

The Application of Virtual Simulation Laboratory in University Physics Teaching

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As a new type of experimental teaching method, virtual simulation laboratory has many advantages, such as safety, economy, flexibility, etc., and has been more and more widely used in the field of education. At present, in the teaching of university physics courses in most colleges and universities in China, the lack of experimental teaching in university physics courses is due to the large class size, insufficient teacher strength, limited course hours, and other reasons. However, experimental teaching has a very important role and status in university physics teaching, which not only helps to stimulate students' learning interest, improve students' hands-on ability, teamwork, and communication skills, but also helps to cultivate students' innovative ability, scientific thinking, and the spirit of inquiry, which is an indispensable teaching link. Based on cognitive learning theory and constructivist learning theory, the application of virtual simulation laboratory technology and the use of inquiry-based teaching methods in university physics courses can effectively improve the quality of teaching and the quality of talent training.

Keywords: virtual simulation laboratories, university physics, laboratory teaching, talent development, inquiry-based teaching

Introduction

With the continuous development and progress of society, the state and society put forward more and more requirements for talent, and more and more need innovative and technical talents, which also put forward higher requirements for the cultivation of talent in colleges and universities. In university physics courses, experimental teaching plays a vital role in cultivating students' innovative ability, practical ability, and spirit of inquiry. However, in the specific teaching process of university physics courses, often because of the large class size, limited class time, insufficient laboratory equipment, and other reasons, the teaching effect of university physics courses is not ideal. This paper introduces the virtual simulation laboratory and its advantages and analyses the necessity of applying virtual simulation laboratory in university physics teaching based on cognitive learning theory and constructivist learning theory. Based on the virtual simulation laboratory, the use of inquiry-based teaching methods can effectively improve the quality of teaching and talent cultivation.

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The Concept of Virtual Simulation Laboratory

Virtual simulation laboratory uses computer technology and virtual reality technology to simulate the real experimental environment so that the user can carry out experimental operations and observations in the virtual environment, to achieve the purpose of teaching, training, or research. It digitizes elements such as experimental equipment, experimental materials, and experimental operations in a traditional laboratory and simulates and emulates them through computer programs to create a virtual experimental scene. Users can interact with the virtual laboratory through computer interfaces or virtual reality devices (e.g., head-mounted displays) to perform experimental operations, observe experimental phenomena, access experimental data, etc. (Tian, T. Luo, H. F. Luo, & Zou, 2015; Wang, Bai, & Ma, 2019)

Features of the Virtual Simulation Laboratory

Virtual simulation laboratories have many features and advantages that make them an important tool in fields such as scientific research, education, and engineering design.

Safety

Virtual simulation labs can simulate a variety of dangerous or expensive experiments in a virtual environment without any real risk to the user or the environment. This reduces the safety risks that may exist during experiments, such as handling toxic substances or high-temperature experiments.

Cost Effectiveness

Compared to the huge investment in building a physical laboratory and purchasing expensive equipment, virtual simulation labs significantly reduce these costs. It requires only a one-time investment in hardware and software, and the maintenance costs are relatively low, making it more cost-effective.

Repeatability and Controllability

Virtual simulation labs allow easy repetition of experiments for validation of results or more in-depth analyses. Additionally, by adjusting parameters or scenarios, the user has greater control over experimental conditions, resulting in a more accurate understanding of the results.

Flexibility in Time and Space

Virtual simulation labs are not limited by time or location, so users can operate them at any time and from any place. This greatly improves the flexibility of experimental activities and enables users to organize their work and study more efficiently.

Personalized Learning

Virtual simulation labs can provide a personalized learning experience based on the users' needs and levels. Users can choose experimental projects according to their interests and learning goals, and adjust and optimize the experimental process according to their learning progress, to meet personalized learning needs.

Current Status of University Physics Teaching

Currently, in the teaching of university physics courses in China's colleges and universities, experimental teaching is often marginalized in the curriculum due to the limited credit hours and extensive theoretical content. Teachers may be more inclined to spend their limited time on theoretical knowledge and regard laboratory teaching as an optional or extra course. Meanwhile, university physics, as a basic compulsory course in science

and engineering at the undergraduate level, involves a large number of students. Due to the lack of faculty, university physics courses are usually taught in large classes, which makes the implementation of laboratory teaching impractical. In addition, due to the large number of experiments included in university physics courses, a large amount of equipment and materials are often needed to conduct physics experimental teaching, some of which are expensive, and the purchase and maintenance of such equipment may constitute considerable economic pressure for universities or faculties that are strapped for funds, thus limiting the scale and frequency of experimental teaching. Physics experiments may also involve dangerous or complicated operations such as high-voltage circuits and high-temperature experiments, which increase the safety risks. To protect the safety of students and laboratories, universities may restrict the conduct of certain experiments (Wang, 2018).

