Thermodynamics Classroom Teaching Reform with Virtual Experiments

Bin Zheng, Youtang Wang, Peng Sun, Jian Meng

***Abstract*— Virtual experiment teaching is an important part of informatization teaching. It has become a research hotspot to integrate virtual experiment into classroom teaching. In the paper, the concept of "experiment first" virtual experiment link into classroom teaching was introduced, the "virtual experiment→the theoretical knowledge explanation→virtual experiment" circular teaching mode to carry out the core knowledge point teaching was adopted. The implementation effect is good and can effectively improve the learning efficiency.**

***Index Terms*— Virtual experiment, Classroom Teaching, Informatization teaching, Thermodynamics**

I. INTRODUCTION

Engineering thermodynamics is one of the earliest branches of thermodynamics and is one of the core courses of the energy and power engineering. It mainly studies the law of the interconversion and application between thermal energy, mechanical energy and other energy. Its main content is the macroscopic theory of thermal phenomena. The method for research is macroscopic major. Under the background of accreditation of engineering education, the engineering thermodynamics is generally included in the course system by all the majors involved in the certification. This course has become a compulsory course for many engineering majors.

Since heat is a kind of invisible object of study, at the same time, the lack of perceptual knowledge in the whole course makes it difficult for students to learn. However, experimental teaching can increase students' perceptual knowledge of the process of thermal, enhance students' understanding of curriculum knowledge, and cultivate the ability to practice and innovation consciousness at the same time, so the experiment teaching plays an important role in the teaching of engineering thermodynamics. However, in reality, the experimental link is often limited by the lack of experimental equipment resources, so it is difficult to ensure that every student can fully participate in the physical experiment, which leads to the teaching effect will be poor. In the context of information-based teaching, virtual experiments can effectively solve this problem[1-4]. This project intends to apply the virtual experiment to the teaching of engineering thermodynamics in order to stimulate students' interest in learning and improve their comprehensive ability.

II. CHARACTERISTICS OF VIRTUAL EXPERIMENT

Virtual experiment is to model real physical phenomenon or process by using theoretical model, numerical method, information network and computer technology, and it is displayed on the computer in the form of pictures, video, animations or curves, and is used through network sharing. Virtual experiment has the following characteristics: (1) the adjustable scope of virtual experimental parameters is large. Students can easily change the experimental parameters, realize the experimental research under different conditions, so that the experiment can be conducted simply. At the same time, the research on the effect of important parameters on the results can be realized by eliminating the confounding interference of secondary information, and the key information of the experiment can be obtained. (2) Virtual experiments has less limitation on objective conditions and high efficiency. It can save a lot of waiting time from unsteady state to steady state condition, and enable students to complete more experimental content and obtain more experimental results in a limited time, so as to improve students' quick understanding and grasp of relevant knowledge points. (3) The virtual experiment can clearly display the experimental phenomena that are inconvenient to observe or have small changes. Many experiments are difficult to realize and observe at the micro scale. Virtual experiments can directly link theoretical knowledge or model equation with physical phenomena or parts application, and then present corresponding experimental results.

III. PRACTICE OF VIRTUAL EXPERIMENT

Four virtual experiments were set up in this course, including experiment on specific heat at constant air pressure, experiment on the phase change of carbon dioxide, experiment on the relationship between temperature and pressure of saturated steam, and nozzle characteristic experiment. In the context of "student-centered" teaching environment and philosophy, the teaching process of this project has established the central status of learning of the student, introduced the concept of "experimental first" experimental link into classroom teaching, and adopted the three-stage feedback teaching model to carry out classroom teaching. The specific scheme is: (1) Before the lecture, the teacher arranged the students into groups and completed the relevant experiments by using the virtual experimental platform. The teacher proposed the scientific problem to be solved, and asked the students to observe experimental phenomena and record relevant experimental data. The students form the explanation of the problem should to be solved by observing relevant experimental phenomena and consulting materials. (2) In class, the lecturer will pick up one group of students to tell the experimental phenomena at any time, and ask them to give theoretical explanations of relevant problems. The teacher and other students will discuss them, so as to clarify the content of knowledge points. (3) After class, students repeat the relevant experimental content again

with the answers, so that the experimental results can confirm the content of relevant knowledge points again, and completed the experimental report. In this mode of teaching, since students are in a state of seeking for reasons and solving puzzles in the learning process, they are more engaged. The practice of theoretical feedback after class allows students to deeply integrate the experimental results of perceptual knowledge with the scientific theories of rational knowledge, strengthen the understanding and memory of knowledge points, and finally achieve the goal of significantly improving the learning effect.

