Thoughts on Improving the Traditional Chemistry Experiment Course in Universities by Virtual Simulation Experiment Teaching

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Abstract: The purpose of this article is to explore the application and effect of virtual experiment teaching in university chemistry experiment course. By comparing and analyzing traditional experimental teaching with virtual experimental teaching, this article reveals the remarkable advantages of the latter in improving teaching quality, ensuring experimental safety and promoting the cultivation of students' practical ability. It is found that the virtual experiment teaching can not only effectively solve the problems of resource consumption and security risks existing in traditional experiment teaching, but also stimulate students' learning interest and innovative thinking through a highly interactive learning environment. However, this teaching mode also faces challenges in technical bottleneck, teaching resource allocation and teacher training. In view of these challenges, this article puts forward a series of coping strategies, and looks forward to the future development of virtual experiment teaching in university chemistry experiment courses. With the continuous progress of technology and the innovation of teaching mode, virtual experiment teaching is expected to bring revolutionary changes to chemistry experiment teaching in universities.

1. Introduction

With the rapid development of science and technology, the field of education is undergoing a profound change [1]. Although the traditional chemical experiment teaching can provide students with intuitive practical experience, it also faces some insurmountable problems, such as large consumption of experimental materials, potential safety hazards during the experiment and uneven distribution of experimental teaching resources [2-3]. These problems limit the development and effect of chemical experiment teaching to some extent.

Furthermore, with the continuous progress of computer technology, virtual simulation technology has emerged and developed rapidly [4]. As a new teaching mode, virtual experiment teaching is gradually changing the traditional instructional method with its unique advantages [5]. By simulating the real experimental environment and process, virtual experimental teaching can provide students with more rich practical experience and improve the effect of experimental teaching on the premise of ensuring safety [6].

The main purpose of this study is to explore the application and effect of virtual experiment teaching in university chemistry experiment course. Its research significance is mainly reflected in two aspects: First, by introducing virtual experiment teaching, the quality and safety of chemical experiment teaching can be significantly improved. Experiments in virtual environment can avoid possible dangers in real experiments, and at the same time, students' experimental skills can be improved through repeated practice. Second, virtual experiment teaching helps to promote the cultivation of students' practice and innovation ability. In the virtual environment, students can explore the experimental process more freely and try different experimental methods and parameters, thus cultivating their innovative thinking and practical ability.

2. Overview of virtual experiment teaching

Virtual experiment teaching refers to the instructional method that uses computer technology to

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simulate the real experimental environment and process, so that students can carry out experimental operations in the virtual environment [7]. This instructional method is highly interactive and authentic, and can provide students with practical experience similar to real experiments. The characteristics of virtual experiment teaching are shown in Table 1.

Table 1 Characteristics and advantages of virtual experiment teaching

Features/advantages	Explanation
High security	Students carry out experiments in a virtual environment, which avoids possible dangers in real experiments and ensures the safety of learning.
Low cost	Virtual experiment reduces the consumption of experimental materials and the depreciation of equipment, and reduces the teaching cost.
Strong repeatability	Students can experiment repeatedly until they master the experimental skills, which improves the learning effect.
The experimental data is abundant	The virtual simulation system can record and analyze the data in the experiment process, and provide students with rich feedback information.
Timely feedback	Students can get the feedback of experimental results immediately, which is helpful to adjust experimental strategies and methods in time.
Improve experimental skills	Through repeated practice and data analysis, students' experimental skills have been effectively improved.
Cultivate innovative thinking	The flexibility and exploration of virtual experiment is helpful to stimulate students' innovative thinking and practical ability.

With the continuous development of computer technology, virtual experiment teaching has experienced the evolution from simple simulation experiment to highly interactive virtual reality experiment [8]. The early virtual experiment teaching mainly focused on the simple simulation of the experimental process, and then gradually developed into a highly realistic and interactive virtual reality experimental teaching system. These systems can simulate the real experimental environment and process, and provide students with more realistic practical experience. In the application of education, virtual experiment teaching has become an important instructional method, which is widely used in various disciplines [9].

The theoretical basis of virtual experiment teaching mainly includes constructivism learning theory and situational teaching theory. Constructivist learning theory holds that learning is an active and constructive process, and students construct their own knowledge and understanding through interaction with the environment. Based on this theory, virtual experiment teaching provides students with rich practical experience by simulating the real experimental environment and process, and helps them to actively construct chemical experiment knowledge and skills. Situational teaching theory emphasizes that learning should be carried out in real situations to stimulate students' interest and enthusiasm in learning [10]. Virtual experiment teaching can simulate the real experimental situation, so that students can learn the knowledge and skills of chemical experiments in the simulated situation and improve the learning effect.

3. Present situation of traditional chemical experiment courses in universities

3.1. Problems existing in traditional chemical experiment courses

The teaching content of traditional chemical experiment courses usually covers inorganic chemistry, organic chemistry, analytical chemistry and other fields, aiming at consolidating and deepening students' understanding of chemical theoretical knowledge through experimental operation. In terms of instructional methods, teachers usually explain the theory first, and then students do experiments themselves. The experimental means mainly rely on traditional laboratory equipment and instruments, and students need to complete various experimental operations step by step according to the experimental instruction manual.

Safety is one of the most prominent problems in traditional chemical experiment courses. Because chemical experiments involve various chemicals and high temperature, high pressure and other dangerous factors, once improper operation may lead to safety accidents. Resource

consumption is also a problem that cannot be ignored. Traditional chemical experiments need a lot of chemical reagents, glassware and other experimental materials, which not only increases the teaching cost, but also causes certain pressure on the environment. In addition, from the instructional effect, due to the large number of students and limited teacher resources, it is difficult to ensure that every student can get full guidance and help, which leads to some students unable to effectively master experimental skills.