However, experimental teaching is a vital part of university physics teaching. Physics is a natural science based on experiments, and physics experiments are the concretization of theoretical knowledge in physics and an important part of the development of physics. The experimental teaching part of the university physics course is a bridge to transform theoretical knowledge into practical application, which can help students deeply understand the physical principles, deepen the memory and understanding of knowledge, and is also an important link to cultivate students' ability of observation, analysis, judgment, generalization, practice, and creation, and to train students to master the skills of physical experimentation and scientific research methods. Therefore, it is necessary to strengthen experimental teaching in university physics teaching.

Theoretical Basis for Applying Virtual Simulation Laboratory in University Physics Teaching

Cognitive Learning Theory

Cognitive learning theory is a theoretical framework for learning and cognitive processes that emphasizes active processing and understanding by learners as they acquire, organize, and use knowledge. The theory suggests that learners actively construct, reorganize, and adapt their knowledge structures through activities such as observation, experimentation, reflection, and problem-solving. Learning is more than simply receiving and remembering information; it is about building a deeper understanding and the ability to apply knowledge through comprehension and reflection. The effectiveness of learning depends on the extent to which learners make connections between new knowledge and what they already know; therefore, instruction should be designed as activities and tasks that help learners make meaningful connections. Learners can deepen their understanding and retention of knowledge and improve their learning effectiveness by using a variety of learning strategies, such as organizing, summarising, classifying, and refining. Timely feedback can help learners identify errors, improve strategies, and adjust the learning process. Feedback from teachers and peers can facilitate learners' reflection on their learning behaviors and understanding, thus deepening the learning effect.

Constructivist Learning Theory

Constructivist learning theory is a theoretical framework about learning that emphasizes that learners are active, constructive participants in the learning process. The theory sees learning as a constructive process in which learners actively construct, reorganize, and adapt their knowledge structures through their own experiences and thinking. Rather than just passively receiving information, learners build their ability to understand and apply knowledge through interaction with their environment. Constructivist learning theory emphasizes the individual differences and diversity of learners. Each individual's learning process is unique and is influenced by his or her

personal experiences, perceptions, and cognitive structures. Therefore, teaching should focus on learners' needs and backgrounds and provide learning environments and support that accommodate individual differences. Learners build understanding and meaning through interaction with teachers, peers, and the environment. Teaching should focus on stimulating curiosity and inquiry, and provide challenging and stimulating learning tasks and activities. Teachers should not only be the transmitters of knowledge but also the guides and facilitators of learning, guiding students to actively explore and discover knowledge. Constructivist learning theory considers learning as a social process in which learners co-construct knowledge through communication and cooperation with others. Therefore, teaching should encourage cooperative learning and teamwork among students, promote their communication and interaction, and co-construct knowledge.

The Necessity of Applying Virtual Simulation Laboratory in University Physics Teaching

An Effective Way to Improve Teaching Quality

A virtual simulation laboratory is a powerful and effective teaching tool, and the use of a virtual simulation laboratory in university physics teaching helps to improve the quality of teaching. This teaching method presents the experimental scene in front of students through computer simulation, providing them with a safe and controllable environment in which they can perform experimental operations and observe the results, thus enhancing their practical skills and scientific investigation ability. The advantage of the virtual simulation laboratory is that it is highly visual and interactive. Students can intuitively observe the process of experimental phenomena through the computer interface, adjust the experimental conditions, and record data and observations at any time. This real-time feedback mechanism can help students gain a deeper understanding of physical principles and deepen their understanding and application of knowledge. In addition, virtual laboratories provide a broader range of experiments and more in-depth experimental content. In traditional physics laboratories, students may not be able to carry out complicated or dangerous experiments due to the limitation of conditions, while virtual laboratories can simulate a variety of complex physical phenomena, allowing students to explore more knowledge in different fields. For example, students can understand the experimental content of optics, electromagnetism, mechanics, and other fields through virtual experiments, thus forming a more comprehensive knowledge system of physics. Compared with traditional experiments, virtual simulation laboratories also have the advantages of flexibility and resource-saving. In traditional experiments, schools need to buy a large number of experimental equipment and consumables and need to consume a lot of time and manpower to prepare and clean up. In contrast, virtual laboratories do not require a large amount of experimental equipment and consumables and can be conducted with only a computer and the appropriate software. This not only saves resources but also saves time, enabling schools to make better use of resources and improve teaching efficiency. In addition, virtual labs can provide a personalized learning experience. By setting up different experimental scenarios and difficulty levels, students can choose according to their learning progress and interest, thus improving the relevance and effectiveness of learning. In summary, the virtual simulation laboratory has an important role in the teaching of university physics, which can help students better understand the principles of physics, improve their practical ability, expand their knowledge, save resources, and provide a personalized learning experience, thus effectively improving the quality of teaching.

