Virtual Reality in the Field of Education Research Hotspot Analysis Based on CiteSpace

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Abstract. In recent years, virtual reality technology has been applied more and more widely in the field of education, and a lot of research results have emerged. In order to understand the research status of virtual reality in education field, explore its evolution path and hot trends. In this paper, CiteSpace information visualization software is used to analyze the knowledge graph of literature samples and strengthen the research on virtual reality technology. The research involves the use of virtual reality (VR) in the teaching of students, and reveals the research on the integration of VR education technology and curriculum, the research on the teaching model and method of VR education, and the research on the learning environment of VR education. This paper will help the field clearly consider the definition of VR technologies for use in education, outline existing VR research for educational Settings, and identify future research needs and directions.

Keywords: virtual reality · education · CiteSpace

1 Introduction

In recent years, virtual reality has attracted the attention of many scholars because of the continuous reduction of equipment cost and increasingly perfect technical functions. VR technology simulates visual, auditory and tactile effects in the real world by virtual environment, and realizes natural interaction by means of computer, sensor and other human-computer interaction means [1]. Its "3I" features are Immersion, Interaction and Imagination [2]. In recent years, virtual reality technology has been gradually applied to the field of education, and its excellent teaching effect makes people find the great potential of using VR technology to promote teaching innovation.

Focusing on VR technology and education, this paper attempts to sort out the application research of VR education in the past five years, explore the characteristics of VR educational Technology and curriculum integration research; VR education teaching mode and method research; Study on the learning environment of VR education, and try to summarize the existing experience, and to promote the application of VR technology in the field of education.

2 Definition of Virtual Reality

VR refers to the complete immersion of a user 'in a synthetic world without seeing the real world'. Understanding VR requires insight into the differences between fully immersive, immersive and non-immersive VR as well as consideration of virtual environments and 360-degree pictures or videos (real-world pictures or videos taken by using technology such as a camera or multiple cameras encompassing panoramic views or 360-degree images).

3 Previous Literature Reviews

Six previous literature reviews have examined the influence of virtual reality technology on learning effect [3, 4], the impact of virtual reality technology on learning performance [5], effects of virtual reality on students' academic achievements [6], the application of VR technology in K-12 education [7] and problems and inspirations in the study of VR in foreign countries [8]. These reviews are discussed in turn below.

The first literature review used meta-analysis method to do a quantitative analysis of 38 relevant empirical research literatures based on the elements of instructional system design. The results show that VR has a moderate positive impact on the overall learning effect.

The second literature review used a meta-analysis method to quantitatively analyze experimental and quasi-experimental studies on VR-supported collaborative learning from 2007 to 2019. The results showed that VR was more effective than the traditional non-VR method in collaborative learning, and had moderate positive effects on learners' cognition, skills and emotions.

The third literature review set out to make a meta-analysis of 59 studies published in international English-medium journals. Results from the analysis show that virtual reality technology can improve learning performance to a considerable extent.

The fourth literature review used a meta-analysis approach to quantify the 40 experimental studies on virtual reality teaching affects students' academic performance in foreign countries in the past decade. The study found that: VR teaching has a positive impact on students' academic performance, but not applicable to all disciplines or courses, cannot be blindly implemented.

The fifth literature review conducted a systematic literature review to summarize the research findings and development trends of VR technology in K -12 education in the past 20 years (2000–2019). The study results reveal that most VR interventions in K-12 settings last for relatively short period of time and are implemented with semi-immersive VR learning environment.

Based on the analysis of the core topics of foreign VR education research, the sixth literature review finds that the key problems it faces are: lack of research context, weak academic research and unbalanced research orientation, and propose three solutions to VR education research context.

Table 1. Research hotspot of the literature approached systematically

Search	• What databases, journals or locations did the researcher use in their search • What words, terms or other parameters did the researcher search using • Did the researcher do further searching beyond their primary search • Define any additional methods used to search for literature
Selection	• What was the process used to select literature for inclusion or exclusion in the study • Reading of Abstract (Include/ Don't Include/ Read Full Paper to decide) • Reading of Full Paper - Further inclusion or exclusion • What criteria did the literature need to meet in order to be selected
Procedure/Coding	• What information did the researcher look for in each piece of literature • How did the researcher manage this information • Prepare data for analysis
Analysis	• What did the researcher do with the prepared data • What groupings or sortings were made in the analysis of the data • How did the researcher manipulate the coded literature • Does the information allow for quantitative measure (meta-analysis) • How did the researcher synthesize the data
Findings	• What did the researcher find through the analysis of the data • The researcher addresses research questions posed in their objective • The researcher highlights findings, interpretations, etc. • The researcher highlights summary of literature findings and implications

4   Method

This paper employed the use of a narrative review that was carried out systematically. A narrative review allows the researcher to examine literature in such a way as to provide clarification, interpretation and critique [9]. In order to reduce bias, through the relevant literature data analysis and map interpretation, a systematic approach was taken to guide the researcher in the selection and analysis of literature [10].

