

# Exploration of Principles of Energy Conversion Course Teaching Based on VR Technology

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**Abstract:** "Principles of Energy Conversion" is a core course for the Energy and Environmental Systems Engineering major, characterized by its strong professionalism and the complexity of the equipment structures involved, making it difficult for students to observe the overall structure of boilers and turbines on-site. This paper explores the integration of virtual reality (VR) technology into the course by introducing a VR-based teaching reform plan, which includes four parts: VR scene tours of power plants, basic principle teaching, interactive structural design, and summary and evaluation. This teaching design meets the requirements of both principle learning and course design for students, enhancing their learning experience and level of understanding.

**Keywords:** VR; Principles of Energy Conversion; Curriculum Construction; Curriculum Reform.

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## 1. Introduction

"Principles of Energy Conversion Course" is a core course of energy and Environmental systems engineering. It aims to make students understand and master the process of converting coal and other fuels from chemical energy to kinetic energy through boilers and steam turbines, as well as the structure and characteristics of two kinds of power equipment, so as to solve environmental problems in the process of energy conversion.

This course involves two types of power equipment, boilers and turbines, which are structurally complex and large-scale devices operating in thermal power plants. Therefore, it is difficult for teachers to provide physical boilers and turbines for students to learn visually. PowerPoint presentations are also weak in displaying three-dimensional images, and it is not easy for teachers to obtain three-dimensional structural models of boilers and turbines. As a result, students find it challenging to learn this course, struggle to digest and absorb the knowledge, and fail to achieve the course objectives.

Virtual Reality (VR) technology is a technique that uses computer-generated virtual environments, allowing students to view the overall structure and operation process of boilers and turbines through head-mounted glasses. Currently, many teachers have explored the application of VR technology in courses. Mao, et al. [1] taking the design of light steel portal frame structures as a starting point, developed a VR virtual simulation teaching system for the design of light steel portal frames, guiding students to learn the basic principles of steel structures and to design a portal frame structure in a virtual reality scenario, achieving good teaching results. Han, et al.[2] applied the "VR+ideology course" teaching concept, based on the red revolutionary culture, using immersive VR technology to explore and construct an immersive teaching model for revolutionary culture in college ideology courses. Xie et al.[3] developed a military food nutrition course teaching model through 5G+VR technology, discussing the application of 5G+VR in theoretical teaching, practical teaching, and differentiated training of students in food nutrition courses. Shen et al. [4] introduced VR technology as a new teaching method, providing a new solution for students' cognitive

internships and enhancing the immersion and participation of students in the learning process.

The course "Principles of Energy Conversion" is offered by a limited number of institutions, and the teaching designs and plans for this course are not yet well-developed. Therefore, this paper explores the application of VR technology in the teaching of the "Principles of Energy Conversion" course, aiming to help students better understand the two types of power equipment, boilers and turbines, as well as the entire energy conversion process, in order to provide talent support for further environmental protection.

## 2. Introduction of VR Technology

### 2.1. Basic Introduction

VR technology is a virtual environment generated by computers that allows users to immerse themselves within it. It includes components such as head-mounted displays, motion tracking technology, and interactive devices, which can simulate real-world scenes and enable user interaction [5]. VR technology has been widely applied in the fields of entertainment, healthcare, and education [6]. For instance, in entertainment, virtual reality games, movies, and concerts allow users to enter the game world, interact with characters, and enjoy an immersive gaming experience through virtual reality devices. Additionally, VR technology has been utilized in the healthcare field for patient rehabilitation training and virtual surgical simulations. The education sector has also begun to apply virtual reality technology in teaching, such as through virtual laboratories where students can perform experimental operations to enhance their practical skills. VR technology will become more widespread and sophisticated. With improvements in hardware equipment and a decrease in prices, VR technology will be more easily accepted and used by ordinary users. At the same time, software developers will also create more applications suitable for virtual reality devices, further expanding the application scenarios of virtual reality technology. Furthermore, VR technology will integrate with other technologies to create a more comprehensive experience. For example, the combination with Augmented Reality (AR) technology[7] can blend virtual objects with the

real world, providing a more authentic experience. The integration with Artificial Intelligence technology can lead to more intelligent virtual characters, offering a better interactive experience.

## 2.2. Application of VR Technology in the Course of Principles of Energy Conversion

### (1) Three-Dimensional Display

Using VR technology to construct 3D models of boilers and turbines, showcasing the complex structures and processes in the principles of energy conversion. Students can better understand the course content and deepen their understanding of the principles through an immersive learning experience.

