



# Application of Virtual Reality Technology in the Chemistry Teaching Process

Zhaoyan Li<sup>1,2</sup>, Yuan Cao<sup>3</sup>, and Jiancheng Luo<sup>1,2</sup>(✉)

<sup>1</sup> School of Biological and Chemical Engineering, Nanyang Institute of Technology, Nanyang 473004, Henan, China

l\_lucky\_lucky66@163.com

<sup>2</sup> Nanyang Key Lab for Catalytic Functional Materials, Nanyang 473004, Henan, China

<sup>3</sup> School of Information Engineering, Nanyang Institute of Technology, Nanyang 473004, Henan, China

**Abstract.** Based on virtual reality technology and its unique advantages in chemistry experimental teaching, the shortcomings in traditional chemistry experimental teaching are addressed by integrating the application of virtual reality technology in chemistry experimental teaching. This paper combines the teaching examples of secondary school chemistry subjects, focuses on the basic features, teaching advantages, and specific applications of virtual reality technology in chemistry experimental teaching, and puts forward several thoughts on how to effectively carry out experimental teaching supported by virtual reality technology in the future.

**Keywords:** Virtual reality (VR) · Chemistry · experimental teaching · course training

## 1 Introduction

Virtual Reality (VR) is an immersive interactive environment based on multimedia computer technology, sensing technology, and simulation technology. The three most prominent features of VR technology are immersiveness, imagination, and interactivity [1]. Virtual reality technology is the integration and comprehensive application of many branches of information technology such as digital image processing and pattern recognition, intelligent technology, multimedia technology, voice processing and sound technology, network technology, and sensor technology. At the same time, virtual reality technology integrates psychology, computer graphics, database, control, real-time distribution system, electronics, multimedia technology, and so on. Compared with the flat two-dimensional environment constructed by traditional virtual simulation technology, the virtual environment constructed by virtual reality technology is multi-dimensional and three-dimensional, which is closer to the real environment. The human-computer interaction based on virtual reality technology is also more vivid, natural, and realistic, which can give people a sense of immersion in the virtual world to the maximum extent possible, and people can immerse themselves in the virtual world to feel the interaction

between the virtual world and themselves. Virtual teaching is a new teaching mode based on VR technology for education and learning in virtual space, that is, VR technology is used to build a virtual learning environment, through the objective and realistic simulation of knowledge points to reproduce, so that teachers and students in the virtual environment to complete the whole process of teaching and learning. VR technology has overcome these difficulties and provided students with a more realistic experimental environment. But the technology also has certain shortcomings, such as the difficulty of giving the user some feedback (pain, smell, etc.) This will be a potential future research direction.

## 2 Virtual Reality Technology Applied to the Advantages of Chemistry Experimental Teaching

Chemistry experimental teaching is an important part of chemistry teaching. Chemistry is an experiment-based discipline, and most of its basic theories come from experiments in the real world. From the development history of the chemistry discipline, the chemical experiment is an important research method to explore the properties of substances. At the same time, chemistry experiments are also an important way for students to conduct inquiry learning. Usually, before conducting a chemical investigation experiment, students have to design an experimental plan or improve an existing experimental plan by consulting literature and books; during the experiment, students have to independently solve various difficulties they may encounter through active thinking, in-depth investigation, and mutual collaboration; after the experiment, students have to analyze data and reflect on the experiment to summarize laws and experiences. Chemistry experiments can cultivate and develop students' creativity, teamwork, communication skills, social responsibility, and information literacy [2].

However, chemistry experiments are often limited by the speed of reaction, cost, safety, and other issues due to their special characteristics. For example, schools in less developed areas often have backward chemical laboratory facilities and equipment, incomplete drug types; teachers do not pay attention to chemical laboratory teaching, almost no chemical laboratory teaching, students memorize experimental principles, experimental procedures, experimental precautions, and other knowledge to cope with the examination; experimental teaching is limited to completing the experimental steps according to the book, the lack of thinking and inquiry process; some chemical experiments or have a certain degree of danger Some chemistry experiments are not suitable for teaching chemistry experiments because they are dangerous, or the reaction time required is too long, or the reaction conditions are harsh, or the reaction phenomenon is not obvious (Fig. 1).

With the development of virtual reality technology, VR is gradually entering people's lives, not only as an entertainment device [3]. The application of VR technology in chemistry experimental teaching can not only guarantee safety to a large extent but also improve the efficiency of experimental teaching and stimulate students' interest in experimental exploration. The advantages of applying VR technology to chemistry laboratory teaching are mainly in the four aspects of virtualization of the teaching environment, contextualization of the teaching process, integration of teaching knowledge, and autonomy of student learning.



Fig. 1. Virtual testbed for chemistry experiments

### 3 Virtualization of Teaching Environment

Virtual teaching is teaching means building a virtual, interactive learning environment close to the real environment through a variety of advanced technologies, and users can interact with the virtual environment to gain experience and knowledge, thus achieving the purpose of teaching [4]. The teaching environment in virtual reality teaching is non-realistic, which avoids the limitations of the real environmental conditions, time, and space for teaching. Traditional chemistry laboratory teaching is often inevitably limited by teaching conditions, such as limited time and space for experiments, expensive experimental equipment and experimental drugs and severe losses, the reaction conditions of some experiments, and so on, are to a certain extent limited teaching. The virtual teaching environment built by VR technology can increase students' learning opportunities by solving the problem of realistic conditions, thus improving learning efficiency.

