 3.5 out of 4, indicating strong support for its ability to reduce manual processes. These results suggest that the system effectively meets core functional requirements, improving accessibility for residents and administrative efficiency for barangay officials. In terms of performance and usability, the system was highly rated for its efficiency in managing large volumes of data and handling multiple user requests simultaneously. Respondents praised the system's speed, reliability, and its capacity to provide essential reports. Usability scores were also favorable, with high ratings for the clarity of the interface, ease of access, and alignment with user needs. The system's design was intuitive, ensuring smooth interactions for both residents requesting documents and officials handling administrative tasks. Additionally, the system's reliability was demonstrated through its high uptime and quick recovery from minor outages, confirming its suitability for daily operations. Testing and validation processes showed that the OCR and blockchain components were effective. Google Cloud Vision OCR was preferred for its higher accuracy in text recognition, particularly in low-light conditions, surpassing Tesseract OCR. Blockchain testing verified the system's ability to maintain data integrity through secure, tamper-proof hash generation and validation. The security features, including user-specific access controls, were well received, with respondents expressing confidence in the system's ability to protect sensitive data.

Table 1. Overall Mean Average Across all Criterias

Criteria	Mean	Verbal interpretation
Functional suitability	3.62	Satisfied
Performance efficiency	3.58	Satisfied
Usability	3.61	Satisfied
Reliability	3.57	Satisfied
security	3.6	Satisfied

4. Conclusions

The research concluded that the developers successfully designed and implemented a user-friendly web-based portal system for barangay document management. The system features a comprehensive dashboard for tracking and reporting census records, blotter cases, and barangay clearance requests through categorized totals, lists, and charts. A blockchain-based framework ensures secure data encryption for processing barangay clearance and blotter cases, while Optical Character Recognition (OCR) using Google Vision API streamlines data extraction with a 96%-98% accuracy rate, optimizing manual processes and reducing errors. Feedback from 396 respondents, including barangay residents and officials, highlighted the system’s functional suitability, performance, usability, reliability, and security, with most users rating it as “Very Satisfied” according to ISO/IEC 25010 standards. However, broader representation from Barangay 494 and Barangay 99 was recommended to enhance the reliability of survey insights.

To further improve the system, recommendations include enhancing user training for barangay officials and residents, integrating Robotic Process Automation (RPA) for repetitive tasks, and bolstering blockchain security with multi-signature authentication while addressing scalability. Additionally, incorporating a feedback mechanism with chatbot support would help identify issues and drive continuous improvement based on user experience. These enhancements aim to increase system efficiency, security, and user satisfaction.

5. References

Bautista, M. T. T., Bolonos, A. K. B., Camba, U. J., De Guzman, L. M., Goh, M. L. I., Raguro, M. C. F., & Tolentino, L. S. (2023b). BALANGAY: A Web-Based Document Request and Incident Reporting System with Decision Support for Barangay Program Development.

Carpio, C. O. (2020). Barangay management system. *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, *3*(2), 26-32.

Clavin, J., Duan, S., Zhang, H., Janeja, V. P., Joshi, K. P., Yesha, Y., ... & Li, J. D. (2020). Blockchains for government: use cases and challenges. Digital Government: Research and Practice, 1(3), 1-21.

Gangadharaiah, S., & Shrinivasacharya, P. (2024c). Secure and efficient public auditing system of user data using hybrid AES-ECC crypto system with Merkle hash tree in blockchain. *Multimedia Tools and Applications*. https://doi.org/10.1007/s11042-024-18363-0

Jayaprakash, J. S., Balasubramanian, K., Sulaiman, R., Hasan, M. K., Parameshachari, B. D., & Iwendi, C. (2022). Cloud data encryption and authentication based on enhanced Merkle hash tree method. Computers, Materials & Continua, 72(1).

Lackner, A., Mirhosseini, S. A. M., & Craß, S. (2022, August). Securing File System Integrity and Version History Via Directory Merkle Trees and Blockchains. In *International Conference on Database and Expert Systems Applications* (pp. 294-304). Cham: Springer International Publishing.

Li, W., Feng, Y., Liu, N., Li, Y., Fu, X., & Yu, Y. (2024). A secure and efficient log storage and query framework based on blockchain. *Computer Networks*, *252*, 110683.

M. Balilia, C., A. Acoba, J., I. Pagulayan, L., C. Mebaña, J., & Dela Cruz, L. (2022). Windows-Based Information Management System with Project Monitoring for Barangay (Vol. 2). (EnRB) Engineering Research Bulletin. http://119.92.172.179/journals/beai/papers/vol2/vol%202%20series%202022-69-78.pd

Sathya, A. R., & Banik, B. G. (2020). A comprehensive study of blockchain services: future of cryptography. *International Journal of Advanced Computer Science and Applications*, *11*(10).

Sharma, D. M., Shandilya, S. K., & Satapathy, S. C. (2023). Maximizing blockchain security: Merkle tree hash values generated through advanced vectorized elliptic curve cryptography mechanisms. Concurrency and Computation Practice and Experience, 35(23). https://doi.org/10.1002/cpe.7829