Application of virtual reality technology in mathematics teaching

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Abstract
Virtual reality technology (referred to as VR technology) as a new generation of information technology has brought new opportunities for the development of the education industry. The three basic features (immersion, interaction, and conception) of VR technology complement the boring, abstract and logical aspects of mathematics teaching and learning. The combination of VR technology and mathematics teaching can make abstract and complicated mathematical formulas, models, algorithms, graphics intuitive and concrete, which is convenient for students to understand and accept, thus enhancing students' interest in mathematics. At present, there are many successful cases combining VR technology with teaching. The combination of VR technology and automobile professional education can make up for the shortage of teaching funds, and combining VR technology with medicine can improve the cure rate of patients, etc. However, the application of VR technology in mathematics teaching has rarely been reported. This paper will start with the combination of VR technology and mathematics teaching, aiming at improving students' interest and efficiency in learning mathematics, and improving the research gap of the combination of VR technology and mathematics teaching.

Keywords: virtual reality technology, mathematical education, virtual teaching

1. Introduction
VR is the abbreviation of virtual reality, which refers to the virtual environment that gives people the immersive reality feeling. It has the characteristics of immersion, interaction and conception. This technology has attracted widespread attention since it first appeared. So how to use VR technology reasonably in mathematics teaching? Which mathematical contents are suitable for the use of VR technology? What reasonable measures should be taken by teachers and students to use VR technology? These problems are worth studying. Nowadays, artificial intelligence and big data analysis are becoming more and more important. Only in-depth study of these issues can organically combine mathematics teaching with VR technology, and guide teachers and students to use VR technology reasonably, thus providing students with rich and diverse personalized learning environment, bringing great assistance and promotion to students' learning, and stimulating students' intrinsic motivation. Therefore, only by studying these problems can we conform to the trend of The Times, promote the reform of mathematics teaching and further improve the teaching quality.

2. Introduction of VR Technology
Virtual reality technology is a technology that simulates the real environment by computer and constructs a scene similar to the real environment in the computer. The user can interact with the computer to give people an immersive reality feeling (Yang, X. P., 2015) [1].

2.1 Characteristics of VR Technology
1. Immersion. A virtual three-dimensional environment is created by computer, which gives users a sense of immersion and makes users feel that they are part of the virtual world. At the same time, users can change their identity from observer to participant and make users more active in the virtual environment (Wong, R. H. & Zhou, P. & Yan, X. M. & Wu, Q., 2017) [2].
2. Conception. Using VR technology to combine rationality and perception will create artificial imaginary scenes or things, help people think and imagine things that do not exist in the real world, enhance perceptual and rational understanding and promote people to deepen concepts and trigger new associations. (Wong, R. H. & Zhou, P. & Yan, X. M. & Wu, Q., 2017) [2].
3. Interaction. Instead of using hardware such as a mouse or a keyboard, the user can detect the user's input signal through the system, and respond to the user through multiple senses. The user can interact with the virtual environment in a natural way and feel like in a real environment. By "handling" objects in the virtual environment with your fingers, you can get tactile feedback at the same time. Interaction refers to the natural interaction and interpersonal interaction characteristics in the virtual environment (Wong, R. H. & Zhou, P. & Yan, X. M. & Wu, Q., 2017) [2].

2.2 Advantages of VR Technology
2.2.1 Virtual 3D Objects, Cultivating Students' Mathematical Thinking
Using VR technology can transform two-dimensional pictures into three-dimensional objects, restore the 3D essence of things, provide students with vivid perceptual and intuitive learning materials and promote students' understanding of three-dimensional knowledge points. It can also simulate a

three-dimensional object similar to the real object or reproduce the change process of natural phenomena or things that cannot be observed in real life. So the detailed features of the three-dimensional object model can be presented to students, and they can observe the same thing comprehensively from different perspectives, which is helpful for students to cultivate the spatial imagination ability. The detailed features of the three-dimensional object model are presented to the students, and the students can observe the same thing from different angles, which helps to cultivate students' spatial imagination.

