Application of Coupling Teaching Mode of Virtual Experiment and Entity Experiment in Engineering Thermodynamics

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***Abstract*—Under the circumstances that the certification process of engineering education is advancing rapidly, The Engineering Thermodynamics has become a compulsory course for certification majors. To improve the teaching effect of Engineering Thermodynamics, under the premise of giving full play to the advantages and complementarities of virtual experiment and entity experiment, this paper introduces a new experimental teaching concept which name is experiment first and the experiment teaching is carried out by adopting the coupling teaching mode of virtual experiment and entity experiment. The implementation of the teaching effect is good.**

***Index Terms*—coupling teaching mode, virtual experiment, engineering education professional certification**

I. Introduction

Professional certification is the basic way of professional evaluation of higher education in developed countries. A professional has passed professional certification, which means that its graduates meet the quality standards recognized by the industry. In 2016, China formally joins the Washington Agreement International Organization on engineering education, this indicates that the quality certification system of engineering education in China has achieved the international substantial equivalence. As a full member of the Washington Agreement, the results of quality certification of engineering education in China have been approved by 18 other member countries (regions). By the end of 2017, the higher Education Evaluation Center of the Ministry of Education and the China Engineering Education Professional Accreditation Association have certified 846 engineering majors in 198 colleges and universities throughout the country, the process of engineering education specialty certification in China is advancing rapidly.

The certification of engineering education requires that the curriculum of the certification profession must include courses in the field of heat. Because the Engineering Thermodynamics mainly studies the law of conversion among thermal energy and mechanical energy. The main content is the macroscopic theory of thermal phenomenon, it is more common to be included in the certification system to participate in the certification program. Thus, the Engineering Thermodynamics has changed from a core basic course of energy and power engineering major to a quasi-compulsory course for engineering major.

Because 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 entity 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]. In order to stimulate students' interest in learning and improve their comprehensive ability, a coupling teaching mode of virtual experiment and entity experiment was studied in this paper.

II. Analysis of Advantages and Disadvantages of Virtual Experiment and Entity Experiment

In the entity experiment, the students have real experience in visual, listening, feeling, touching, etc. By actually operating the equipment and real observation of experimental entity phenomena, which plays an important role in improving students' ability to observe and analyze problems. For comprehensive design experiments, teamwork is required to complete, which is very meaningful for the team spirit and collaboration spirit of the students. However, entity experiments also have problems such as large investment, limited number of equipment sets, tight laboratory area, conflicts between experimental time and teaching practice, and difficulty in meticulous observation of subtle experimental phenomena [5].

Virtual experiment is to model real entity 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 entity phenomena or parts application, and then present corresponding experimental results. However, virtual experiments also have certain limitations. First of all, there is no entity sense. Students can't get the experience of actually operating equipment and equipment, which is not conducive to the cultivation of practical hands-on ability. Secondly, the virtual experiment is too precise. Each experimental process is exactly the same. It is difficult to actually simulate the various interference factors and errors existing in the entity experiment, which is unfavorable to the cultivation of students' innovative ability and awareness of the problem.

III. Coupling Teaching Mode of Virtual Experiment and Entity Experiment

Virtual experiments and entity experiments with well complementary, students will form a relatively intuitive impression by using their own observation and analysis of the model in a virtual experiment environment, and then use the operation of various equipment functions to understand, strengthening the understanding of experimental principles and rules will form peliminary cognitive skills and operational skills. In the entity experiment, there is positive migration effects, which can effectively promote the development and completion of entity experiments, and enable students to continuously improve their practical skills in practice.

Based on the advantages and characteristics of the experimental teaching method of "virtual and real", the coupling teaching mode of virtual experiment and entity experiment was applied in Engineering Thermodynamics. 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 (as shown in Fig. 1). 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 virtually do the entity first 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.

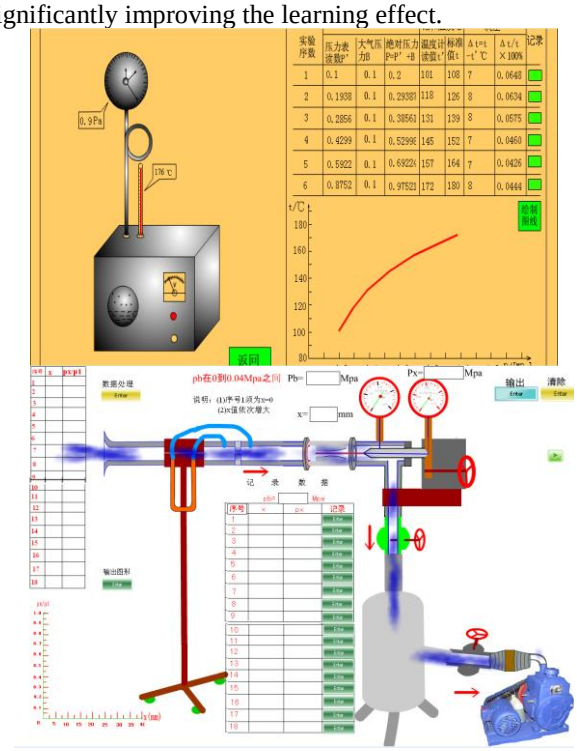

Figure 1. Virtual experiments.

IV. Reform 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 average scores of the two classes were analyzed. The results are shown in Table 1. It can be seen from Table 1, the average grade of the reform class using the teaching plan of this paper is 3.4 points higher than the regular 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	40	78.2 ± 4.3
2	experimental class	39	81.6 ± 3.3

V. CONCLUSION

Under the rapid development of the engineering education professional certification process, the Engineering Thermodynamics has become a compulsory course for the certification profession. Because heat is an invisible research object, in order to let students better master the knowledge of heat, the experimental teaching is a way to effectively improve teaching effectiveness. Under the premise of giving full play to the advantages and complementarities of virtual experiments and entity experiments, this paper introduces a new experimental teaching concept which name is experiment first and the experiment teaching is carried out by adopting the coupling teaching mode of virtual experiment and entity experiment. The teaching effect of this paper is good, and the learning efficiency of students is obviously improved, which provides a certain reference value for the teaching of related courses.

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