### (2) Virtual Laboratory

Utilizing VR technology to establish a virtual laboratory, simulating the assembly process of boilers and turbines. Students can experience firsthand through VR devices, operate virtual equipment, observe and analyze the entire assembly process of boilers and turbines, allowing for a more profound understanding of their structures.

### (3) Virtual Scene Demonstration

Creating virtual scenes to simulate actual thermal power plant engineering cases. For example, how to change the operating parameters of the boiler, how to handle various dangerous situations, students can observe the operation of various energy conversion equipment in a virtual environment, and understand the layout and working principles of the equipment.

## 3. Curriculum Reform Plan for Principles of Energy Conversion Based on VR Technology

"Principles of Energy Conversion" is a core course in the field of modern energy engineering, involving knowledge from thermodynamics, fluid mechanics, and other disciplines. Traditional teaching methods often struggle to vividly display abstract concepts and complex principles. To enhance students' interest and in-depth understanding, introducing Virtual Reality (VR) technology has become a feasible teaching method. "Principles of Energy Conversion" is divided into two parts: the upper part is the principle of boilers, mainly covering the main structure of boilers, the working principle of boilers, the basic theory of the boiler working process, and the basic methods of boiler thermodynamic calculations and water circulation calculations. The lower part is the principle of turbines, mainly including the working principle of turbine stages, multi-stage turbines, and the variable working conditions characteristics of turbines. Students are required to master the basic principles of boiler operation, have general knowledge of safe and economical boiler operation, understand the working principles and thermodynamic characteristics of turbines, be familiar with the basic structure of turbines, and train students to have preliminary abilities to analyze engineering problems, make judgments, and solve practical problems. The turbine principle part mainly includes the working principle of turbine stages, multi-stage turbines, and the variable working conditions characteristics of turbines.

### 3.1. Design of VR Simulation Teaching System

The teaching of the "Principles of Energy Conversion" course based on VR technology takes VR simulation teaching

as the entry point. The VR virtual simulation teaching system mainly includes teaching management modules, scene tour modules, principle demonstration modules, and structural construction modules, as shown in Fig. 1.

The teaching management module consists of student information management, teaching data management, and grade management; the scene tour module builds a real thermal power plant at a 1:1 scale, including boiler and turbine modules, where students can observe various equipment along the power generation process; the principle demonstration module mainly includes the process demonstration of the coal milling system, combustion system, steam and water system, and slag and ash removal system during boiler operation, as well as the working fluid cycle system of the turbine; the structural interaction design module includes structural calculation, selection, and assembly, where students can choose the correct equipment model and parameters in the VR scene according to the structural design parameters, and then build the entire system.

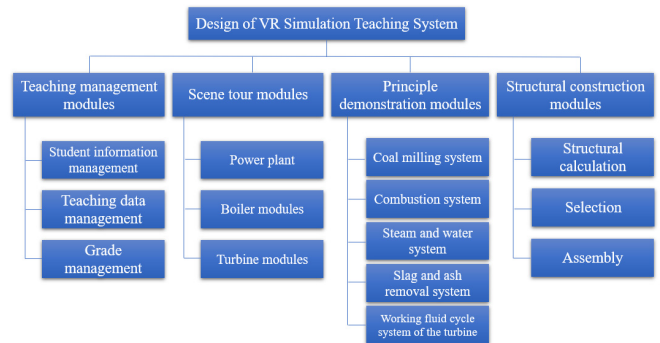


Fig 1. VR Simulation Teaching System

### 3.2. Design of the Teaching Process

Following the principles of free exploration and theory guiding practice, the VR virtual simulation teaching of the "Principles of Energy Conversion" course is divided into four main sections: VR scene tour of a thermal power plant, basic principle teaching, interactive structural design and summary and assessment, as shown in Fig. 2.

