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Exploration and Practice of Chemical Engineering Principle Experiment Teaching under the Background of Engineering Education Certification

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Abstract: *Professional accreditation is the basis for the implementation of engineering education, which is conducive to promoting the connotative development of higher education in China and improving the quality of talent cultivation. The experiment of chemical principle is the main course of chemical engineering and process majors. In line with the standards required by professional accreditation, this paper explores teaching conditions, teaching modes, teaching content assessment, and teacher teams to foster engineering literacy and innovation among students, which will play a role in promoting comprehensive literacy among students and deepening practical teaching reforms in the curriculum.*

Keywords: *Engineering Education, Professional Accreditation, Chemical Principle Experiment, Teaching Exploration*

1. Introduction

Engineering education is an important component of higher education and is vital to the development of the industrial system. The pace of development of engineering education in domestic colleges and universities is gradually accelerating, and the implementation of engineering professional certification is a major measure to improve the quality of engineering education and a key step in the internationalization of engineering professional education in colleges and universities. The accreditation of engineering education programs examines factors such as professional curriculum settings, school conditions, and faculty allocation, emphasizes the cultivation of students' practical and innovative engineering abilities, determines graduation requirements that can be assessed by graduates, and is capable of cultivating innovative talent in chemical engineering. These factors all focus on the graduation ability of students, which helps to enhance the core competitiveness of chemical talent and contribute to sound development of the chemical industry.

Currently, there are three engineering majors at Taishan University's School of Chemistry and Chemical Engineering: Chemical Engineering and Technology, Pharmaceutical Engineering, and Polymer Materials and Engineering. Under the environment of professional certification of engineering education, teachers in charge of the courses find out the problems in teaching according to the current teaching status of Chemical Principle Experiments and propose measures for reform, so as to lay the foundation for the improvement of students' comprehensive ability and cultivate engineering talents needed by society.

To enable students to meet graduation requirements, specific index points required for engineering professional certification are supported by specific foundation and professional courses. Chemical Principles and Experiments is a professional foundation and compulsory course covering a wide range of content, including chemical unit operations, equipment principles and applications. They are close to actual industrial production and support the problem analysis and research, engineering and social aspects of the basic requirements for professional accreditation. In order to raise the level of experimental teaching and meet the requirements for professional certification in engineering, we have explored and practiced experimental teaching of chemical principles as follows.

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2. The present state of the experimental course of chemical principles

Through experiments, students can deepen and consolidate their understanding of the operation process of chemical plants, establish engineering concepts for chemical production, strengthen experimental manipulation skills, enhance skills training for solving practical problems, improve communication skills, and lay the foundation for solving practical engineering problems. With the deep implementation of professional certification, existing experimental teaching suffers from the following shortcomings.

2.1. The teaching system needs to be optimized

The teaching mode of the experimental course on principles of chemical engineering is outdated, with little interaction between teachers and students, and low motivation of some students to learn, which limits the improvement of the quality of the teaching. The evaluation system of most universities attaches importance to scientific research and neglects teaching, resulting in teachers rarely explaining the latest scientific and technological progress and achievements in the teaching process, and insufficient innovation in teaching methods and contents [1]. In our laboratory courses on chemical principles, students are able to develop practical and collaborative skills, but deficiencies in chemical safety and large-scale practical training make it difficult to effectively cultivate innovation, engineering application and independent thinking in students, and the teaching system needs to be further optimized.

When the pace of theory classes does not coincide with the teaching arrangement of chemical principles experiments, it will reduce the teaching effect and affect the theory guiding practice [2]. In experimental classes, students were vague about knowledge points and could not remember them. Teachers need to lead students through a review of theoretical knowledge and then explain the experimental procedure and steps of operation. As a result, students are unable to actively analyze and solve the problems they encounter and are receptive to learning, which does not foster the ability of students to analyze and solve problems independently.