2.2.2 Provide Timely Data Feedback and Provide a Personalized Learning Environment
VR technology can provide students with personalized learning environment by providing timely data feedback for any operation of users in the scene through dynamic changes of data, text, language and even the whole scene. Students can try to complete different tasks in the virtual environment or complete tasks in different ways according to their personality expression, so as to achieve more proactive planning, organization and monitoring of course activities (Huang, Y. Y., 2018) [3].

2.2.3 Interactive Situation Learning to Improve the Autonomy of Learning
VR technology can create vivid and distinct situations. The complex and difficult problems in mathematics can be specific, visualized and intuitive by conceiving certain scene modeling and programming, with sound, picture and three-dimensional effects. It is easy for teachers to explain, and is more conducive to students' understanding and acceptance. At the same time, it can also stimulate students' enthusiasm for learning mathematics, activate classroom atmosphere, further deepen interactivity and enhance students' interest in learning (Jiang, D. R., 2015) [4].

2.2.4 Omnidirectional, Multiple Angles Immersion Learning
Traditional classroom teaching make it easier for students with lower motivation to distract themselves from their attention because of some classroom environment factors. And VR technology can provide students with the opportunity to interact with the learning environment and instantly give immersive interactive feedback, which makes students have a strong sense of presence and greatly enhances their participation in learning (Ding, N. & Wang, Y. M., 2017) [5].

2.2.5 Breaking the Limitations of Time and Space
VR technology can completely break the limitation of space, from cosmic celestial bodies to small atomic particles. Students can enter the interior of these objects for observation. VR technology can also break through the limitations of time. Some changing processes that take decades or even hundreds of years to observe can be presented to students in a short period of time through virtual reality technology (Liang, Y. T., 2006) [6].

2.2.6 Construction of Virtual Mathematics Laboratory
In the experimental teaching, it is difficult to do the experiments under the existing environment, or it needs a lot of money to realize the experiments, or in some experiments with greater danger, more intense reaction and longer time, using VR technology can dynamically and vividly simulate these phenomena or processes. There is no need to worry about equipment damage or harm to students (Li, G. P., 2006) [7].

2.3 Disadvantages of VR Technology
2.3.1 At the Teaching Application Level
1. The teaching methods of teachers have not changed. Traditional teaching is still used in virtual environments, so that the advantages of VR technology to mathematics teaching are difficult to work.
2. The production of virtual reality content has high requirements for teachers, and the traditional teaching strategy is not suitable for virtual teaching. The application of VR technology in practical teaching will put forward higher requirements for the professional level and emerging technology application ability of front-line teachers. The content production requires teachers with many years of teaching experience to participate in the teaching, and the difficulty of teaching and preparing lessons will be further improved.
3. VR technology causes students to be overloaded with cognitive load. The multiple information transmission methods used by virtual reality are likely to cause the student's cognitive overload, and there is no effective evaluation of the relevant monitoring data of students' learning process. It is not clear whether students are using virtual reality technology for learning or entertainment (Liu, D. J. & Gao, Y, 2016) [8].
4. VR Technology is easy to cause thinking stereotype. Although VR technology is authentic, sometimes it is too real to lead to students' thinking stereotypes, so that students can not quickly realize the transformation from virtual world to real world.

2.3.2 At the Product Technology Level
1. Insufficient interactive experience. There is a poor experience in the use of head-mounted display devices. The viewing area of the display device is relatively narrow. The weight and volume of the device are too large, and the freedom of movement of the user is limited by hardware, which leads to insufficient interactive experience and other defects (Ding, N. & Wang, Y. M., 2017) [5].
2. High cost. VR technology is currently costly and not suitable for large-scale popularization. To some extent, the high cost investment has restricted the technology to civilians.
3. Graphics rendering requirements are high. The performance of graphics rendering hardware needed to be further improved. Although the level of hardware has developed rapidly and the ability of graphics processing has been greatly optimized, it still can not meet the requirements of virtual reality technology for hardware, especially for image rendering (Wei, W. & Ma, G., 2012) [9].
4. It is difficult to develop VR teaching programs. Software

writing costs are high, and it is difficult to popularize among the teachers who need it most. The VR writing program that is easier for teachers to use is still to be developed.

