



# Research on the Application System of VR Technology-Enabled Digital Education Transformation

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**Abstract.** With the development of digital technology and innovative application in the field of education, the education informatization has entered a new stage of education digitalization, and digital education transformation has become the main content of promoting education informatization. As a new digital technology, virtual reality technology can promote the reform of existing education methods, promote intelligent learning, reshape the teaching and research process, promote home-school collaboration, and achieve educational equity in digital education transformation. The research on the application system of virtual reality technology to assist digital education transformation is an important link to achieving this goal. This paper puts forward the “FPTE” model, which effectively integrates virtual reality technology with the four subsystems of “road, vehicle, cargo, and driver” of education digitalization, and constructs the application cycle system of virtual reality technology-enabled digital education transformation. Through the organic combination of VR facilities, VR platform, VR technology, VR ecology and four subsystems, the circular application system provides a new idea for integrating virtual reality technology into digital education practice. At the same time, this paper also discusses the technical dilemmas, integration dilemmas, and transformation dilemmas of virtual reality technology in the application of digital education.

**Keywords:** VR Technology · Digital Education Transformation · Application System · Virtual Learning Environments

## 1 Introduction

In the 21st century, digital technologies represented by big data, the Internet of Things, cloud computing, and artificial intelligence have been widely used in social production, promoting the digital and intelligent transformation of production methods, and promoting the deep transformation of politics, economy, science and technology, culture, and other fields. Digital Education Transformation has become the international community’s consensus, and educational informatization has entered a new stage characterized by digital education. Digital education refers to the widespread use of digital technology in education, the establishment of digital awareness and thinking the cultivation of

digital capabilities and methods, the construction of a “smart education” development ecology, and the formation of a digital governance system and mechanism [1]. One of the bases for realizing Digital Education Transformation is to rely on the new generation of digital technology. In recent years, VR Technology, as a new digital technology, provides a new platform and means for the digitalization of education [2], which has aroused widespread concern in the academic community.

VR Technology is to take computer technology as the core and combines relevant science and technology to generate a digital environment that is highly similar to a certain range of real/imaginary environments in terms of vision, listening, touch, etc. Users can interact with objects in the digital environment with the help of necessary equipment, which can produce the feeling and experience of personally visiting the corresponding real environment [3]. The subversion of virtual reality technology is reflected in breaking through two-dimensional display and realizing three-dimensional display; Breaking through the traditional input mode to realize the overall interaction between humans and landscape; Breaking through the fixed screen to achieve eyeglass viewing; Breaking through the limitation of time and space to realize the immersive simulation environment experience. VR Technology creates a lifelike “activity environment”, in which users can feel the information of vision, hearing, touch, smell, and other aspects, providing users with an immersive experience. In recent years, there has been a lot of research on the combination of virtual reality technology and education. Through the keywords of “Virtual Reality and education”, 3493 relevant papers have been screened in the EI search, with the period from 2000 to 2022, as shown in Fig. 1.