2.2. The ideological elements of this course need further discussion

Contemporary university students have a strong sense of individuality and a weak sense of teamwork. Not only do we offer special ideological and political courses, but we also integrate ideological and political education into each course. Experimental courses on chemical principles can develop students' ability to analyze and deal with practical engineering problems using dialectical materialism and scientific methods. On the other hand, it can adopt implicit infiltration, classroom discussion, and heuristic teaching modes to incorporate elements of moral education such as national sentiment, scientific spirit, and engineering morality into experimental teaching, and train students to establish correct socialist core values.

3. Practice and exploration of experimental teaching of chemical principles

3.1. Pre-course pre-study

Pre-course pre-study mainly consists of on-site pre-study and written pre-study. The experimental apparatus of chemical principles (figure 1) is so close to the actual engineering apparatus, and the engineering features are so obvious, that it is difficult for the student to understand the structure and principles of the experimental apparatus by mere book study (figure 2). Therefore, prior to the experimental course, students are organized for on-site pre-study, under the direction of an instructor, to view the experimental apparatus and understand the experimental process. Written pre-study means that students complete a pre-study report based on their on-site pre-study, understanding the basic requirements of the experiment and the experimental apparatus, combined with what is presented in the experimental lecture notes. The teacher grasps the students' pre-study situation by reviewing the pre-study report, which can be used as part of the experimental grade.

It has been demonstrated that by pre-study on site, students are able to learn and understand the apparatus and experimental procedures in lecture notes prior to the experimental lesson. With the written pre-study report, the students were reinforced the purpose of the experiment, the principles of the experiment, and the steps of the experiment, and were more clear about the requirements for the

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experimental parameter measurements. Pre-study sessions significantly improve the teaching effectiveness of lab classes, mobilize student initiative, avoid situations where students are simply operators in lab classes, and play a primary role as students.

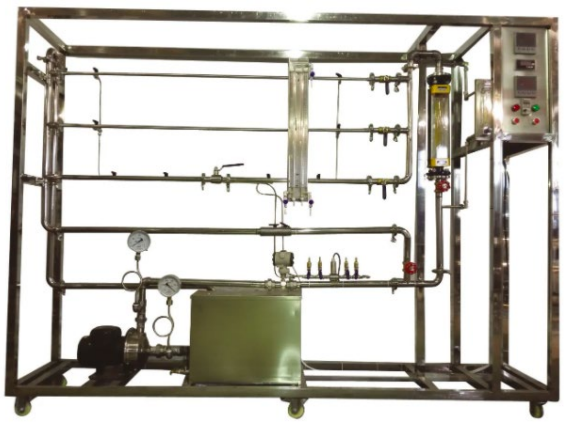

Figure 1: Physical picture of comprehensive experimental device for flow process.

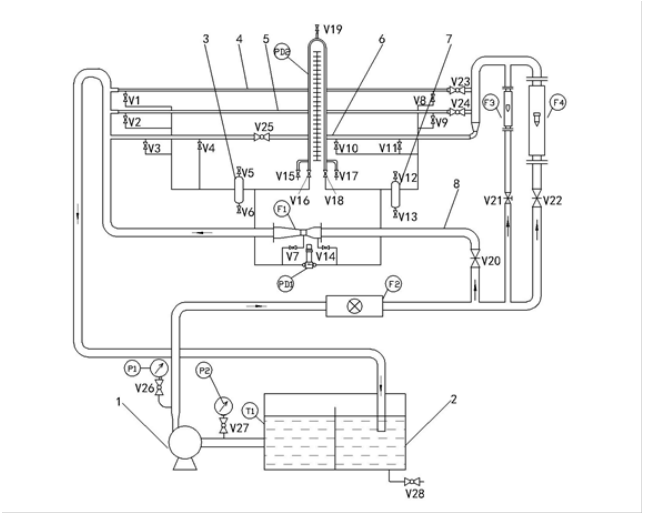

Figure 2: Diagram of comprehensive experimental device for flow process.

