

Exploration and Practice of Diversified Chemical Experiment Teaching Mode—Taking the Local Colleges as an Example

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ABSTRACT

The comprehensive competence of chemistry majors requests the capacity of “thinking” and “doing”. There exists certain indivisible intrinsic relation between the “thinking” and “doing”. Considering the vital role of experiment in the coordination of “thinking” and “doing”, it is urgent to foster the innovative abilities and comprehensive competence of chemistry majors. Aiming at the characteristics of chemical experiment teaching, the paper summarizes the main measures of the Diversified Chemical Experiment Teaching Mode in our college. For example, we improve the multi-layer and integrated experiment teaching system in talent training program, optimize chemical experiment teaching contents, implements exploratory experiment teaching methods, rise of basic experiment teaching level, encourage and instruct outstanding students to take part in teachers’ scientific research programs, establish the mutual-assistance mechanism among students. At present, we have been through more than ten years of reform, practice and construction, and gradually popularized and applied this achievement, with remarkable results.

Keywords: diversified teaching mode, chemistry experiment, teaching reform, practice

1. INTRODUCTION

Diversified chemical experiment teaching mode dominated by students and supplemented by teachers, takes second classroom as the carrier and opened the laboratory as the platform. On the basis of experimental skills, it aims to cultivate students’ innovative consciousness and ability, and improve students’ comprehensive ability. Students may also choose the multi-layer diversified teaching mode composed of multiple teaching contents and teaching means apart from classroom experiment teaching [1]. The original objective of the mode is to break through traditional experiment teaching mode, which is dominated by classroom theory teaching, supplemented by experiment teaching, and instructed by teacher-centered teaching instructions. This liberated experimental teaching from strict imitation teaching and promoted the development of experimental teaching in the direction of independent innovation learning.

2. DIVERSIFIED CHEMICAL EXPERIMENT TEACHING MODE

During the implementation process of diversified chemical experiment teaching mode, we attach great importance to existing experiment teaching process. Since cultivating students’ experimental professional knowledge and basic

skills is the foundation of diversified experimental teaching mode, it is necessary to consolidate teachers’ leading status in this process. Meanwhile, the new experiment teaching mode is exploited to strengthen the dominant status of students in place of teachers. Through guidance, discussion and collaboration, teachers can participate in classroom teaching, continuously improve students’ independent problem analysis ability, and cultivate students’ awareness and ability of independent innovation.

2.1. Improving the Multi-Layer and Integrated Experiment Teaching System in Talent Training Program

According to the professional norms prescribed by the Ministry of Education College Chemistry and Chemical Engineering Teaching Committee for chemical specialty, and the school-running policy of our school for applied talents, the experimental teaching system of chemistry has been researched and improved. The comprehensive chemistry experiment and innovation experiment courses were added, forming a multi-layer comprehensive experiment teaching system consisting of basic chemistry experiments, professional skills experiments, comprehensive chemistry experiments, technological innovation experiments and graduation thesis. Basic chemical experiment and professional skill experiment are both traditional experiment courses in

chemistry specialty, in which the former mainly trains students' basic expertise and skills about chemical experiment, and cultivates their favorable scientific experiment quality; while the latter integrates chemical experiment skills and professional theories into the experiment. In this way, students may further command professional experiment techniques, and master more experimental skills and attainments. As the bridge connecting basic chemical experiment (focusing on knowledge learning and ability training) and scientific research (solving the unknown by the known), integrated chemical experiment perfectly works out practical problems by all sorts of expertise and experimental techniques, promotes undergraduates to coordinate mind and hand in chemistry learning, develops students' scientific thinking capacity, training research capacity, as well as systematic experimental thinking [2].

2.2. Strengthening the Construction of Basic Chemical Laboratory and Building a High-Quality Experimental Management and Teaching Team

The key to fostering the training of innovative talents is to reinforce the fundamental role of basic chemical experiments and improve software and hardware construction and level of the teaching staff in experimental teaching practice [3]. Accordingly, the school has established the Chemical Experiment Teaching Center equipped with a full-time experimental management team. In recent years, the school has made considerable investments into the upgrade and reformation of the Chemical Experiment Teaching Center. With a gross coverage of 8000m², the Chemical Experiment Teaching Center has built fully functional basic laboratories, professional laboratories, simulation laboratories, analytical test laboratories, and more than 20 innovative laboratories for teachers' scientific research and students' innovative experiment uses. Considerable precision testing apparatuses worth over 30 million RMB provide favorable conditions for the implementation of high-quality professional basic experimental teaching, professional experimental teaching and scientific research work. The center in all-round operation strongly supports students' self-independent innovation activities. By optimizing the structure of the teaching staff, the center had built a qualified experimental teaching team staffed by 46 full-time teachers, including 52% advanced-level teachers and 97.8% of them have obtained the master's degree. In cooperation with well-known colleges and local enterprises in China, the school intends to attract more senior engineering technicians and thus cultivates outstanding applied talents.