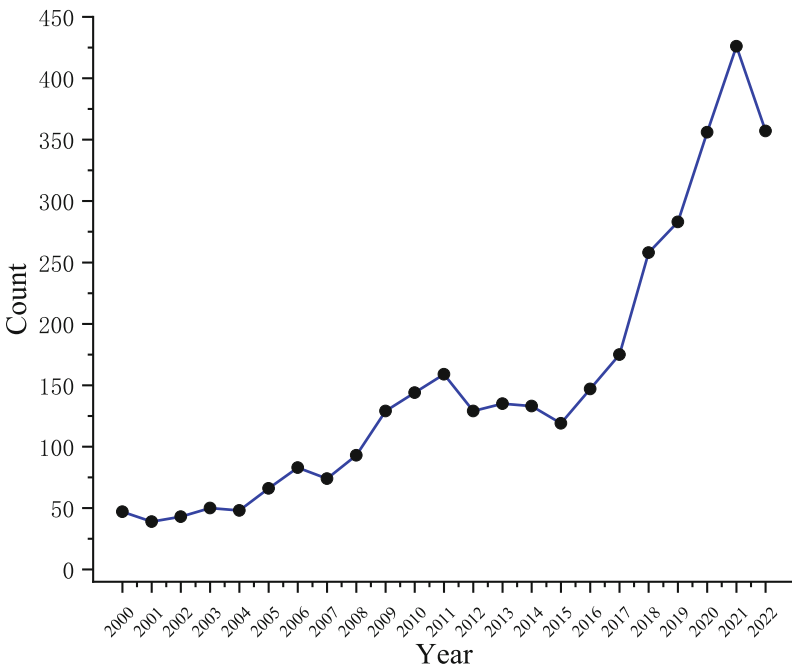


Fig. 1. Annual trend of the number of papers

From the year of distribution of the number of documents, from 2000 to 2006, the number of documents fluctuated, and the overall number of documents issued was small; From 2006 to 2011, the number of documents showed an upward trend and reached a small peak; The number of documents from 2011 to 2015 fluctuated; From 2015 to 2022, the number of documents increased sharply, and the academic research on virtual reality technology and education reached a new peak. In the application of virtual reality technology to education research, the two countries with the largest number of publications are the United States (660) and China (452), followed by the United Kingdom (196), Spain (170), Germany (169), Greece (130) and Australia (122). In general, more and more countries and regions around the world have begun to participate in the research of virtual reality technology to help education. From the content of the retrieved documents, a large number of documents focus on the application of computer technology and education. Among them, the most frequent keywords of research related to virtual reality technology and education are Interactive Learning Environments, Virtual-Reality, Augmented Reality, e-Learning, Students, Design, Science, Visualization, Immersion, and Information Technology.

It can be seen from literature review, the academic research on virtual reality technology supporting digital education transformation mainly focuses on the impact of technology, lacking the corresponding application system research. We put forward the “FPTE” model to build the application cycle system of virtual reality technology-enabled digital education transformation, and expand and deepen the dimensions and content of the digital transformation of education.

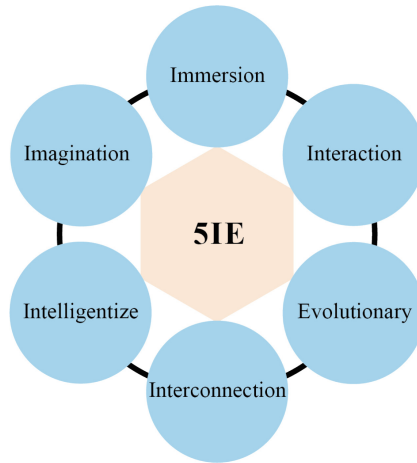
## **2 Characteristics of Virtual Reality Technology and Its Application in the Transformation of Digital Education**

VR Technology 1.0 is characterized by immersion, interaction, and imagination. With the rapid development of Internet technology and digital technology, VR Technology has moved from a stage of 1.0 with only 3I characteristics to a stage of 2.0 with 5IE characteristics. VR Technology can present digital education resources to teachers and students in a lifelike and perceptible virtual learning environment. Its massive knowledge and fast problem-solving speed can become teachers’ partners, realize student-centered situational and personalized learning, and enrich and enhance the connotation and effectiveness of digital education.

### **2.1 5IE Features of VR Technology**

Simulating the real world is a dream that human beings have had since ancient times. With the development of high-performance computing, graphics and image processing, human-computer interaction, and other technologies, VR technology is the latest level of human simulation of the real world. The 5IE features of VR 2.0 include Immersion, Interaction, Imagination, Intelligentize, Interconnection, and Evolutionary [4], as shown in Fig. 2.

Immersion refers to the user’s immersive feeling in the virtual world. The individual’s sense of immersion shows that he has forgotten the existence of time and the real world,



**Fig. 2.** 5IE features of VR 2.0

and has a feeling of “being in” the task environment due to his wholehearted devotion, which is similar to the psychological experience of flow. Immersion is the key factor for virtual reality technology to enable digital education.

Interaction refers to that users can use various input/output devices to operate objects in the virtual world as if they were in the real world. Interactivity is an objective attribute to measure VR technology and its controllability. In the educational scene, students can flexibly use this feature to learn and improve the learning effect through the interaction between the sensor device and the virtual environment.

Imagination refers to that users conceiving and designing the virtual world according to their imagination and creativity in the virtual world. Imagination is one of the basic characteristics of VR technology, and also the main way to present digital teaching resources according to actual needs. In the educational scene, teachers can reasonably use VR Technology to create the real scene and imagination spaces that meet the classroom needs, so that students can obtain a better classroom experience.

Intelligentize is formed with the mutual penetration and fusion of VR and AI. The low-level mental state and simple linear behavior of autonomous individuals and group objects in VR environment gradually develop into high-level mental states, such as belief, desire, and intention, and complex behavior. Intelligentization in the educational scene is represented as intelligent interaction in the educational scene. Virtual training scenes can effectively promote inquiry and adaptive learning.