The Need to Cultivate Innovative Talents

In today's rapidly developing scientific and technological era, cultivating innovative talents has become one of the important tasks of higher education. The application of virtual simulation laboratories in university physics teaching precisely meets this demand. The virtual laboratory provides students with a safe, controllable, rich, and diverse experimental environment, which helps to cultivate students' innovative thinking, and practical and problem-solving abilities. First of all, virtual simulation laboratories provide students with a platform for exploration and experimentation. Traditional physics experiments are usually limited by conditions, time, and safety, while virtual laboratories can simulate various experimental scenarios and allow students to explore in a safe environment. Students can gain an in-depth understanding of physical principles through independent operation and observation, and develop a positive spirit of exploration and a sense of innovation. Secondly, virtual labs provide opportunities for independent and personalized learning. Students can choose experimental projects with different levels of difficulty and content for exploration according to their interests and learning progress. This kind of independent learning fosters students' independent thinking and problem-solving abilities, stimulates their interest in learning, and thus subconsciously cultivates their sense of innovation and creativity. In addition, the virtual simulation laboratory promotes interdisciplinary cross-fertilization. In the process of experimentation, students may acquire knowledge and skills in many subject areas such as physics, computer science, engineering, and so on. Through interdisciplinary co-operation and communication, students can not only broaden their disciplinary horizons, but also learn the connections and applications between different disciplines, and develop a comprehensive creative ability and interdisciplinary way of thinking. Finally, the virtual laboratory also provides students with the opportunity to connect with the international advanced level. Through the use of advanced virtual simulation technology, students can come into contact with the latest scientific research results and technology applications, understand the international scientific research frontier dynamics, develop the ability to solve practical problems and a sense of innovation, and lay a solid foundation for them to engage in scientific research and innovation in the future. In summary, the application of a virtual simulation laboratory in university physics teaching is the need to cultivate innovative talents. By providing a safe, rich, and diverse experimental environment, promoting independent and personalized learning, interdisciplinary cross-fertilization, as well as convergence with the international advanced level, the virtual laboratory helps to cultivate students' innovative consciousness, practical ability, and problem-solving ability, thus making a positive contribution to their future innovative work and social development.

Inquiry-Based Teaching of University Physics Based on Virtual Simulation Laboratory

College physics inquiry-based teaching based on a virtual simulation laboratory is a teaching method that guides students to deeply understand physics principles through experiments and investigations. In the teaching process, the teacher first introduces the learning objectives and the content of the experiment. The teacher introduces students to the purpose of the experiment, the physical concepts involved, and the questions to be explored. At the same time, the teacher can provide some background knowledge and theoretical basis to help students understand the meaning and importance of the experiment. Second, students enter the virtual simulation laboratory to experiment. Students log in to the virtual simulation experiment platform, choose the corresponding experimental projects, and follow the teacher's instructions to carry out the experimental operation. In the virtual environment, students can simulate different experimental conditions, adjust parameters, observe experimental phenomena, collect data, and analyze results. Then, students carry out data analysis and discussion of the

experimental results. Based on the experimental results, students analyze and process the data and propose possible conclusions and explanations. Under the guidance of the teacher, students work together to explore the significance of the experimental results and possible physical principles through discussion and communication to deepen their understanding. Then, students carry out further investigations and experimental designs. Based on the analysis and discussion of the experimental results, students may formulate new questions or hypotheses and design further experiments to verify or explore in depth. In the virtual simulation laboratory, students can flexibly adjust the experimental conditions, perform experimental operations, and observe experimental phenomena, to further investigate the physical principles. Finally, students summarise the experimental results and reflect on them. Based on the experimental results, students summarise the conclusions and findings of the experiment and generalize the physical principles and laws. At the same time, students should also reflect on the experimental process and results, think about the possible errors and uncertainties in the experiment, and make suggestions for improvement and optimization. Throughout the teaching process, the teacher plays a guiding and facilitating role, guiding students to conduct experiments and investigations by providing learning objectives, background knowledge, and experimental instructions, as well as giving timely feedback and guidance. Students, on the other hand, are the main body of learning, and through experiments and investigations, they gain a deeper understanding of the physical principles and cultivate the spirit of scientific investigation and experimental design ability.

Conclusion

The application of virtual simulation laboratories in university physics courses can effectively solve the problem of the lack of experimental teaching in university physics courses in China's colleges and universities, but also make up for the shortcomings of the traditional physics experimental teaching, for the reform of the university physics course teaching to provide a new idea, so that students can better master the theoretical knowledge of physics and experimental skills, to stimulate the students' interest in learning physics, and to improve the innovation ability of the students. At the same time, the application of a virtual simulation laboratory also puts forward higher requirements for college physics teachers, not only to require teachers to have a solid theoretical foundation and rich practical experience but also to continuously improve their quality, master advanced information technology, and improve the quality of teaching and teaching level. In conclusion, the combination of a virtual simulation laboratory and a university physics course gives full play to the important role of a virtual simulation laboratory in the experimental teaching of a university physics course, which is of great significance in improving the quality of university physics teaching, stimulating students' interest in learning, and cultivating students' ability.

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