3. The Current Situation of High School Mathematics Teaching

Mathematical knowledge is abstract, systematic, logical, knowledge-structured and widely used. This brings a certain degree of difficulty for students to learn mathematics knowledge. At present, mathematics teaching is faced with the following teaching situations:

1. Mathematical thinking ability is difficult to cultivate. High school freshmen's mathematical thinking ability are poor, coupled with the introduction of abstract sets and logic at the beginning of the textbook, and then abstract functions are also included. Besides some teachers can not deal with the problem of junior and senior high school convergence, of which the teaching progress is fast and they just repeat what the textbook says. They can not explain profound theories in simple language and do not know how to control the teaching progress. And the main purpose is to help students master math knowledge and solve problems. The main problem is that mathematics thinking is not enough to train and understand, which makes students feel that it is too difficult to learn mathematics (Zhao, D. Y., 20009) [10]. For example, in the teaching of solid geometry, teachers mainly use vector method to solve the problems of common point, collinear, coplanar, parallel, vertical, angle, distance and so on. To some extent, it avoids the complicated and difficult thinking process, but it reduces the students' ability of space imagination, logical thinking, abstract thinking and reasoning and argumentation.

2. Teaching in large classes is not easy to teach according to students' aptitude. Class size is large and students' grades are uneven. Teachers cannot pay attention to every student, let alone "tailor-made" their own study plan for each student.

3. Students are not interested in mathematics and passive learning. Because mathematics has a high degree of abstraction, strong logic and high precision, many students lose confidence in mathematics learning. For example, in the study of probability and statistics, teachers often hear complaints from students. The students complained that they can not understand in class or they can understand in class and did not know how to solve the problem after class. They are forced to study under the pressure of college entrance examination.

4. Students lack intuitive perception of certain mathematical concepts. In mathematics learning, due to time constraints and heavy tasks, it is very difficult for students to correctly grasp their conceptual meanings and establish perceptual knowledge for some mathematical concepts such as area, volume, and three views in real life. And teachers can not explain them intuitively in ordinary teaching.

5. Rules, concepts, theorems, formulas are rigid and abstract, and students learn mechanically. From the perspective of teachers' teaching, the rules, concepts, theorems and formulas are relatively abstract. In addition, teachers neglect the occurrence and development of knowledge in teaching. The teacher only tell the conclusion that the student is only mechanically accepted and can not understand the nature of knowledge. From the perspective of students, students feel vague when applying and memorizing formulas, and the context is confusing, and the understanding of the construction of knowledge is not profound. Students use mechanical learning, and the understanding of knowledge rigid and empty. The rules, concepts, theorems and formulas are mechanical memories. Then, the knowledge is reviewed and consolidated by imitating examples and teachers' explanations.

6. Students have less chance of doing mathematics experiments. In schools with economic and cultural backwardness, mathematics laboratories cannot be provided for students, and students' hands-on ability and understanding of mathematics knowledge are greatly reduced.

4. The Feasibility of VR Technology in Mathematics Teaching

Through the above analysis, the six advantages of VR technology can complement the boring, abstract and logical characteristics of mathematics teaching and learning. The combination of VR technology and mathematics teaching can make abstract and complicated mathematical formulas, models, algorithms, graphics intuitive and concrete, which is convenient for students to understand and accept, thus enhancing students' interest in mathematics. Therefore, the application of VR technology in mathematics teaching is feasible.

