The Comprehensive Reform of Special Experiment for Chemical Engineering and Technology

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Abstract: The curriculum of Special Experiment for Chemical Engineering and Technology includes Chemical Engineering Thermodynamics, Chemical Reaction Engineering, Chemical Separation Engineering, and Chemical Technology and so on. Each experiment is corresponding to different course and theoretical knowledge. However, each experiment is independent, separately corresponding to one certain theoretical knowledge, lacking the systematisms. This study integrates knowledge belonging to the same technological category together, whose contents and logics are closely related, breaks the limitation that experiments belong to different professional courses, weakens the independence of each experiment, combines related course experiments to one comprehensive experiment, strengthens the compatibility of different courses, promotes students' learning of systematical knowledge, builds unified knowledge system, and cultivates students' ability to solve complex engineering problems, whereas, not just verifies the practical process of theoretical knowledge.

1. Teaching Objectives of Chemical Engineering Experiment

The chemical engineering, with strong practicableness, is a major to train talents with higher engineering technology. It requires graduates to apply professional theory into engineering practice, and develop strong ability to analyze and solve problems, operational ability, awareness of engineering, innovative ability and creative spirit. Chemical engineering helps students to better understand chemical engineering through simple and practical cases related to daily life [1-4].

Special Experiment for Chemical Engineering and Technology is a course for students in the major of chemical engineering and technology, including Chemical Engineering Thermodynamics, Chemical Reaction Engineering, Chemical Separation Engineering, and Chemical Technology and so on. It is to train students' ability to apply basic knowledge of chemical engineering and technology and basic skills of chemical experiment to design and carry out experiment, and process and analyze experiment results; to promote students to experience, understand and apply theoretical knowledge, experiment research method and experiment technology to practice, and understand the impact of engineering practice for complex problems on social sustainable development; in the process of experiment, to strengthen safety education of chemical lab can help students to understand the influence of relevant laws and regulations on health and safety, and realize the responsibility they shall take; in carrying out experiment and data process, students' teamwork spirit can be developed to play the role of individual, team member and manager, laying a solid foundation for training modern engineers for production and management.

2. The Integration of Experiment Contents

The experiment types of this major include demonstration experiment, confirmatory experiment and comprehensive experiment. The setting of experiment topics comes from relevant theoretical contents of Chemical Engineering Thermodynamics, Chemical Reaction Engineering, Chemical Separation Engineering, and Chemical Technology. The curriculum reform of special experiment is an important part of professional teaching reform all the time. It is mainly to optimize experiment

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contents, to establish innovative experiment, comprehensive experiment, design experiment and research experiment by integrating experiment contents [5-7].

Experiment training can consolidate students' understanding of theoretical knowledge, playing an important role in training students' comprehensive application ability, scientific research ability, ability of expression, interpersonal skill and teamwork spirit.

However, experiment topics and contents involved in this course are distributed in different courses, contents are scattering and students lack coherent and logic systematic knowledge. This study integrates knowledge belonging to the same technological category together, whose contents and logics are closely related, breaks the limitation that experiments belong to different professional courses, weakens the independence of each experiment, combines related course experiments to one comprehensive experiment, strengthens the compatibility of different courses, promotes students' learning of systematical knowledge, builds unified knowledge system, and cultivates students' ability to solve complex engineering problems, whereas, not just verifies the practical process of theoretical knowledge.

3. The "Preparation of Anhydrous Ethanol" Experiment

Taking the comprehensive experiment of preparing anhydrous ethanol as an example, it includes the knowledge and experiment of gas-liquid equilibrium of binary system in the course of chemical thermodynamics, as well as the knowledge and experiment of rectification of separation engineering. Due to water and ethanol are azeotrope. For 4.43% water and 95.57% ethanol under normal pressure, the azeotropic point is 78.15 °C. In other words, ethanol is purified by ordinary rectification, and the highest concentration of ethanol is 95.57%, which cannot meet the separation requirement of anhydrous ethanol. This requires us to consider adding entrainer to increase the ethanol concentration. Then it is necessary to examine the physicochemical properties of the entrainer with ethanol and water, that is, the ternary liquid-liquid equilibrium data. This involves the knowledge of the ternary gas-liquid phase balance of the chemical thermodynamics course and the special rectification knowledge in the chemical separation engineering course. In addition, this experiment, as a project, involves technology development, engineering design, chemical environmental protection, safety, economic benefits and so on, covers various knowledge in this project, develops students' awareness of engineering and ability of solving complex engineering problems, trains students' will and promotes students' communication and cooperation.

