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Design and Practice of Integrated Teaching of Chemical Engineering Principle Experiment under the Background of Professional Certification—Taking Absorption as an Example

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Abstract: *Absorption is a key component of chemical unit operations, and it is particularly important for chemical and pharmaceutical engineering students to master the absorption process. This paper attempts to promote a new mode of experimental teaching of chemical principles, proposing a "theory-experiment-simulation" integrated teaching mode, designing the classroom teaching process, using a variety of teaching tools, combining simulation exercises and field operations effectively, and greatly improving the effectiveness of classroom teaching. This not only provides a good foundation for engineering education accreditation, but also promotes students to participate in competitions and promote learning through competitions.*

Keywords: *Integrated Teaching, Chemical Engineering Principle Experiment, Professional Certification, Design, Practice*

1. The current situation of chemical principles course

1.1. Nature of the course

It has a strong engineering background and is a bridge from theory to engineering and from basic to professional, and plays an important role in the cultivation of professional quality and engineering ability of students of chemical engineering and related majors.

The introduction of chemical principles experiments is an important way to cultivate students' comprehensive and innovative abilities. Due to the limitations of experimental space and experimental instruments, students need to work in groups to complete the whole experimental process.

The chemical simulation experiment is a mathematical simulation of the chemical process, based on the basic laws of the chemical process, to establish a mathematical model to implement the applied technology of that chemical process on the computer. Some mature and complex processes in actual industrial production can also be used in process simulation teaching, thus maximizing the use of simulation laboratories to achieve practical education in chemical engineering [1]. The combination of simulation experiments and chemical principle experiments shows a unique teaching advantage and provides a good foundation for practical training.

1.2. Professional accreditation

Engineering education is an important component of higher education and is vital to the development of the industrial system. The professional accreditation of engineering education examines factors such as professional curriculum, school conditions and teacher allocation, emphasizes the cultivation of students' engineering practical ability and innovation ability, determines the graduation requirements that can be assessed by graduates, and is able to cultivate innovative talents in chemical industry [2, 3]. These factors are all focused on students' graduation abilities, which help to improve the core competitiveness of chemical talents and contribute to the sound development of the chemical industry.

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The School of Chemistry and Chemical Engineering currently has three engineering majors: Chemical Engineering and Technology, Pharmaceutical Engineering and Polymer Materials and Engineering. Under the environment of professional certification of engineering education, teachers of the courses find out the problems in teaching according to the teaching status of the theory, experiment and simulation of chemical principles. We carry out integrated teaching reform, so as to lay the foundation for the improvement of students' comprehensive ability and cultivate the engineering talents needed by the society.

2. Teaching design of "theory-experiment-simulation" integration

Chemical principles and chemical principles experiments are professional foundation courses and compulsory courses, while chemical simulation experiments are professional extension courses, covering a wide range of contents, including chemical unit operations, equipment principles and applications. All these contents are close to the actual industrial production and support the problem analysis and research, engineering and society aspects of the basic requirements for professional accreditation [4, 5]. In order to improve the teaching level and meet the requirements of engineering professional accreditation, we have explored and practiced the integration of some contents of the theory; experiment and simulation of chemical principles (see Table 1).

Table 1: Theoretical-experimental-simulation fusion teaching knowledge points

Theory	Experiment	Simulation
Fluid transport machinery	Centrifugal pump characteristic curve	Centrifugal pump unit simulation
Sedimentation and filtration	Experiment on constant pressure filtration	Simulation of constant pressure filtration
Heat transfer	Integrated fluid heat transfer experiment	Heat exchanger unit simulation
Absorption	Absorption experiments	Absorption process simulation
Distillation	Distillation column experiment	Distillation column process simulation

Through integrated teaching (as shown in Figure 1), theory guides simulation and experimentation, while experimentation deepens and strengthens theory [6]. Students can deepen and consolidate their understanding of chemical plant operation processes, establish engineering concepts of chemical production, strengthen experimental manipulation skills, enhance skills training in solving practical problems, improve communication skills and lay the foundation for solving practical engineering problems.