Interconnection refers to the multimodal data interchange between virtual objects/environments and corresponding real objects/environments, which can accurately acquire feedback on the VR environment and users’ real state in real-time. In the educational scene, users can evaluate the credibility and feasibility of VR teaching resources and learning environments.

Evolutionary refers to the real-time adjustment of the virtual object model with the change of physical object shape and state, and the time-varying model can evolve by itself according to the corresponding laws. In the educational scene, the whole classroom

is “live” rather than predetermined “rules”. Students can fully experience personalized learning and form a sense of independent learning.

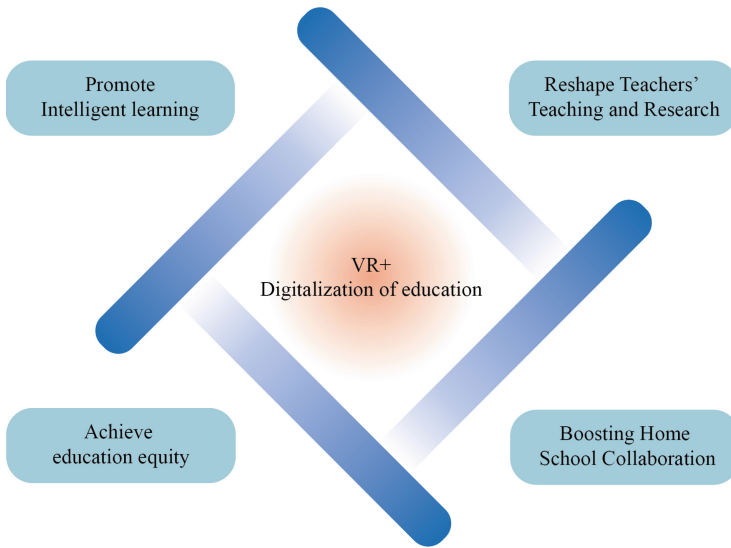
## 2.2 Advantages of VR Technology in Digital Education Transformation

At present, different research groups have conducted empirical studies on the application effects of virtual reality technology in education impact, scientific education and complex collaborative tasks, and the results show that virtual reality technology can effectively promote the realization of educational destinations. Liu et al. conducted empirical research on the educational impact of immersive virtual reality technology. They randomly assigned 90 sixth grade students to immersive VR teaching group and traditional teaching group. The experimental results show that the students who use immersive virtual reality technology to learn have significantly higher participation and learning performance in cognitive, behavioral, emotional and social aspects than those who use traditional teaching methods [5]. Makransky et al. explored the value of immersive virtual reality laboratory in science education through empirical research. The research group asked 99 students in grades 7 and 8 to use the immersive VR simulation laboratory and video simulation laboratory for learning. The results showed that the interest and social expected benefits of the immersive virtual reality group before and after the test were significantly higher than those of the video group. The properly developed and implemented immersive virtual reality simulation laboratory can solve the challenges faced by science education [6]. Johanna Bertram et al. assigned 24 people to the virtual training group, the standard training group and the non-training group for empirical research to judge the effect of training police personnel to complete complex collaborative tasks in the virtual training environment. The experimental results show that the virtual training environment can enable the police to experience complex tasks that are difficult to train in reality, and enable them to achieve better performance in real tasks [7]. It can be seen that virtual reality technology has broad application prospects in the field of education.

Virtual reality 2.0 with 5IE features is applied in the field of education. It greatly overcomes the limitations of the traditional teaching environment, builds virtual objects of educational entities, and establishes two-way data channels between them. It updates, evolves, timely predicts, and reasonably monitors the historical data and real state change data of the four links of student learning, teacher teaching and research, home-school collaboration, and education supply in education and teaching, and finally forms intelligent learning, Intelligent teaching and research, home-school collaboration, and education equity are the new digital ecology of education, as shown in Fig. 3.

### Promote Intelligent Learning

The important aspect of education digitalization is to innovate learning methods, which makes students’ learning present a precise and personalized development trend. VR education system creates a lifelike education and teaching environment, which enables students to immerse themselves in the teaching process. This process also records the students’ classroom behavior, emotional reaction, physiological state, and other data through the interaction between the sensor equipment and the virtual environment, to help teachers more comprehensively and accurately master the students’ cognitive



**Fig. 3.** Virtual reality 2.0 with 5IE features applied in digital education

development and thinking progress, recommend appropriate learning content and teaching methods to students, and promote intelligent learning that considers accuracy and individuality.