3.2. Student feedback on traditional chemistry experimental courses

In order to get a deeper understanding of students' views and feelings about traditional chemistry experiment courses, this article collected students' feedback through questionnaires and interviews, as shown in Table 2.

Table 2 Students' feedback statistics on traditional chemical experiment courses

Feedback content	Student ratio	Detailed description
Deepen the understanding of chemical knowledge	Most students	Students generally believe that the traditional chemical experiment course is helpful to consolidate and deepen the understanding of chemical theoretical knowledge.
Fear and uncertainty in the process of experiment	Some students	Some students said they were worried about the operation of the experiment, fearing that their mistakes would lead to safety problems.
Eager for more experimental opportunities	Some students	Some students expressed the hope that they would have more opportunities to do experiments by themselves to improve their experimental skills.
Suggestions on introducing advanced technology to assist teaching	Some students	Some students suggest using more advanced technical means, such as virtual simulation, to assist experimental teaching, so as to improve instructional effect and experimental safety.

The results show that most students think that the traditional chemical experiment course can really help them deepen their understanding of chemical knowledge, but there are also some problems. For example, some students feel afraid and uncertain during the experiment, and worry that their operation will cause safety problems; Some students expressed the hope that they would have more opportunities to do experiments by themselves to improve their experimental skills. In addition, some students suggest introducing more advanced technical means to assist experimental teaching, so as to improve the instructional effect and safety.

4. The application of virtual experiment teaching in chemical experiment courses in universities

4.1. Design and implementation of virtual experiment teaching system

The design of virtual experiment teaching system usually includes three parts: system architecture, functional modules and operation flow. System architecture is the skeleton of the whole system, which determines the stability and scalability of the system. Functional modules are different functional units according to the requirements of experimental teaching, such as experimental operation simulation, data recording and analysis, experimental report generation and so on. The operation flow is a concrete step to guide students how to use the system to carry out virtual experiments. In the process of implementation, students' learning needs and habits, as well as teachers' instructional methods and objectives, need to be fully considered to ensure the usability and practicability of the system.

4.2. The combination of virtual experiment teaching and traditional chemical experiments

Virtual experiment teaching is not to completely replace the traditional chemistry experiment, but as an auxiliary instructional method to make up for the shortcomings of the traditional experiment. In practical application, virtual experiment teaching can be combined with traditional

chemistry experiment to form a teaching mode of combining reality with reality. For example, before the traditional chemistry experiment, we can preview and simulate the operation through the virtual experiment teaching system to help students get familiar with the experimental process and matters needing attention; During the experiment, virtual simulation system can also be used to assist data recording and analysis to improve the accuracy and efficiency of the experiment.

4.3. Case analysis of virtual experiment teaching

In this section, a specific case is selected for analysis to better illustrate the application effect of virtual experiment teaching in university chemistry experiment course. The effect of virtual experiment teaching system in chemistry experiment course is shown in Table 3.

Table 3 Effect comparison of virtual experiment teaching system in chemical experiment course

Indicators (1-10 points)	Before introducing the system	After introducing the system	Change rate/improvement rate
Student's understanding of the experimental process and precautions	6.8	8.9	+30.88%
Accuracy of experimental results	7.5	9.2	+22.67%
The quality of student experimental reports	7.2	9.0	+25.00%
Student satisfaction with instructional effectiveness	7.0	9.1	+30.00%

This table displays the comparison of various indicators of students in the chemistry experiment course before and after the introduction of the virtual experiment teaching system through specific numerical values. It can be seen that after the introduction of the system, students have significantly improved their understanding of the experimental process and precautions, accuracy of experimental results, quality of experimental reports, and satisfaction with instructional effectiveness. This table is organized based on student feedback, reflecting their different views and suggestions on traditional chemistry experimental courses, including course effectiveness, psychological feelings during the experimental process, expectations for practical opportunities, and the need for technical assistance in teaching.

By comparing and analyzing the instructional effects and student feedback before and after the introduction of the virtual experiment teaching system, it can be found that the system has played a positive role in improving the quality of chemistry experiment teaching and student satisfaction.

5. Conclusion and Outlook

5.1. The improvement effect of virtual experiment teaching in university chemistry experiment courses

By comparing and analyzing traditional teaching and virtual simulation teaching, it is evident that the latter has a significant improvement effect in university chemistry experimental courses. Virtual experiment teaching not only provides a safer and more economical experimental environment, but also allows students to repeat experiments multiple times without burden until they master key skills. In addition, the interactivity and participation of students in virtual environments have greatly improved, promoting their interest and enthusiasm for chemical experiments.

5.2. Challenges and countermeasures of virtual experiment teaching

Although virtual experiment teaching has many advantages, it also faces technical bottlenecks, teaching resource allocation and teacher training challenges. Technical limitations may affect the authenticity of simulation and the fluency of operation. Furthermore, the development and maintenance of high-quality teaching resources is also a long-term and expensive investment. In

response to these challenges, universities should increase investment in technology research and development, optimize resource allocation, and strengthen professional training for teachers to ensure that they can effectively use this new instructional method.

5.3. Prospect of virtual experiment teaching in university chemistry experiment course in the future

With the continuous progress of technology, the future virtual experiment teaching will be more realistic and intelligent. Combining augmented reality and virtual reality technology, students will be able to immerse themselves in a more realistic experimental environment. Furthermore, with the continuous innovation of teaching mode, virtual experiment teaching is expected to be more closely combined with traditional experiment teaching to jointly promote the quality improvement of chemical experiment teaching in universities.

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