The steps taken in this paper of the literature are outlined in "Table 1" [11].

5   Data Collection and Analysis Procedure

This paper takes "VR" "Education" "Teach" as the key words, and retrieves 114 high-quality Chinese papers from CNKI database in recent 5 years as research materials.

Three core research themes are extracted: VR educational Technology and curriculum integration research; VR education teaching mode and method research; Study on the learning environment of VR education.
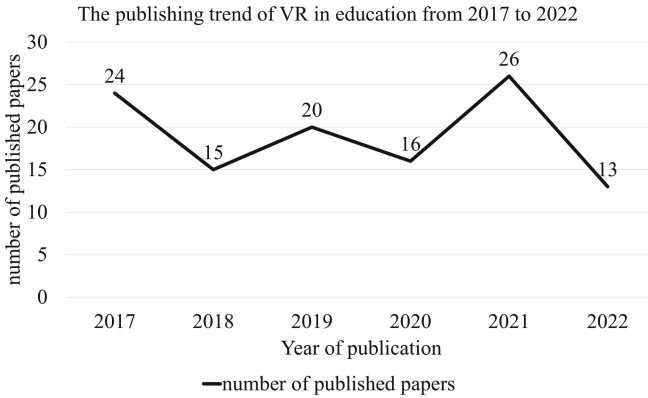
The publishing trend of VR in education from 2017 to 2022

Fig. 1. The publishing trend of VR in education from 2017 to 2022

5.1 Analysis of the Time Distribution of the Number of Published Documents

The research uses Excel to sort out the retrieved journal data and literature, and calculates the number of publications from 2017 to 2022, as shown in Fig. 1. As can be seen from the figure, the publication trend in the application research field of virtual reality technology education can be clearly found: the number of publications shows a steady and fluctuating trend in the past five years. It fluctuated steadily from 2017 to 2020 and reached a peak in 2021, during which 26 papers were published, which was a turning point in research popularity. After that, the number of publications decreased from 2021 to 2022, indicating that research on the educational application of virtual reality technology has declined.
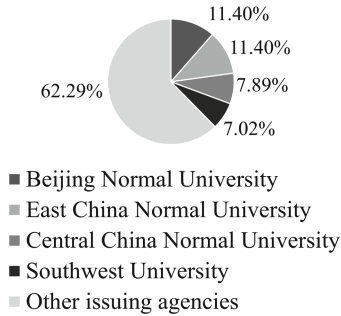
5.2 Organization Distribution and Source Distribution

According to the distribution of publishing institutions in Fig. 2, the number of publishing institutions in Beijing Normal University (13 articles) and East China Normal University (13 articles) was more, followed by Central China Normal University (9 articles) and Southwest University (13 articles). According to the distribution of article sources in Fig. 3, it can be found that the most articles on virtual reality in the field of education are published in Research on Visual Education (22 articles, 19.3%), China's Visual Education (21 articles, 18.42%) and Distance Education Journal (21 articles, 18.42%). These journals pay more attention to the application of virtual reality technology in the field of education. This was followed by Research on Modern Distance Education (11 articles, 9.65%).
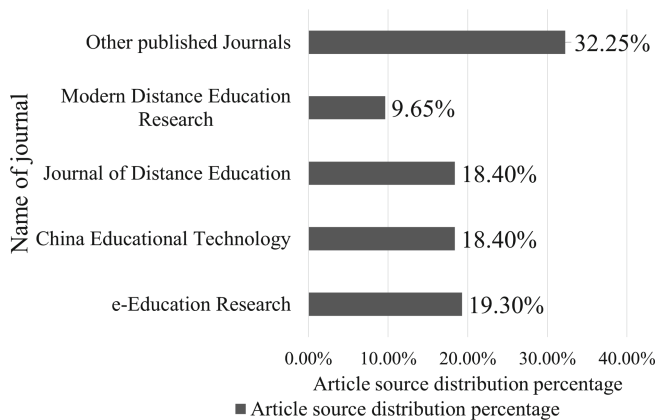
5.3 Keywords Co-occurrence Atlas Analysis

In order to further study the hot issues in education application of virtual reality technology in recent years, this paper imported the literature samples obtained into CiteSpace software for knowledge graph analysis, and obtained the following keyword co-occurrence graph, as shown in Table 2 and Fig. 4.

