International Journal of Education and Humanities
ISSN: 2770-6702 | Vol. 15, No. 3, 2024

Research on Teaching Reform of Chemistry Experimental Course under New Engineering Background

Lijuan Zhao*, Xurundong Kan

School of Biology and chemistry, Pu`er University, Pu`er 665000, China
***Corresponding author:** 1611801200@qq.com

Abstract: With the proposal of new engineering education concept, new challenges are posed to the teaching reform of chemical experiment course. This study aims to explore the teaching reform path of chemistry experiment course under the new engineering background, so as to improve the students' practical ability and innovation ability. As an important part of engineering education, the teaching objectives of chemistry experiment should be consistent with the new engineering education concept, and pay attention to cultivating students' ability to solve practical problems and teamwork spirit. At present, there are some problems in chemistry experiment teaching, such as outdated curriculum system, too theoretical experiment content, lack of combination with engineering practice, and low participation of students. These problems restrict the improvement of teaching quality, and can not meet the needs of new engineering education for talent training. Therefore, the primary task of the reform is to update the experimental curriculum system and integrate more experimental projects with engineering background and cutting-edge technology, in order to improve the practicality and challenge of the experiment. In terms of reform strategies, it is suggested to implement the "student-centered" teaching mode, and encourage students to take the initiative to explore and innovate through project-driven and problem-oriented teaching methods. At the same time, strengthen the integration of experimental teaching and theoretical teaching, so that students can deepen the understanding of theoretical knowledge in the experiment, and use theoretical knowledge to solve practical problems. In addition, the information level of experimental teaching should be improved, and virtual simulation and other technologies should be used to expand the space-time dimension of experimental teaching and improve the teaching effect. The change of the role of teachers is also the key. Teachers should change from the teacher of knowledge to the guide and collaborator of students' learning. By building an open and interactive classroom environment, stimulate students' interest in learning and innovative thinking. At the same time, the establishment of a diversified evaluation system, in addition to the investigation of students' experimental skills, but also should pay attention to the evaluation of their innovative thinking, teamwork and solving practical problems. To sum up, the teaching reform of chemistry experimental curriculum under the background of new engineering should focus on the update of curriculum content, the transformation of teaching mode, the integration of teaching resources and the reform of evaluation system. Through the implementation of these strategies, it aims to build an experimental teaching system that can not only meet the needs of new engineering education, but also cultivate high-quality chemical engineering talents. Such reform is of great significance to enhance the competitiveness of chemical engineering education in China.

Keywords: New Engineering; Chemistry Experiment; Teaching Reform; Practical Ability; Innovation Ability.

1. Research Background and Significance

With the rapid development of global science and technology, the new concept of engineering education arises at the historic moment. This concept is guided by innovation-driven, crossover, openness, collaboration and internationalization, and aims to cultivate modern scientific and technological talents with broad discipline foundation, deep engineering practice ability, strong innovative spirit and good sense of social responsibility. Under this background, the traditional teaching mode of chemistry experiment course is facing severe challenges, and it is urgent to deeply reform to adapt to the new requirements of new engineering education for talent training.

As the core part of engineering education, the teaching objectives of chemistry experiment should be closely consistent with the new engineering education concept, and shift from knowledge teaching to ability cultivation, especially the cultivation of practical ability, innovation ability and teamwork spirit. However, the current chemistry experiment teaching is often too focused on the theoretical knowledge, the experimental content is too old, lack of combination with engineering practice, lead students in the process of practice, innovative thinking not fully stimulate, these problems seriously restricted the teaching quality and the realization of the new engineering education goal.

The importance of chemistry experiment curriculum reform is self-evident, it is not only the key to improve the teaching quality, but also the necessary means to shape the chemical engineering talents in the new era. New engineering education emphasizes interdisciplinary skills and application ability, which requires that chemistry experiment courses not only enable students to master basic experimental operation skills, but also enables students to solve practical engineering problems and exercise their ability to solve complex problems through the design and implementation of experimental projects. At the same time, the experimental courses should integrate more cutting-edge technologies, such as virtual simulation, big data analysis, so, to enhance the practicality and challenge of the experiment.

In terms of reform strategy, the "student-centered" teaching

mode should be deeply implemented, and project-driven and problem-oriented teaching methods should learn and apply chemical knowledge in practice, so as to cultivate their habit of active exploration and innovation. This can not only improve students' understanding of theoretical knowledge, but also enable them to flexibly use the knowledge they have learned when facing specific problems, so as to realize the seamless connection between theory and practice. In addition, the deep integration of experimental teaching and theoretical teaching is also very important. The two complement each other and jointly promote the improvement of students' comprehensive quality.