### **Reshape Teachers' Teaching and Research**

The important indicator of digital education is the digital literacy of teachers. Digital literacy requires teachers to effectively carry out teaching effect prediction, teaching content improvement and teaching goal feedback based on data analysis to promote the high-quality completion of teaching tasks. Teachers make full use of the 5IE features of virtual reality technology to create virtual scenes and imaginative spaces that meet the needs of the classroom so that students can get immersive experience and interaction, and promote exploratory and adaptive learning through intelligent behavior modeling and intelligent human-computer interaction, to achieve intelligent teaching and research that conforms to the educational mechanism and laws.

### **Boosting Home-School Collaboration**

The important link of education digitalization is to break the barriers of scene separation and information non-circulation and form a virtuous circle of family school education. With VR Technology, the education and teaching process can realize the multimodal data exchange between the virtual classroom and the corresponding real classroom, accurately obtain the students' learning state changes in the VR environment in real-time, and track the student's performance in home-school cooperation. It can help educators to promote the theme activities and relevant knowledge of home-school education more specifically, innovate the model of home-school interaction education, achieve the accuracy

and timeliness of home-school communication, and achieve the effect of collaborative education and individualized education.

### **Achieve Educational Equity**

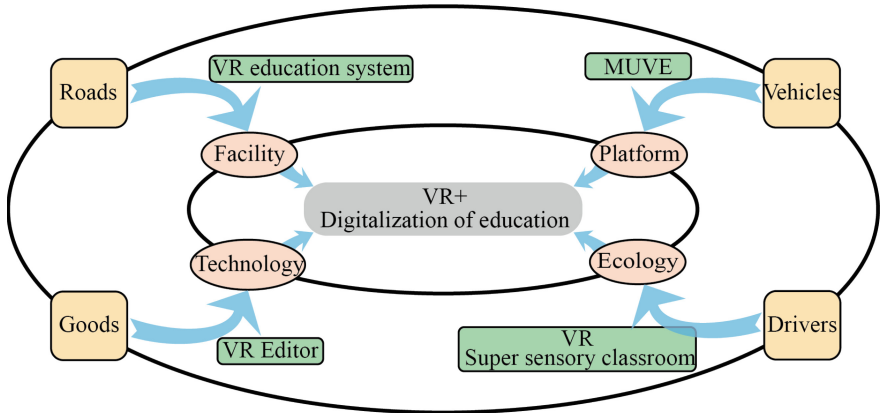
The ultimate goal of education digitalization is to realize the process equity of education scale supply and the result equity of giving full play to individual potential. With the widespread use of the VR education system, education is no longer “learning” and matching educational resources, but “learning well” and matching educational resources well. High-quality virtual teaching space can not only provide students with a sense of presence and stimulate their initiative, but also can carry out more effective cooperative learning with other learners which are far away, achieve the unity of large-scale and personalized education and teaching, and finally achieve the ultimate goal of education equity.

## **3 “FPTE” Model Enables Digital Transformation of Education**

To promote the digital transformation of education, it is necessary to define its subsystems, and realize the digital education transformation through the overall planning and coordinated development of subsystems. Education digitalization includes four subsystems namely “roads, vehicles, goods, and drivers” [8]. Among them, “Roads” refers to the hardware facilities to promote the digital transformation of education; “Vehicles” refers to various teaching and learning platforms, data security management systems, data operation systems, etc. that promote the digital transformation of education; “Goods” refers to digital educational resources and teaching contents that promote the digital transformation of education or various special websites that provide these educational resources; “Drivers” is a participant in promoting the transformation of digital education, mainly composed of teachers, students, parents, and education administrators. These four subsystems work together to promote the ecological formation of digital education. At present, there is a lack of research on the specific implementation mode of the integration of virtual reality technology and the four subsystems of “roads, vehicles, goods, and drivers”. We propose an “FPTE” model to solve this specific implementation path problem. “FPTE” model includes four aspects: “F” refers to the configuration and improvement of the VR education system; “P” refers to the Multi-User Virtual Environment (MUVE) in the Desktop-VR platform, which can promote the update and iteration of the “car”; “T” refers to the virtual presentation of “goods” for subject teachers through the development of VR editors for the field of education; “E” refers to the immersion teaching mode of “teacher-student combination” instead of “teacher-centered” traditional teaching structure through the popularization and application of virtual super sensory classroom, as shown in Fig. 4.