3.2. Experimental operations

3.2.1 Pre-course lecture

Experimental interpretation consists mainly of experimental purposes, experimental principles, and experimental requirements. In experimental interpretation, attention should be paid to the penetration of the desired engineering concept, reflecting the engineering characteristics. For experimental purposes, in addition to the introduction of the experiment, one needs to examine the relationship between the parameters or the principles and formulas to be verified, and also to introduce the practical implications of the experiment in engineering.

Experimental principles are interpreted by combining the parameters to be investigated in the experiment with the parameters measured in the experiment, as well as knowledge learned from textbooks, to derive a computational relation between the experimental test data and the experimentally investigated parameters. In addition, the basic construction of the experimental apparatus and the principles of its use, such as the principle of using a turbine flow meter, the reason why the centrifugal pump must be filled before the motor is turned on, and the closing of the exit valve before the motor is turned on and off.

The teacher asks questions and guides the students in group experiments to think about how to solve these problems. Students with strong practical and theoretical skills complement each other and participate in the same experimental group, so that students learn from each other during the

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experiment and achieve twice the results with half the effort. If students encounter problems during the experiment, the teacher will motivate them to explore the causes of the problem, guide them through the process, and hone their practical skills. Students with strong organizational skills were chosen as experimental group leaders to organize and supervise the operation of the equipment and the collection of data for the experiments, improving the efficiency of the collaboration. When time and conditions permit, allow team members to take turns operating so that students can learn from each other and improve their operating skills.

3.2.2. Live operation

While the experiment is being explained, the instructor can assess the effectiveness of the explanation by asking questions and arranging for the student to start the experimental operation. During the experiment, the students operate in groups and focus on the cooperation among each of them. The division of labour between personnel during the operation of the instrumentation and data recording is clear and the responsibilities are clearly defined [3]. First, this ensures that the experimental site is orderly, facilitates teacher identification of problems, helps the teacher to provide on-site guidance, and allows for the effective organization of experimental teaching to occur. Secondly, this helps the teacher to grasp the student's attendance, reducing the phenomenon of late arrivals and early departures, and improving the overall teaching effect.

During the experimental operation session, the students should strictly follow the requirements set by the instructor, carefully collect data, and pay attention to the experimental phenomena at the same time. During the operation, the instructor sets up some unexpected situations without affecting the experimental setup so that the students can try to eliminate them to improve their resilience. For example, in the experiment "Determination of the characteristic curve of centrifugal pumps", the motor can be started without filling the pump, so that students can practically experience the concept of gas binding. In the 'Determination of the hydrodynamic properties of tower equipment' experiment, the spray volume and gas flow rate are adjusted so that students can observe the real phenomenon of liquid flooding, understand the causes of liquid flooding and consider the consequences of liquid flooding in industrial production. This will not only strengthen students' grasp of textbook knowledge and improve their experimental skills, but also help them to develop their engineering skills and engineering concepts [4, 5].

3.3. Data processing and experimental reporting

After the experimental data collection is completed, the students calculate to derive the experimental results. After the on-site evaluation by the instructor, it can not only assess the good or bad experimental effects of the students, but also combine the experimental results and propose problems for the students to think about, thus improving their ability to deal with and solve problems.

For example, in the experimental teaching process of "determination of heat transfer coefficient", it is required to verify the quasi-numerical equation of a fluid in a circular straight tube doing forced turbulence. The experimental results will be inaccurate due to the fact that the system cannot be fully insulated, the non-negligible thermal resistance of the heat transfer tube walls, and other effects. Students can be asked to analyze their errors, find the possible causes of the errors, determine the effect of different conditions on the heat transfer effect, and deepen their understanding and grasp of the heat transfer equations.