Mechanism distribution statistics

- Beijing Normal University
- East China Normal University
- Central China Normal University
- Southwest University
- Other issuing agencies

Fig. 2. Mechanism distribution statistics

Article source distribution

Fig. 3. Article source distribution

As can be seen from the figure, scholars have mainly conducted researches on topics such as "virtual reality", "augmented reality" and "artificial intelligence". The keyword with the highest frequency is "virtual reality", which is an important retrieval term for data sources, which also indicates the correlation reliability of the mapping. The second is "augmented reality". Augmented reality is an extension of virtual reality technology. It can be used to simulate objects, allowing learners to see the virtual generated model objects in the real environment background, and the model can be quickly generated, manipulated and rotated. Because of these characteristics, augmented reality has great potential and application space in the field of education. In addition, "embodied cognition", "human-computer interaction" and "mixed reality" were also frequently embodied, indicating that the research directions represented by these keywords were also paid attention by scholars and reflected research hotspots.

Table 2. Keywords co-occurrence frequency of related articles (Top 10)

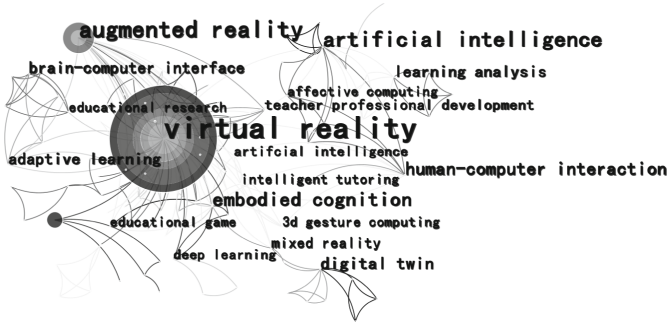| Keywords	Count	Centrality	Year
virtual reality	44	0.75	2017
augmented reality	14	0.04	2017
artificial intelligence	8	0.23	2017
embodied cognition	6	0.01	2017
human-computer interaction	4	0.04	2017
mixed reality	4	0.12	2017
digital twin	3	0.09	2019
virtual experiment	3	0.06	2021
adaptive learning	2	0.04	2018
learning analysis	2	0.05	2017

Fig. 4. Visualized maps of related literatures are found together

6   The Research Hotspot of Virtual Reality in the Field of Education

This paper attempts to sort out the application research of VR education in the past five years, explore the characteristics of VR educational Technology and curriculum integration research; VR education teaching mode and method research; Study on the learning environment of VR education.

6.1   VR Educational Technology and Curriculum Integration Research

At present, this field has received a large discussion. The cases of technology and curriculum integration research almost cover most scientific disciplines, especially basic education, medicine and other disciplines. The research in this field mainly presents several characteristics: first, the research method adopts quantitative analysis; Second, the research idea is based on "technology presentation course content", technical support with VR mature equipment; Thirdly, the research focus is inclined to the practical and operational curriculum content.

A quasi-experimental study is conducted to investigate the impact of VR on middle school students' science learning by integrating it into science argumentative teaching and applying it to the unit "Earth and the Universe"[12]. Yang Wei et al. based on the perspective of virtual reality technology, the article demonstrated the necessity and feasibility of the scene simulation in geography teaching [13]. LI Xiaodong et al. established the VR-supported seamless flipped classroom model [14]. Ye Xindong et al. constructed an ecological model of language learning based on virtual reality technology [15]. Gao Yidong et al. studied the Development of Red VR Memorial in Practical Teaching of Ideological and Political Courses, the paper analyzes its content selection, goal setting and development process [16]. Yang Xue et al. systematically designs the exploratory traffic safety education mode supported by virtual reality technology [17].

6.2   VR Education Teaching Mode and Method Research

The research in this field is mainly to explore new teaching modes and methods under the new technology environment by using VR technology characteristics and educational principles.