2.3. Unremitting Persistence in Developing Available Experiment Teaching Techniques

2.3.1. Optimizing chemical experiment teaching contents

We have reformed existing experiment teaching mode by decreasing replication experiment and adding more comprehensive design experiment and course design as of 2000. However, the decrease of replication experiment results in the weakening of students' chemistry perceptual cognition. Therefore, we reopen some classical and traditional replication experiments, in a bid to deepen the depth of chemistry theory courses, and consummate students' knowledge structure and chemical experiment basics.

2.3.2. Implement exploratory experiment teaching methods

For urging students to complete the experiment in a limited time, traditional experiment teaching concentrates the focus on lecturing. This encourages students to cultivate stereotyped imitation learning habits. As a result, we implemented the exploratory experiment teaching methods, and adopted the research subject study mode to propose experimental requirements and gave more operating instructions at different levels. Specifically, in the experiment teaching for junior grade students, they will give priority to the basic operation, standardize the experimental operation, and cultivate students' experimental interest and ability throughout the learning process of simple design experiments, such as the measurement of potassium nitrate solubility, the measurement of calcium chloride crystal water content, and the measurement of Avogadro's constant. The experimental teaching for senior students introduces more common design experiments in daily life, such as the measurement of vitamin C content in fruits, and the content of amino acids in soy sauce. There is no doubt that these experiments deny the idea that chemical research is useless. After receiving the training of basic experiment, comprehensive experiment, and design experiment, students are requested to complete graduation paper in the laboratory. Teachers should be responsible for instructing students on how to look up documents, design experimental plans and complete procedures. The role of the teacher is heuristic, which means that the teacher should inspire the students to improve the program and solve the problems in the operation. During the learning process, students will gradually learn, experience and control the basic ideas, basic methods and basic research procedures of the experiment, greatly enhance the comprehensive experimental ability, and innovate on this basis.

2.4. Establishing Open Laboratory, Raise Laboratory Use Ratio and Support Diversified Experiment Teaching Mode

2.4.1. Rise of basic experiment teaching level

We have built a multi-layer laboratory for extracurricular experiments. The first layer is provided for both outstanding students and academically poor students. The open laboratory allows underperformed students to continue their experiment in spare time, guaranteeing that they can reach up to experiment teaching requirements by repeated trials. Outstanding students have the freedom to select other experiments on their own as long as they finish basic experiments. The second layer is extracurricular experiment mode. Before the implementation of extracurricular experiments, teachers prescribe thesis subjects, order students to select one subject and consult related documents, and then design the experimental procedures on this basis. After the experiment, students need to write a paper and exchange opinions with one another in group discussion. The third layer is the platform afforded by college student chemical experiment innovation association favoring academic exchange and promotion, which aims at facilitating the professionalism and specialization of student association. The fourth layer is student extracurricular research group under the led of teacher, dedicated to cultivating students' innovation abilities throughout teacher scientific research and college student innovative activities, graduation thesis, etc [4].

2.4.2. Encouraging and instruct outstanding students and specialty students to take part in teachers' scientific research programs

By proactively incorporating outstanding students into teachers' scientific research programs, the teacher broadens the students' horizons, teaches them more cutting-edge knowledge, cultivates their basic scientific research capabilities, and gives full play to the individuality of all students. Therefore, students gain more insights into the prospects of the chemistry specialty and prepare themselves well for future work after graduation. By now, around 100 students participate in teachers' scientific research programs.

2.4.3. Establishing the mutual-assistance mechanism among students

Considering the continuity of many graduation thesis subjects and scientific research programs, one program may take the efforts of several generations. Therefore, we arrange senior students to help junior students, so that a small number of junior students with a good professional foundation have the opportunity to practice and scientific

research, find their position in experimental process, and improve their overall personal quality. Moreover, as students give full play to their initiative in the experiment, they will show a stronger sense of honor and confidence, exercise their courage to overcome difficulties, and develop collaboration skills and irrational thinking skills. When graduating students enter the laboratory, outstanding junior students can also follow them and participate in teachers' scientific research programs in spare time. In addition, junior students are allowed to audit the graduation thesis defense. At present, approximately 30 students enter the laboratory by self-selection subjects or teachers' scientific research subjects. These measures, to a large extent, have mobilized the learning interests of students [5].

2.4.4. Proactively participate in competitions

Teachers should organize students to actively participate in chemical experiment skills, science and technology competition, and all sorts of systematic and multi-layer contests to cultivate students' innovation and comprehensive ability, and provide serious guidance for training and selection. In this way, while exerting students' strong points to the fullest, teachers also cultivate students' teamwork spirits and enhance their innovative abilities. Besides that, we revised experiment teaching contents and experiment teaching techniques to refine experiment teaching mode, and further improved students' innovative abilities and comprehensive quality as per the shortcomings in contests.

2.5. Organizing Frontier Lecture

We have successively held knowledge lectures, such as Chemistry and Society, Laboratory Knowledge Lecture for the chemistry industry. Combining with the teachers' scientific research subjects, we have launched doctoral professor forums to stimulate students' intrinsic learning motivation and innovative requirements, boost students' initiative in experiment, instruct students to command basic knowledge and basic skills, improve their professional expertise, and ascertain their development orientation.