### 4 Contextualization of the Teaching Process

Contextualized teaching refers to the teaching in which students learn knowledge and construct meaning independently through problem exploration and problem-solving in the real situations created. Contextual teaching believes that knowledge can only produce meaning in context, and contextual construction is the necessary prerequisite for meaning construction, while meaning construction is the purpose of learning. In other words, students need to actively construct knowledge through the context to achieve the purpose of meaning construction.

The virtual teaching environment is characterized by immersion, imagination, and interactivity, and its virtual environment is realistic, vivid, intuitive, and well-interacted. Students can feel the multi-dimensional sensory stimulation in the virtual environment, and get the near-real practice experience so that they can actively construct knowledge. Therefore, VR virtual environment is one of the effective means to realize contextual teaching. Contextualization of chemistry experiments can help students deepen their understanding of the relationship between chemistry and life and production, broaden their knowledge of chemistry experiments, stimulate their interest in chemistry, and enhance their core literacy in chemistry.

## 5 Integration of Teaching Knowledge

Virtual reality system integrates images, diagrams, audio, video, and animation in a complex way by computer, builds a teaching environment based on human cognitive characteristics, organizes and presents teaching knowledge, reflects the diversity and complexity of the form and content of knowledge information, provides students with a dynamic, open and free form of structured cognition, and is conducive to students' comprehensive mastery and application of the knowledge they have learned.

Traditional teaching tends to focus only on chemistry subjects, focusing on the systematic learning of single subject knowledge, and textbooks present experimental teaching content in text and pictures, and the presentation is flat and rigid. It is difficult for students to effectively construct contexts and make connections between the new knowledge they learn and their existing experiences, making it difficult to integrate multidisciplinary learning. Traditional teaching methods inevitably cause fragmentation between disciplines and do not help students establish logical relationships between disciplines. Virtual teaching not only shows the basic content of chemistry vividly but also helps students to recognize the connection between chemistry and other disciplines, to build an integrated knowledge structure, and improve students' innovation and practical ability.

## 6 Students Learning Independently

The main role of VR teaching in school education is to stimulate students' interest in learning. Students can experience real situations through VR, and teaching in real situations can maximize students' interest in participation and improve their learning efficiency [5]. The second is to enhance the main position of students. Virtual teaching is student-oriented teaching. Traditional teaching often has a fixed teaching sequence, that is, teachers explain, then students remember, understand, practice, and finally achieve the purpose of teaching. Students often play a passive role in traditional teaching. Virtual teaching, on the other hand, places more emphasis on students' active participation in knowledge construction. Students can choose, think and explore independently in the virtual environment, and construct knowledge in the process of independent thinking, analysis, induction, and synthesis, to achieve the teaching purpose. This will largely solve the problems of education and teaching such as students' rote memorization, difficulty in learning to apply, heavy learning burden, and low learning efficiency.

## 7 Application Case Design: Reduction of Iron Oxide by Carbon Monoxide

Carbon monoxide reduction of iron oxide experiments requires students to master not only the experimental principles, experimental devices, and experimental phenomena, but also require students to master the experimental operation of the notes and reasons that can be flexibly applied and transferred. Provinces and municipalities in the chemical examination paper examination of this experiment, often focus on the experimental



**Fig. 2.** The vision from the students

operation of the notes, for example, the reaction began before the introduction of carbon monoxide gas and ignition of the alcohol lamp and the consequences of the wrong operation; the end of the reaction to stop heating and stop the sequence of carbon monoxide and the consequences of the wrong operation; the tail gas treatment and its improvement; anti-reverse suction and the consequences of the wrong operation; and so on (Fig. 2).

There are many difficulties in teaching iron oxide reduction by carbon monoxide experiment in the real world, for example, the experiment needs to continuously pass carbon monoxide gas, and carbon monoxide is toxic; there is a risk of explosion in the experimental device; the experiment needs to be exhaust gas treatment, if the exhaust gas treatment is not complete, it will produce safety hazards; the experiment needs to be carried out in the fume hood, it is not convenient for students to observe the experimental phenomenon; the experiment takes a long time; and so on. For the above reasons, the experiment does not have the conditions of classroom live demonstration or student operation. Therefore, teachers tend to take the experimental video broadcast, animation demonstration, and other ways to teach, and students tend to memorize the experimental phenomena by mnemonic or rote to remember the sequence of lighting the alcohol lamp and carbon monoxide and the consequences of the wrong operation. Although this method is safe, time-consuming, and simple, it does not stimulate students' desire to explore and enhance their motivation to learn, not to mention optimizing their learning experience and cultivating their interest in chemistry. By using VR technology to build a virtual chemistry lab, students can experience the experimental operations in the virtual lab, which can effectively solve the above problems.

## 8 Conclusion

As a new technology applied to experimental teaching, virtual reality technology still has problems such as expensive equipment, imperfect industry standards, and difficulty in developing educational resources, but its advantages in experimental teaching are still unparalleled. With the development of VR technology and the solution of related problems, the application of this technology in experimental teaching will be further expanded.

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