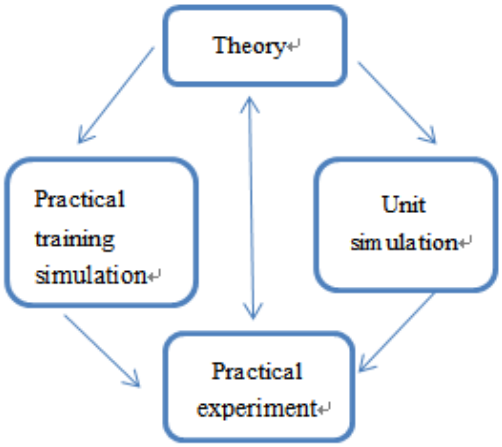

Figure 1: Schematic diagram of the integration relationship.

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3. Absorption experiments as an example of integrated teaching cases

3.1. The experimental teaching system needs to be optimized

The teaching mode of chemical principles experimental class is old, and some students have low learning motivation, which restricts the improvement of teaching quality [7,8]. Most of the evaluation systems in higher education emphasize scientific research rather than teaching, resulting in teachers rarely explaining the latest scientific and technological advances and achievements in the teaching process, and insufficient innovation in teaching methods and content. In our experimental chemical principles classes, students can develop practical and collaborative skills, but there are deficiencies in chemical safety and large-scale practical training, making it difficult to effectively train students' innovation, engineering application and independent thinking skills, and the teaching system needs to be further optimized.

To ensure that students absorb experimental teaching after absorbing theoretical class learning, otherwise it will reduce the teaching effect and affect the theory guiding practice. In the experimental classes, students are vague and cannot remember the knowledge points. Teachers need to lead students to review theoretical knowledge, and then explain the experimental process and operation steps.

3.2. Absorbing the exploration practice of experimental integration teaching

3.2.1. Pre-learning before class

Figure 2: Physical diagram of the absorption experimental apparatus

Combine the theoretical knowledge learnt with the pre-reading of the experimental content. The absorption experimental device (see Figure 2) is relatively close to the actual engineering equipment, with obvious engineering features, and it is difficult for students to understand the construction and principles of the experimental device through book pre-study only. We can delegate the pre-study tasks through platforms such as Learning Pass, and students can complete the pre-study assignments to understand the basic requirements of the experimental apparatus and experiments, and complete the experimental pre-study report by combining the contents introduced in the experimental lectures.

The practical training simulation (Figure 3) and the unit operation simulation (Figures 4) will deepen the students' understanding of the absorption process. The absorption simulation is characterized by the requirement for students to master the principles and processes of the absorption and separation process, the operation of the absorption tower and the factors affecting it, the structure of the packed tower and ancillary equipment, and to understand the abnormal conditions such as pressure drop and liquid flooding in the packed tower. They are able to use basic skills to complete

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industrial absorption and desorption operations, deal with problems arising in absorption operations independently and solve process problems in absorption and desorption operations, which plays an important role in cultivating the engineering practice ability of students in chemical engineering.