2.6. Establishing Extracurricular Interest Group

Since 2006, freshmen have spontaneously established an extracurricular interest group led by the teachers, regularly holding chemical knowledge contests, chemical experiment skills contests and other related extracurricular activities; invited well-known experts in coal chemical industry and other chemical related industries to give lectures; carried out a variety of life and social practice activities, such as establishing a soil quality survey service

team. The main method of cultivating students' innovative ability is to introduce extracurricular practical activities into experimental teaching, which is an essential link in experimental teaching.

2.7. Strengthening the Appraisal for Basic Chemical Experiment

In order to improve students' practical ability and innovation ability, the evaluation of basic chemistry experiments includes program evaluation, on-site inspection evaluation, theoretical written examination and comprehensive evaluation [6]. The main measures are as follows: First, before entering the laboratory, students must receive training and assess safety knowledge in the laboratory. Second, each basic experiment should include a 20% course evaluation to examine students' experimental skills. Third, one group of experiments should be selected for on-site inspection and evaluation each semester to test students' comprehensive experimental ability. Fourth, the final examination of each semester should introduce theoretical examination evaluation to test students' experimental professional knowledge and basic theory.

3. IMPLEMENTATION AND RESULTS

3.1. Mature Experiment Teaching System

According to the integrity, basicity, integrity and innovation of teaching in the experimental teaching system, the school has established basic chemistry experiments, professional skills experiments, comprehensive chemistry experiments and technological innovation experiments in the teaching stage, and gradually improved with the help of teaching. With the help of the open laboratory platform, the "integrated, multi-layered and open" innovative chemistry experiment teaching system has been gradually improved.

3.2. Prominent Achievements in Specialty Construction and Curricular Construction

Chemical specialty in our school has gained sponsorship from Shandong Province Special Building Program. The "coal chemical engineering" laboratory is credited as key provincial-level college laboratory. Five courses, including *Inorganic Chemistry Experiment*, *Organic Chemistry Experiment*, *Analytical Chemistry Experiment*, *Physical Chemistry Experiment* and *Fine Chemicals Synthesis Experiment* have been screened as "provincial-level quality courses". Subsequently, the supporting courses were published successively. As the basic courses in all specialties have been rated as quality courses, students can

get access to quality teaching resources. That conforms to the "people-oriented" teaching philosophy.

3.3. Significantly Build Students' Professional Qualification

During the process of implementing diversified chemical experiment teaching mode, teachers not only recognize the importance to cultivate students' problem-solving abilities amid interaction, but also promote their own business qualifications and teaching proficiency. In school teaching staff, one has gained provincial-level Outstanding Teacher Award, two have gained The Third Prize in Young Teacher Competition in Shandong Province, two have gained school-level Outstanding Teacher Award, three have gained school-level Honorable Award, and two have gained the title of "Outstanding Adviser" in College Student Extracurricular Academic Technical Work Competition in Shandong Province. This ensures the implementation of the "Diversified Chemical Experiment Teaching Mode".

3.4. Prominent Scientific Innovation Results of College Students

Since the implementation of the diversified chemical experiment teaching model, the comprehensive quality of students has been greatly improved. Especially through the opening of open experimental teaching and comprehensive innovative chemical experiment courses, scientific research has fully penetrated into innovative education and talent training, and progress has been made in cultivating students' scientific interest, chemical research and innovative ability.

In recent years, in a series of scientific innovation activities, students have achieved excellent results. Students have attained 9 national-level college student innovation and entrepreneurial training proposals, issued over 30 academic papers on professional journals, obtained 2 national third prizes, 2 provincial first prizes, 1 provincial second prize and 2 third prizes in "Challenge Cup" College Student Extracurricular Academic Technical Work Competition; 2 national second prizes, 2 national third prizes, 1 second prize in Huabei Competition Area, 1 third prize in College Student Chemical Design Competition; 1 first prize, 3 second prizes, and 9 third prizes in Shandong College Student Chemical Experiment Skill Competition, 1 second prize, and 1 third prize in Shandong College Student Chemical Process Skill Competition.

4. CONCLUSION

The cultivation of innovation ability is a long-term task. Considering the vital role of experiment in the coordination of “thinking” and “doing”, it is urgent to foster the innovative abilities and comprehensive competence of chemistry majors. Teachers need to develop students' innovation ability through experiment teaching. Therefore, teachers need to change the traditional concept of thinking, improve teaching methods, and promote the development of students' personality. According to the requirements of the orientation of the application-oriented talents in our college, we should give full play to the position and role of the basic chemical experiment in the cultivation of the application-oriented innovative talents. The author puts forward the reform measures from the aspects of the experimental teaching staff, the reform of the experimental curriculum system, and the selection of experimental contents, aiming at improving the teaching quality of the basic chemical experiment and cultivating high-quality applications for the local undergraduate colleges and universities. The diversified chemistry practice teaching mode is a platform built by the school for students' technical activities. Oriented towards overall students, it enables students to demonstrate their personality and talents to the fullest.

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