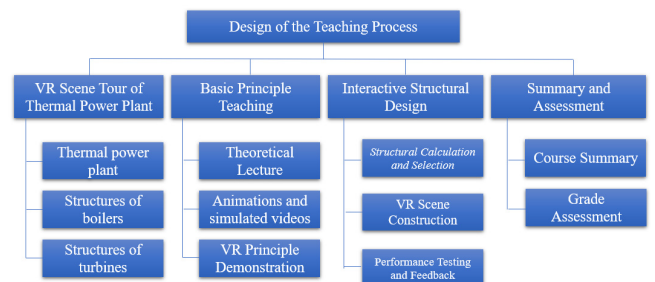


Fig 2. Design of the Teaching Process

#### (1) VR Scene Tour of Thermal Power Plant

Students are guided to wear VR glasses to tour a thermal power plant. Through preset scene descriptions, students are introduced to the key equipment of thermal power generation, boilers and turbines, and are instructed to observe the main structures of boilers and turbines. This gives students a basic understanding of these two types of power equipment and clarifies their research direction for the next steps.

#### (2) Basic Principle Teaching

After gaining a direct understanding of the thermal power plant through the VR scene tour, the next step is the teaching of basic principles.

**Theoretical Lecture:** Teachers use multimedia presentations to explain the basic principles of energy conversion in detail, including the basics of thermodynamics and the working principles of boilers and turbines. Animations and simulated videos are used to demonstrate the working processes of boilers and turbines, helping students understand complex physical processes.

**Interactive Q&A:** During the theoretical lecture, teachers can set questions to encourage students to ask and discuss, in order to test their understanding and answer doubts in a timely manner.

**VR Principle Demonstration:** Students enter the principle demonstration module through VR devices to observe the coal milling system, combustion system, steam and water system, and slag and ash removal system during boiler operation, as well as the process demonstration of the working fluid cycle system of the turbine. Teachers provide guidance on the side, explaining the function of each system and their role in energy conversion.

### (3) Interactive Structural Design

After students have mastered the basic principles, they enter the interactive structural design phase, applying theoretical knowledge to practical operations.

**Structural Calculation and Selection:** Students perform structural calculations for boilers and turbines based on their knowledge, selecting appropriate equipment models and parameters. Teachers provide guidance to help students understand the impact of different parameters on system performance.

**VR Scene Construction:** Students choose the right equipment models and parameters in the VR scene according to the design parameters and build the entire boiler system. Through VR interaction, students can visually see their own design structure and make adjustments and optimizations.

**Performance Testing and Feedback:** The system designed by students is tested for performance by a computer preset structural calculation program, providing feedback on the correctness of the design. Teachers guide students to analyze the problems based on the test results and make design improvements.

### (4) Summary and Assessment

**Course Summary:** At the end of the course, teachers summarize the entire teaching process, emphasizing key knowledge points and skills. Students share their learning experiences, and teachers provide feedback and suggestions.

**Grade Assessment:** Students' performance in the VR scene tour, basic principle teaching, and interactive structural design sections is comprehensively assessed. The assessment includes not only the mastery of theoretical knowledge but also practical operation ability and innovative thinking.

## 4. Prospects of VR Technology in the Teaching of Principles of Energy Conversion

VR technology holds broad prospects in the teaching of the Principles of Energy Conversion course, offering new possibilities and transforming the classroom experience from traditional two-dimensional methods to a more immersive and practical learning experience. Here are the prospects of VR technology in this field:

**Enhancing Learning Experience:** VR technology can create virtual three-dimensional environments, allowing students to virtually visit actual scenes such as energy conversion

equipment and power plants. This immersive learning experience helps students better understand abstract theoretical concepts and enhances their interest in the subject.

**Cultivating Practical Operation Skills:** The introduction of virtual laboratories allows students to perform practical operations in a safe environment, manipulate virtual equipment, and observe real-time data. This helps cultivate students' hands-on abilities and experimental design skills, preparing them for future work.

**Global Collaboration and Resource Sharing:** Using VR technology, students can participate in virtual collaboration projects worldwide, sharing resources and knowledge. This global collaboration model helps broaden students' horizons and gives them a better understanding of energy conversion issues and solutions in different regions.

**Personalized Learning Paths:** VR technology can provide personalized learning paths based on students' learning styles and levels. Through virtual scenes and experiments, students can learn at their own pace, better understanding and mastering the course content.

## 5. Conclusion

This paper successfully integrates VR technology into the teaching process of "Principles of Energy Conversion" through four parts: VR scene tours of power plants, basic principle teaching, interactive structural design, and summary and evaluation. The application of VR technology in the course has shown its potential to enhance teaching effectiveness and student experience. The use of VR not only revolutionizes traditional teaching methods but also provides students with a more enriched, interactive, and practical learning platform. With the continuous advancement of technology, VR is expected to play a more critical role in engineering education, helping to cultivate professionals with innovative and practical skills in energy and environmental systems engineering.

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