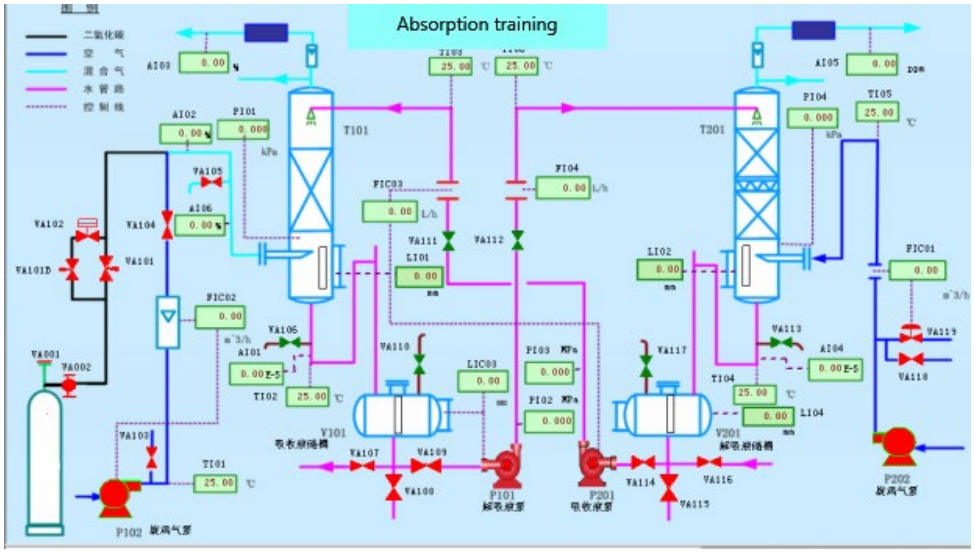

Figure 3: Absorption desorption practical diagram

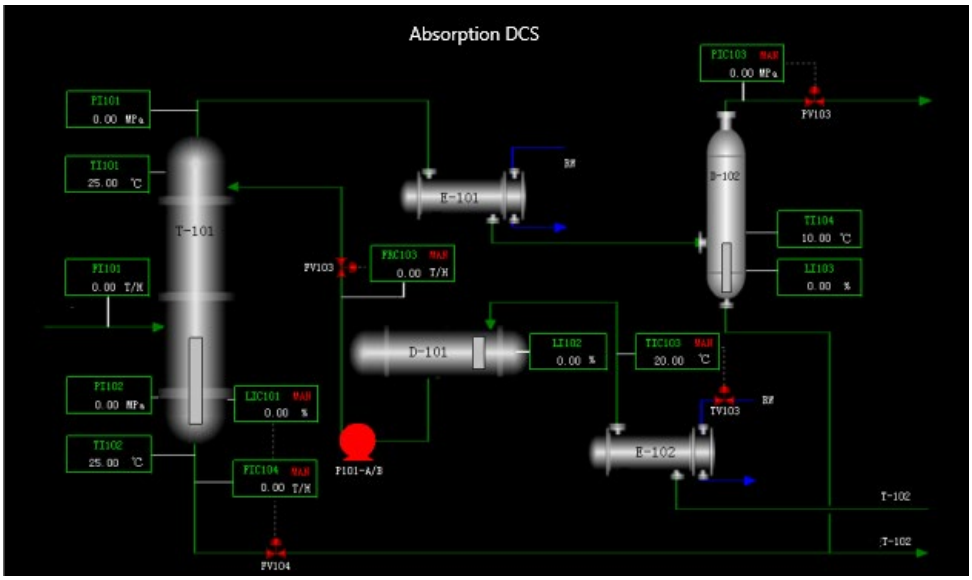

Figure 4: Simulation of the operation of the absorption unit

3.2.2. Experimental operation

The air carrier is supplied by an air pump and the carbon dioxide is supplied by a cylinder. After mixing the two, the air enters the absorption tower from the bottom of the tower and flows upwards through the tower, where it is absorbed in counter-current contact with the falling absorbent. The absorbent enters the absorbent reservoir from the bottom of the tower.

The absorption experimental set-up mimics the actual production process and provides the possibility to train students to determine the name of the fault, to analyse the cause of the fault and to determine the method of troubleshooting, to the final hands-on troubleshooting. The absorption device requires automatic control of the rising gas flow in the desorption tower, automatic control of the liquid flow in the absorption and desorption tower, and a self-locking and linkage function when an accident occurs.