1. By using the characteristics of VR technology "virtual three-dimensional object" can make up for the shortcomings of students' spatial imagination and logical reasoning ability. For example, the positional relationship between the spatial straight lines, the positional relationship between the planes, and the line-of-plane angle and the dihedral angle are the key and difficult points in the teaching of high school mathematics stereo geometry. Geometric graphics are abstract, difficult to perceive, and out of practice. It is difficult for students to form an objective image. However, the required geometric model can be virtual by VR technology. With its unique interaction and integration characteristics, students can observe from different perspectives according to their own wishes, and more easily accept and perceive three-dimensional objects, but also save the production of physical objects, so that teachers and students are not entangled in the transformation of plane and stereo in traditional teaching.

2. By using the function of VR technology "timely data feedback" can provide high-quality educational resources for students, increase the opportunity for each student to hands-on learning, and make up for the defect that students can't individualize learning in large class teaching. According to each student's condition, teachers can teach students according to their aptitude, so that students can receive better education.

3. Utilizing the characteristics of "interaction" of VR technology, students can freely click, view, drag, rotate

and other simple interactions with any object in VR virtual situation, control learning content and process by themselves, and improve learner's autonomy. At the same time, the novel interactive form can make up for the boring and dull defects in traditional mathematics teaching, increase students' motivation and interest in learning mathematics, and the enthusiasm for learning is high.

4. Utilizing the characteristics of "immersion" of VR technology to restore the real scene in an all-round and multiple angles way can remedy the shortcoming of students' lack of intuitive perception of certain mathematical concepts, help students establish the connection between mathematical knowledge and real life scene, and improve students' intuitive perception of knowledge. For example, in mathematics teaching, when the area of analogical circle is used to estimate the surface area of a ball, traditional teaching uses the method of division to solve the problem. Firstly, it is limited to divide the ball, and then to find the limit. It is difficult for students to understand the limit knowledge for the first time, so how to help students establish their perceptual knowledge of the limit is a key and difficult point to break through in this lesson. However, the virtual environment is created by VR technology, so that students can sit in the classroom and really feel the deduction process of the surface area of the ball when n increases infinitely, and grasp the formula of the surface area of the ball correctly. Another example is that students cannot accurately grasp the concept of size in terms of large volume units such as "cubic meters" and "cubic kilometers". Through VR technology, students can sit in the classroom with VR glasses to feel how big a cubic meter or a cubic kilometer is.

5. By using the advantages of VR technology to "break the limitations of time and space", we can reproduce the discovery, deduction and application process of the theorem, meet the requirements of the new curriculum standard, and try to let students experience the occurrence and development of knowledge to make up for the defects of students' hard acceptance of knowledge. For example, in the teaching of derivative, derivative is a completely new concept, which is different from the knowledge of equations contacted in elementary school. If the concept of derivative is totally stuffed to students, students will be bound to feel blunt and not easy to digest. However, through VR technology, it is possible to break the limitation of time and space, reproduce the history of scientists' discovery of derivatives, and present the origin, development and role of derivatives in real life to students, which not only arouses the enthusiasm of students, but also eliminates the drawbacks of derivatives such as boredom. Another example is the student's first contact with vector knowledge. The concepts and theorems of vectors are too abstract for students to understand the nature of vectors. The operation of vectors only stays on the superficial understanding of directly implementing formulas. The awareness of using vectors as tools to solve problems is not enough. The addition of VR technology can make up for this shortcoming.

6. By using the advantages of VR technology to "construct a

virtual mathematics laboratory" can effectively improve the problem of shortage of educational resources, saving traditional experiments and teaching instruments, and making up for the gaps in student thinking. For example, in the teaching of probability and statistics, students can do a lot of random experiments through VR technology. The real experience and feelings "when the frequency is gradually stabilized to a certain constant, it can be approximately equal to the probability", thus improving the acceptability of students.