### **3.1 Facility: Perfect the VR Hardware Equipment and Create the Virtual Education Premise of Digital Education.**

More than ever, promoting the digital transformation of education needs the support of hardware facilities. VR education system is one of the cutting-edge hardware facilities in



**Fig. 4.** The realistic path of VR technology-enabled digital education transformation

the development of information technology at this stage. VR education system includes four technologies: data acquisition, analysis and modeling, rendering and presentation, and sensor interaction. First of all, data, as the key to the digital transformation of education, is also the basis for VR modeling and constructing a VR education system. The validation of data acquisition equipment determines the application effect of VR technology in the digital transformation of education. Secondly, modeling is to establish a digital model of real-world objects in computer space. This requires data processing equipment to process a large number of educational data for accurate modeling. Thirdly, VR presentation technology enables users of the VR education system to get a real experience by presenting object models in the virtual environment to users in different forms such as vision, hearing, touch, smell, etc. Finally, the natural interaction between different objects in the VR education system, including the student's operation of the virtual world, and the perception and feedback of the virtual classroom to the students, need to be realized by VR somatosensory interaction devices.

### 3.2 Platform: Innovate and Apply a Multi-user Virtual Reality Platform to Establish a Virtual Education Platform for Digital Education

Entering the digital education stage requires the start and establishment of a virtual education platform, which is supported by the virtual reality system. Virtual reality systems can be divided into non-immersive systems, also known as desktop virtual reality, semi-immersive systems, and immersive systems [9]. At present, the Multi-User Virtual Environment (MUVE) in the Desktop-VR platform is commonly used in educational practice and research. In this system, teachers and students as users can interact with objects and environments in the scene through avatars. Users can also communicate and cooperate through changes in the text, language, and even facial expressions. At the same time, teachers and students can complete thematic education, course assignments, required experiments, etc. through the user's virtual reality platform.



### 3.3 Technology: Develop an Easy-to-Use VR Editor to Realize the Educational Technology Reform of Digital Education

Based on virtual education equipment and virtual education platform, education digitalization also requires innovative development of education technology. If virtual reality technology wants to be popularized in the field of education, it also needs a simple and easy-to-use VR editor as tool support. The VR editor designed and developed by developers according to the actual needs of the education process is an educational technology that meets the needs of teachers and students and can minimize the duplication of work between teachers and students. Through the digital educational resources and content provided by the editor, teachers can build their VR teaching content according to their own subject needs, achieve the consistency of content output and teaching output, and ensure the professionalism of the content. Students can also stimulate creativity and creativity through the editor to expand the material database. In addition to building visual teaching content in the VR editor, teachers can customize the scene and camera track according to the teaching time and teaching rhythm to make the course content more vivid and improve students' receptivity.

### 3.4 Ecology: Focus on Popularizing VR Super Sensory Classroom, and Form a Virtual Education Ecology of Digital Education

The value pursuit of digital education is to cultivate people's digital literacy. Focusing on popularizing VR super sensory classrooms will help to build a virtual education ecology of digital education. VR super sensory classroom platform integrates teaching resources and multiple functions and is committed to creating a more convenient and efficient super immersion and full sensory teaching environment so that students can devote themselves to classroom learning. VR super sensory classroom is an immersive virtual teaching scene built based on the characteristics of 5IE of VR technology and matched with the content of the syllabus, which effectively expands the way for teachers to impart knowledge, enables students to have an intuitive understanding of abstract concepts in a realistic virtual environment, and transforms the traditional teaching structure of "teacher-centered" teaching classroom into an immersive teaching mode of "teacher-student combination", Create a virtual education ecology of digital education.

To realize the virtual reality technology to help the digital transformation of education through the four subsystems of "Roads, Vehicles, Goods, and Drivers", it is necessary to use the consistency test method to check the consistency of the weight vectors of the four subsystems to determine the feasibility of the "FPTE" model. First, the consistency indicator of the "FPTE" model is  $CI(n)$ . Where, "n" represents the specific number of indicators, and the consistency test formula of the "FPTE" model is:

$$CI = \lambda_{\max} - n / (n - 1) \quad (1)$$

Among them,  $\lambda_{\max}$  represents the largest characteristic root of the weight vector of the "FPTE" model. After passing the test, the indicators of each layer of the four subsystems in the "FPTE" model are obtained, and the judgment matrix is established. According to the weight of the indicators of each layer, the feasibility of the "FPTE" model in the virtual reality technology to help the digital transformation of education is judged, providing a guarantee for the digital transformation of education.