3.1 Experiment contents

Taking Exploration and Practice of Green Chemistry Thinking Construction in College Chemistry Experiment Education by Ran Xiuzhi et al as a reference, from the perspective of green experiment teaching contents, the system adopted in this experiment is determined.

The task of preparing anhydrous ethanol by azeotropic distillation, with 30% ethanol as original material is given to students. First of all, to complete lab safety education, experiment preview by online study, referring to Chemistry Experiments Teaching Mode Based on "Online + offline" by Ye Hong et al and Application of WeChat in Experiment Teaching of Materials Chemistry Specialty by Xu Minhong at al [9, 10]; secondly, configure 30% ethanol aqueous solution with 95% ethanol; thirdly, adopt Rose equilibrium still, measure ethanol-water binary gas-liquid equilibrium data and analyze binary phase diagram; fourthly, refer to literature, review the preparation method of anhydrous ethanol, choose azeotropic distillation, determine the entrainer, adopt liquid-liquid equilibrium still, measure ethanol-water-entrainer ternary liquid-liquid equilibrium data after adding entrainer, and choose appropriate thermodynamic model regression; fifthly, taking physical data and regression model of thermodynamics as an reference, simulate the preparation of anhydrous ethanol through azeotropic distillation with simulation software of chemical engineering, optimize operation parameters of technology and determine the optimal distillation scheme; sixthly, refer to the simulated optimal distillation scheme, carry out experiment and analyze experiment results; seventhly, write research report, including literature review, experiment design, feasibility report, chemical environmental protection and safety, engineering economy and so on.

3.2 Experiment instrument

The binary gas-liquid equilibrium data measurement experiment device photo, ternary liquid-liquid equilibrium data measurement device photo, normal distillation device photo, azeotropic distillation device photo, and gas chromatography.

3.3 Experiment method

Take the students of the chemical engineering specialty as an example. There are 30 people in the class, divided into six groups, with give people in one group. Grouped by the teacher, each group is assigned a team leader, self-recommended by student or recommended by the same group of students. Under the leadership and organization of the team leader, determine the division of labor, main work content, working methods and cooperation forms with other team members in the group, and perform follow-up work according to procedures and working methods determined by the group.

This work is advantageous in various aspects. First of all, it combines theoretical knowledge of classroom teaching and practical operation, organically integrates the knowledge belonging to the same application technology category in different disciplines, fully explore students' potential, improve students' innovative awareness, develop students' ability to solve complex engineering problems and enhance students' teamwork awareness; secondly, it changes teacher-oriented teaching mode to student-centered and teacher-guided experiment, and train students' ability of independent learning; thirdly, it changes classroom-centered teaching mode to be the mode oriented by problems solving, develops students' engineering quality and the ability of solving practical engineering problems; fourthly, in this project, students communicate each other, discuss different methods and thinking, learn from each other and complement each other, which can mobilize students' enthusiasm and enhance their sense of group honor and develop students' teamwork awareness.

3.4 Evaluation method

The period of project is two weeks, and the evaluation is carried out each week. The groups present their results through PPT and oral debate, and guiding teachers and students from other groups give the mark. The sum of marks of two times is the final marks of this group; the performance of each member in this group is shown by the final mark composed of evaluation of students from the same group (30%) and group mark (70%).

4. Conclusion

The chemical engineering major in this university, with the goal of training talents for production and management, focuses on the training of students' practical ability. Professional experiment is the core practical link, and its teaching result plays a critical role in developing students' professional quality. In order to improve the teaching effect, the professional experiment of this major shall be reformed to explore the teaching methods, means and cultivation paths suitable for this major.

On the one hand, the comprehensive experiment project can separate the experiment from theoretical knowledge, and integrates the knowledge belonging to the same technological category into one experiment project, so that students can have a comprehensive and complete understanding of a certain technology, form systematical knowledge structure and break the tradition of independent course knowledge system. On the other hand, this experiment project can relate theoretical knowledge of classroom teaching to practical operation, integrate the knowledge belonging to the same application technology category, fully explore students' potential, improve students' innovative awareness, develop students' ability to solve complex engineering problems and enhance students' teamwork awareness.

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