The material system separated by the absorption unit is a carbon dioxide - water system, and the concentration of carbon dioxide in the exhaust gas of the absorption tower is less than the specified value. During the experiment, the teacher needs to remind the students of the parameters to be investigated in the experiment and the experimental measurement parameters, and to derive the

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calculation relationship between these two types of parameters according to the theoretical knowledge. In addition, they need to master the basic construction of the experimental device and the principles of its use [9-11]. The teacher asks questions and guides students in their experiments to think about how to solve these problems, so that they can learn from each other and get twice the result with half the effort in the experimental process. If students encounter problems during the experiment, the teacher will inspire them to explore the causes of the problems, guide them through the procedure and hone their practical skills. When time and conditions allow, group members are given turns to operate so that students can learn from each other and improve their operational skills.

Students operate in groups during the experiment, with attention to cooperation between them and a clear division of labour and responsibilities between personnel during the operation of the apparatus and equipment and data recording. This helps the teacher to provide on-site guidance and can effectively organise experimental teaching and learning to take place. In the experimental operation, students should strictly follow the requirements put forward by the instructor and collect data carefully, while paying attention to the experimental phenomena. After the experimental data collection is completed, students calculate the experimental results [12]. After the instructor's on-site evaluation, it is possible to evaluate the effectiveness of the students' experiments, and also to combine the experimental results with the theoretical knowledge they have learned to strengthen their knowledge and improve their comprehensive ability.

3.2.3. Promote the cultivation of innovation ability through competition

The National Student Chemical Design Competition and the National Student Chemical Experimentation Competition are the competitions with the highest level, the largest number of participating teams and the greatest influence in the chemical industry. Under the background of engineering certification, the competitions will promote the reform of experimental teaching of chemical principles and prompt students to grow rapidly in the competitions. The theory, experiment and simulation of chemical principles are closely connected with the competition. The teachers can integrate various resources of chemical principles teaching, improve experimental means and methods, highlight the content of cultivating students' engineering practice ability and innovation spirit, so that the innovation of experimental teaching and chemical competition can complement each other and fully serve the cultivation of innovative talents.

4. Conclusion

Facing the needs of the current new engineering construction, the trinity teaching mode of chemical engineering principle theory, experiment and simulation is adopted, so that the theory and practice are closely combined, the theory guides the practice, and the theoretical knowledge is further sublimated in practice.

In terms of theoretical teaching, we should update the teaching concept and strengthen the engineering point of view; improve teaching methods and use modern educational means to promote the improvement of education and teaching quality. We constantly update the knowledge system, explore the teaching mode of integration of production, teaching and research, and adopt the integration and flipped classroom in classroom teaching to promote the improvement of teaching quality. More case teaching is introduced, engineering examples are introduced, students' engineering awareness is improved, and first-class courses of chemical engineering principles are constructed. In the aspect of experimental teaching, the entity operation is arranged in time after the corresponding content chapter teaching, so that students can combine theoretical knowledge with experimental practice in time. In terms of simulation teaching, virtual simulation is adopted to strengthen students ' understanding of chemical unit operation, and the practical ability of students ' virtual simulation operation is improved through subject competition.

The integrated teaching is based on the new practice of teaching mode and teaching method. The teachers of chemical engineering teaching and research section have made continuous efforts to summarize this complete and systematic experimental teaching method of chemical engineering principle. The practical teaching shows that this method can fully mobilize the enthusiasm and initiative of the students. In the experimental class, the teachers can better grasp the progress and rhythm of the classroom, and understand the students ' mastery of the textbook knowledge. It is a powerful supplement to the study of the principle of chemical engineering, and plays a good role in the cultivation of the students ' engineering concept and the strengthening of the team spirit.

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After years of practical teaching, students can choose the appropriate spray density, temperature, air flow and operation mode, etc., and adopt the correct operation method to complete the training assessment indicators. It can analyze and judge abnormal phenomena, find out the reasons, put forward solutions and implement them. It effectively deepens the students' understanding of the operation knowledge of the absorption unit, and uses the theoretical knowledge to solve the skills of engineering practice problems, improves the ability of engineering practice, and achieves the integration and interconnection of the three, truly realizes the integration of theory with practice. It improves the practical operation ability and information virtual simulation ability of college students, and greatly promotes the comprehensive development of college students ' professional basic quality.

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