## **4 The Challenge of Virtual Reality Technology-Enabled Digital Education Transformation**

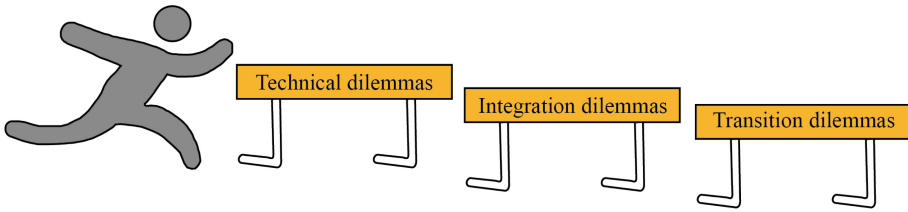
Although the digital transformation of virtual reality technology empowering education can generate a symbiotic scene of education and technology that transcends time and space constraints and breaks through real boundaries, the practical and effective use of virtual reality technology is prone to its predicament in the technological arrogance dominated by instrumental rationality. The difficulties in the integration of virtual reality technology and learning environment design, as well as the difficulties in the transformation of new and old teaching methods caused by the application of virtual reality technology, etc., as shown in Fig. 5.

### **4.1 Technical Dilemmas**

The virtual reality learning environment needs to be realized through virtual presentation technology, but the current virtual reality presentation technology is a headworn reality device, which has some defects that need to be overcome. First, the resolution and refresh rate of the head mounted display device are low, which is prone to the phenomenon of window screening and visual retention. This affects the user's sense of experience, and some users may even feel dizzy. Second, the field of view of the headworn device is relatively narrow, but its volume and weight are too large. Users need to drag the data line connecting to the fixed host all the time. It is inconvenient to walk or turn around, which makes it impossible for users to use it for a long time. Third, the human-computer interaction ability is not strong. The head mounted display is usually closed, and students cannot see the real scene at the same time when learning with a helmet, so it is difficult to take into account the real activities such as taking notes and avoiding obstacles while learning.

### **4.2 Integration Dilemmas**

The design integration of virtual reality technology and the learning environment needs to consider three aspects: the presentation of learning content, the availability of the learning environment, and the consistency of teaching theory. First of all, the learning content in the virtual reality learning environment is different from real classroom teaching. We should not only consider the sequence of the teaching content, but also pay attention to avoid the occupation of students' cognitive resources by too many virtual scenes. Secondly, the availability of the virtual reality learning environment has a great impact on students' satisfaction with learning. Only by allowing students to participate in it can we truly achieve the effective integration of virtual technology and the learning environment. Finally, different subject knowledge content and teaching theoretical basis have different classroom contents presented by virtual reality technology. A proportional history classroom requires a virtual learning environment to present immersive historical scenes, while a chemistry classroom needs to design operable chemical experiment scenes.



**Fig. 5.** Three dilemmas of VR Technology Promoting Digital Education Transformation

### 4.3 Transition Dilemmas

The innovative application of virtual reality technology in the digital transformation of education has changed the traditional “teacher-centered” teaching mode and the formation of the “teacher-student interaction” teaching mode. In the virtual reality environment, teachers are no longer designers and instructors of existing courses, but also guides and aids; Students are not only the completers of established tasks and passive absorbers of knowledge but also the participants and leaders of active exploration and acquisition of knowledge. How to connect the new and old teaching methods requires further research and development in virtual reality technology and teaching content design and practice.

## 5 Conclusions

With the development of digital technology, the competition of the whole international community for digital education transformation strategy has started. At present, the practice of digital transformation of education is still at the initial stage, which requires new educational technology as the support for transformation. As a subversive digital technology to the existing technology, virtual reality technology is bound to become a new means and platform for enabling the digital transformation of education. The 5IE feature of virtual reality technology is helpful to promote intelligent learning, reshape the teaching and research process, promote home-school collaboration, and achieve educational equity. Through the coordinated development of virtual reality technology and the four subsystems of digital education, the final virtual education ecology of digital education will promote the development of education reform. However, in the process of virtual reality technology innovation and application in the digital transformation of education, we should pay attention to the challenges of virtual reality technology itself, the integration of virtual reality technology and learning environment design, and the transformation of new and old teaching methods caused by the application of virtual reality technology. In a word, from the general law of technological development, the wide application of virtual reality technology in the digital transformation of education is an inevitable trend. The key is how to reduce the negative impact of technology based on giving full play to its technological advantages.

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