5. Measures of Using VR Technology in Mathematics Teaching
Through the analysis and understanding of the advantages of VR technology and the present situation of mathematics teaching, I think it is reasonable to take the following measures in the current mathematics teaching:

5.1 Teachers should make Reasonable use of VR Technology to Prevent Improper use or Abuse
VR technology is only an auxiliary means of teaching, not the ultimate goal of teaching. When the teaching content is relatively unfamiliar and students encounter difficulties in understanding and mastering the knowledge, they need to use the intuitive teaching aids. When using VR technology, teachers must grasp the scales to prevent students from relying too much on the actual experience, and put the cart before the horse. At the same time, teachers should give full play to their leading role and pay attention to inspiring and guiding students. Therefore, based on the cultivation of students' core literacy, the reasonable use of VR technology makes the teaching classroom of VR technology truly becomes a platform for teachers and students to actively participate, interact and develop together.

5.2 Teachers should change their teaching concepts appropriately
When using VR technology in teaching, teachers must change their teaching concepts and make full use of the new technology platform, so as to realize the transformation of teachers from knowledge imitators to guiders of students' learning and promoters of students' development; to realize the transformation from knowledge demonstrators to instructor of cultivating students' innovative ability; to realize the transformation from cultivating experienced talents to cultivating innovative talents.

5.3 According to the characteristics of teaching content, teachers should effectively present knowledge through vr technology
In some practical courses, teachers must reasonably use VR technology on the premise of teaching students theoretical knowledge. For example, in the teaching of Cosine Theorem, it is necessary to measure the distance by detecting tools, which provides the basis for later proof. If teachers did not teach students the theoretical knowledge of measuring methods in advance, students would not use measuring tools to measure a certain angle or a certain distance in virtual environment, which greatly wasted teaching time and resources. Effective knowledge presentation can help students

to deeply process, and encode knowledge and promote the mastery of knowledge.

5.4 Teachers should combine the characteristics of VR technology to develop new teaching strategies

The production of VR technology content has put forward higher requirements for teachers. Traditional teaching strategies may not be suitable for the teaching of VR technology. Teachers need to be good at developing new teaching strategies, improve the skills of preparing lessons and teaching, encourage students to think independently, explore independently, cooperate and communicate, so as to continuously improve students' ability of innovative thinking, problem analysis and problem solving.

5.5 Teachers should rationally guide students to transform from virtual world to real world, and avoid thinking stereotypes

In the VR world, for teachers, it is necessary to correctly and rationally guide students transform from the virtual world to the real world, so that they can develop good cognition, correctly understand VR technology, prevent indulging in the VR world and not extricate themselves. For example, in the teaching of "Three Views", teachers can use VR teaching to let students build various objects in the virtual environment and observe them from different angles, such as from the top to the left, etc. Once the transition from the virtual world to the real world, students' thinking may not keep up for a while, and they can not restore the shape of the three views, and the purpose of improving students' spatial imagination can not be achieved.

5.6 Textbook developers should rationally reform the teaching content according to the advantages of vr technology

In the introduction of VR technology into teaching, the textbook makers should reform the teaching content according to the advantages of VR technology, deeply study the characteristics of each course, and make up for the deficiency of traditional teaching content with the advantage of VR technology. VR technology can be used to assist with content that cannot be explained due to time and space constraints; For the past experiments which could not be carried out due to backward economy, lack of equipment, too long experiment time and danger, etc, virtual experiments can be set up to continuously promote students' all-round development and cultivate innovative talents.

5.7 Establishing a trinity education network

The attitudes of education departments, governments and enterprises also directly affect the application of VR technology in teaching. The education departments should positively respond to the application of VR technology in teaching. The government should increase educational investment. Enterprises should actively develop software beneficial to teachers' teaching and reduce the cost on a large scale. We must strive for the active cooperation of the three departments to form a trinity education network.

6. Conclusion

The use of VR technology has fundamentally changed the way of people's thinking. With the further maturity and development of related technologies, the improvement of the performance of corresponding hardware devices and the development of software systems, the application of VR in the field of teaching has been expanded. And with its successful application in the fields of biology and physics, VR is used in the field of Mathematics teaching and research, which will bring subversive changes to mathematical teaching.

7. Funding

8. References

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