IV. Practical Effect

This project has been carried out in the course of teaching engineering thermodynamics in energy and power engineering. There are regular class and experimental class for comparison. The regular class adopts the regular teaching mode, which is dominated by classroom teaching and experimented after teaching, while the reform class adopts the teaching mode introduced in the third part of this paper. The effect evaluation of this project consists of two parts: performance assessment and questionnaire survey.

A. Performance Assessment

The average scores of the two classes were analyzed, and the results were shown in Table 1. It can be seen from Table 1 that the average score of the virtual experimental fusion class adopting the teaching program of this project is 5.2 higher than that of the conventional class. The main reason is that students are always in a state of active learning throughout the teaching process. From finding problem (experimental phenomena and experimental data which were obtained from virtual experiments), to solving problems(determining the answers of the questions independently, discussing and improving them in class), to proving theoretical knowledge in practice (the experiment after class feedback the classroom teaching link), students always maintain a state of inquiry, which can effectively improve the learning initiative and interest of students, and then the improvement of teaching effect was realized (in the form of final grade).

Table 1 Comparison of average scores

Serial number	Name	Number of people	Test score
1	regular class	59	78.2±4.3
2	experimental class	63	83.4±3.3

B. Questionnaire Survey

For the teaching effect, this survey evaluates it from three aspects: classroom teaching, knowledge acquisition and ability training. The score of questionnaire ranged from 0 to 10, the number 0 means that there is no enhancement, the number 10 means that there is a significant improvement. Fig.1 shows that students have a high evaluation to the teaching program , and they think that the program has positive significance to the improvement of students' comprehensive ability. In terms of classroom teaching, students believe that the teaching mode of this project is conducive to the improvement of the activity of classroom atmosphere and the effective communication between teachers and students. In terms of knowledge acquisition, this teaching mode can combine theoretical knowledge with practice, encourage students to think independently and improve their learning efficiency significantly. In terms of ability training, the teaching model encourages students to study in a project-driven way, which improves their thinking ability in scientific research and their ability to analyze problems. At the same time, students' organizational and teamwork skills have also been greatly improved.

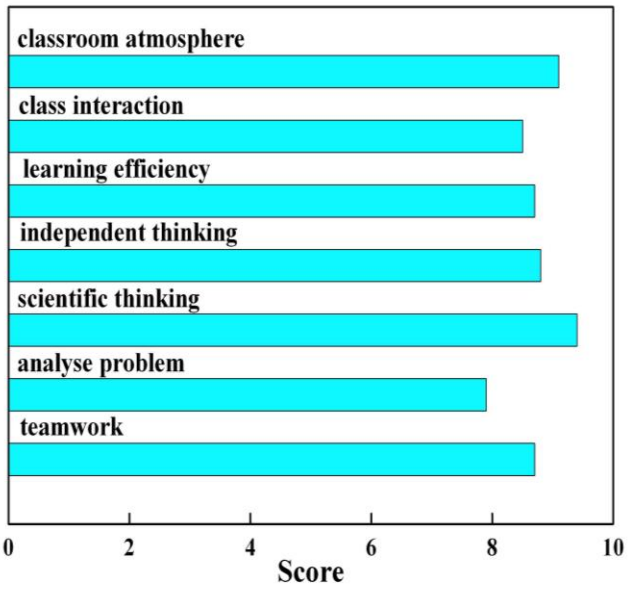

Fig.1 Questionnaire evaluation results

V. Conclusion

Virtual experiment teaching is an important part of information-based teaching. Through simulation, digital modeling and multimedia technology, a visualized 3d environment is created on the computer to create a simulated performance of instrument, experimental objects, experimental conditions and environment. In teaching, it is beneficial to expand the scope of experimental teaching, enrich students' online learning resources, and break the limitation of the traditional teaching mode in time and space. In addition, the learning enthusiasm of students will be stimulated by it. it, which makes up for the deficiency of traditional experimental teaching, and helps to improve the teaching quality greatly. The project sets the teaching goal of "student-centered", introduces the idea of "experimental first" into classroom teaching, and adopts the three-part feedback teaching model to carry out classroom teaching. The teaching effect of this project is good, and the learning efficiency of students is obviously improved, which provides certain reference value for the teaching of related courses.

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Bin Zheng works as an associate professor in the School of Transportation and Vehicle Engineering, Shandong University of Technology. He is specialized in virtual experiment teaching method. He is the corresponding author of this paper.

Youtang Wang graduated from Ph. D. and works as a lecturer in the School of Transportation and Vehicle Engineering, Shandong University of Technology. His main research field is virtual experiment teaching method.

Peng Sun graduated from Ph. D. and works as a lecturer in the School of Transportation and Vehicle Engineering, Shandong University of Technology. His main research field is virtual experiment teaching method.

Jian Meng graduated from Ph. D. and works as a lecturer in the School of Transportation and Vehicle Engineering, Shandong University of Technology. His main research field is virtual experiment teaching method.