Virtual Reality and EEG Linkage System providing education researchers with a manipulative and immersive learning environment, a real-time accurately interactive learning mode, and a multi-dimensional social and cultural context [18]. Hu Hanlin et al. explores the value of virtual reality technology in the process of subject teaching and proposes the practical path of virtual reality-assisted subject teaching [19]. Tu Mingjiang et al. Studied the VR-based Distributed Teaching [19]. He Juhou, Li Hongxiu et al. studied the deeper learning field model based on Virtual Reality [20, 21]. Hu Yiling et al. studied the VR technology enabling experimental teaching from the perspective of embodied cognition [22]. Xiang Wei et al. studied feedback on learning performance in Virtual Reality environment [23]. Hua Zixun et al. studied Virtual Reality technology teaching effectiveness model [24].

6.3   Study on the Learning Environment of VR Education

The most obvious change of VR technology to education is the addition of virtual reality learning environment. This part of the research focuses on exploring the impact of changes in VR education learning environment on teaching participants, teaching process and teaching methods.

Wang Cuiru et al. uses experimental methods and uses research tools to collect multi-modal data in the learning process of learners, and analyzes and compares the impact of desktop VR learning environment (DVR-LE) and the online learning environment (O-LE) on learning engagement and academic performance [25]. Sun Zhiwei puts forward a learning space continuum with virtual -actual combination, and holds that the key path of virtual reality technology to expand learning space is the superposition of technology and real space, and the rich learning environment and information presentation forms as well [26]. It can enhance interest and motivation of learning, reinforcement learning experience, and promote knowledge and situated learning [27]. Yang yuhui et al. aimed at the distance teaching space structure three involved scenarios, software and hardware components were analyzed emphatically [28]. He Juhou et al.'s empirical research shows

that when VR -based educational games are applied in teaching activities, learners' learning motivation is affected by multiple factors such as evaluation and feedback, technical availability, interaction, immersion and imagination [29].

7 Conclusion

Through the data analysis and graph interpretation of the literature related to the application of virtual reality technology in the field of education in the past five years, it can be seen that relevant scholars are paying increasing attention to this research topic. The new generation of technologies such as virtual reality, augmented reality and artificial intelligence have had a profound impact on the educational concept, teaching model and learning style, providing a new opportunity for education reform and innovation. The research results show that with the improvement of technical equipment, the application of VR technology in the field of education has an obvious trend of growth, and has a generally positive impact on the teaching effect. Based on the findings of this research, the following two suggestions are proposed to provide reference for the application of VR technology in the field of education.

First, we should strengthen disciplinary research. Adopt the VR education development model with government guidance and enterprise participation, formulate detailed VR education evaluation standards, and guide the benign development of VR industry and education. First of all, according to the discipline of the core concepts, scientific and engineering practice and the connotation of the interdisciplinary three key dimensions, covering from preschool education to the compulsory education, higher education to a new generation of science education standards, from the perspective of macro policy, make full use of policies and legal means, to VR education industry support, at the same time also can use between colleges and other institutions of research technology advantage, Combined with market economic benefits, accelerate the development of VR education industry.

Second, teaching with a variety of guidance. VR environment is quite different from classroom environment, which requires different teaching guidance. Besides, vertigo, fall and other safety risks brought by VR equipment cannot be ignored. However, most of the literature lacks equipment use training and environment adaptation training before VR teaching, which easily leads to physical discomfort of students in the experience process. The lack of effective guidance in VR experience causes students to explore aimlessly in VR learning process; VR experience fails to guide students to summarize and reflect, which affects self-construction and transfer of knowledge. Therefore, necessary learning guidance and evaluation should be provided during VR learning to improve the learning effect. The guidance and evaluation methods can be comprehensive and diversified, and can be carried out flexibly in virtual environment and real environment.

8 Future Research

Studies to date have largely focused on presenting existing information to students through VR technologies. In this respect, these technologies are considered largely as an 'alternative' approach to delivering or presenting information that is currently taught

through other means. It is important to consider not only students' ability to consume instruction and information through technology but further, the need for students to create and produce using these emerging technologies.

One area in which there is a dearth of research is in relation to immersive head-mounted-display VR and immersive VR as accessed through a smartphone with a low-cost budget viewer. In future research, we can investigate the use of these technologies in learning environments. Studies in this area should consider both the subject content, which content would be most fitting, as well as the experiences of students exploring existing 360-degree video or pictures in comparison to a control group exploring the information through traditional video.

To sum up, the application of virtual reality technology in the field of education is bound to be more and more extensive in the future, and the prospect will be more and more broad. As an emerging technological means, virtual reality technology changes the traditional teaching mode, provides new teaching means, creates a more advanced intelligent learning environment for learners, transforms the new learning mode and improves the learning effect.

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