The requirements for student lab reports are to continue to complete the recording of experimental raw data, data processing, analysis and discussion of results, and conclusions of experiments based on pre-lab reports. For the data processing part, to ensure that students have a better grasp of the knowledge learned in the experimental classes, they are required to perform manual computational processing in the experimental reports to strengthen their grasp of the experimental principles. The analysis and discussion of experimental results, should mainly include discussion of experimental phenomena and the law of variation of data, and analysis of experimental errors. Finally, the students are asked to summarize the experimental conclusions. Through experimental report writing, students are urged to strengthen their mastery of textbook knowledge on the one hand, and are required to learn to think independently and to grasp what they have learned flexibly on the other hand.

3.4. Evaluation methods

In the past, the evaluation of experimental performance was usually based on experimental reports

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and written test results. The students' lab reports had a high rate of repetition and the phenomenon of coping was evident. The written test questions are mainly fill-in-the-blank and short-answer questions, which cannot test students' innovative ability [6]. Thus, the composition of the experimental grade of chemical principles consists of 30% of the usual grade, 40% of the experimental reported grade and 30% of the experimental operational grade.

The usual grades depend mainly on attendance, preliminaries, experimental operations, answering questions, and post-lab cleaning.

Writing a lab report consolidates the student's understanding and memory of the lab project. Based on the completeness and correctness of the student's lab report and the soundness of the analysis of the lab results, the teacher gives a grade to the lab report for the project. The mean value of the lab reports of all experimental projects are used as the lab report marker for the course.

During the practical examination, the teacher selects a particular experimental project for the student to operate for the examination. The Operational Examination tests not only the ability of students to operate, operate correctly, analyze and solve problems, but also the ability of students to apply their knowledge in a comprehensive manner by asking random questions based on equipment conditions. The experimental enthusiasm of the students has been greatly enhanced by the reform of the examination methods.

4. Promote the cultivation of innovation capacity through competition

The National Student Chemical Design Competition is the highest-level competition, with the largest number of participating teams and the greatest influence in the Chinese chemical industry. In the context of engineering certification, the competition will promote the reform of experimental teaching of chemical principles and prompt students to grow rapidly in the competition [7].

According to the teaching concept and running conditions of our university, teachers can integrate and optimize various resources of experimental teaching of chemical principles, improve experimental means and methods, highlight the content of cultivating students' engineering practice ability and innovation spirit, so that experimental teaching innovation and chemical competition can complement each other and fully serve the cultivation of innovative talents [7]. By organizing and participating in national university student chemical design competitions, teachers can identify shortcomings in professional teaching, clarify gaps with similar institutions, identify weak points in the teaching process, and examine gaps. At the same time, the competition clearly stimulates students' interest in learning and enhances their professional skills. Colleges and universities should continue to promote discipline competitions and raise the importance that teachers and students attach to them.

5. Strengthen the construction of teachers

Engineering professional certification requires a number of teachers to meet the teaching needs and a reasonable structure, which places higher requirements on the level of expertise of the teachers teaching the experimental courses. The comprehensive quality of the teaching team is key to cultivating innovative talents in chemical engineering. The teachers' knowledge structure, education level, teaching experience and engineering practice experience influence the construction of the teaching team [8, 9]. Our institute already provides pre-service training for teachers of chemical principles experiments, and they can only teach experiments after passing a pilot test. Secondly, teachers are organized to go to enterprises and factories for field research and research training to enhance their practical ability to promote the level of teaching. Again, experts from the business or industry are employed as part-time teachers to guide the students in practical activities. Young teachers must constantly improve their own practical ability and engineering literacy to guide students to improve their engineering practice ability and quality of engineering innovation.

6. Conclusion

The School of Chemistry and Chemical Engineering has trained more than a dozen classes of students, and the faculty of the Department of Chemical Engineering Teaching and Research has made constant efforts to generalize this complete and systematic experimental teaching method of chemical principles, based on years of teaching practice. Practical teaching shows that through this method,

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students' enthusiasm and initiative in experiment can be fully mobilized, teachers can better grasp the class progress and rhythm in the experiment class, and understand students' mastery of textbook knowledge, which is a powerful supplement to the learning of chemical principles course and plays a good role in cultivating students' engineering concepts and strengthening team spirit.

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