It is also the focus of reform to improve the informatization level of experimental teaching and expand the time and space dimension of experimental teaching with modern technological means. The introduction of virtual simulation technology can break the space-time limit of physical experiment and make the experiment safer and more convenient. At the same time, it can also provide more experimental scenes and enrich students' experimental experience. At the same time, the change of the role of teachers is also critical. They need to change from the traditional knowledge imitator to the guides and collaborators for students 'learning, and stimulate students' learning enthusiasm and innovative thinking through an open and interactive classroom environment.

The construction of a diversified evaluation system is also indispensable. In the new engineering background, the evaluation system should focus not only focus on students' experimental skills, but also on their innovative thinking, teamwork ability and ability to solve practical problems. This will help to cultivate students' overall quality and make it better adapt to the needs of the future society.

Studying the teaching reform of chemical experimental course under the background of new engineering aims to build a teaching system that can not only meet the needs of new engineering education, but also cultivate high-quality chemical engineering talents with practical ability and innovative spirit. This is not only conducive to improving the competitiveness of chemical engineering education in China, but also an important way to realize the modernization of education and serve the national innovation-driven development strategy. Through the reform, we look forward to injecting new vitality into the prosperity and development of chemistry education in China, and cultivating more outstanding chemistry talents for the scientific and technological progress in China and even the whole world.

2. New Engineering Education Concept and Chemistry Experiment Course

2.1. Connotation and Characteristics of New Engineering Education

The proposal of the new engineering education concept is a profound reflection and innovation of the traditional engineering education. It advocates the education mode characterized by student-centered, interdisciplinary integration, openness and collaboration, and internationalization. The connotation of new engineering education is extensive, including not only the updating and broadening of subject knowledge, but also the comprehensive reform of teaching methods, evaluation system and educational environment.

New engineering education emphasizes the broad subject foundation, which is no longer limited to a single engineering knowledge, but integrates interdisciplinary content, such as computer science, data science, environmental science, etc., to cultivate innovative talents with interdisciplinary thinking and the ability to solve complex problems. This educational model requires students to have the understanding of other related fields while mastering the core knowledge of the major, so as to adapt to the rapidly changing technical environment in their future work.

The new engineering education model advocates practical orientation and encourages students to operate and solve practical problems through project-driven and problem-oriented ways in the learning process. This teaching method aims to promote students' active learning, and cultivate their ability to use the knowledge to solve practical engineering problems, as well as the spirit of innovative thinking and engineering practice.

New engineering education focuses on open sharing and collaborative innovation, advocates school-enterprise cooperation, and realizes the integration of industry and education with the help of industry resources. This education mode not only enables students to have more opportunities to contact with practical projects, but also improves students' professional quality and industry cognition through exchanges and cooperation with industry experts, so as to make education closer to the social needs.

Internationalization is also one of the distinctive features of the new engineering education. It focuses on international exchanges and cooperation, encourages students to participate in international academic activities, and improves their global vision and cross-cultural communication skills. Through an international learning environment, students will be able to better understand and adapt to the global technological and economic environment and prepare themselves for their future career.

The implementation of new engineering education needs the change of the role of teachers. They are no longer only the transmitters of knowledge, but to become the guides and collaborators of students' learning. By guiding students to explore, question and innovate, they can improve their critical thinking and the ability of independent learning. At the same time, the teaching evaluation system will also change from a single test score to a comprehensive evaluation of students' innovative thinking, teamwork, the ability to solve practical problems and the integrated application of interdisciplinary knowledge.

The connotation and characteristics of new engineering education are reflected in the four aspects of interdisciplinary, practice orientation, open coordination and internationalization. This education mode aims to cultivate modern scientific and technological talents with global vision, innovative spirit, practical ability and teamwork spirit, so as to adapt to the new requirements of scientific and technological development and economic globalization on talents. In this context, the teaching reform of chemistry experiment course must keep up with the new engineering education concept, so as to cultivate high-quality chemical engineering talents and promote the modernization process of chemistry education.

2.2. The Position of the Chemistry Experiment Course in the New Engineering Education

Chemistry experiment course plays a pivotal role in the new engineering education, which is the core link of

cultivating the practical ability, innovative spirit and engineering accomplishment of chemical engineering talents. Under the guidance of the new engineering education concept, the status of chemistry experiment course has been unprecedented improved, from the previous auxiliary status to the main content of theoretical teaching. The reform of chemistry experiment curriculum is not only an innovation of the traditional education mode, but also a direct response to the goal of the new engineering education. Its importance is reflected in the following aspects:

The chemistry experiment course is a bridge to transform theoretical knowledge into practical skills. New engineering education emphasizes the close combination of theory and practice, and chemical experiment is a platform for students to apply the theoretical knowledge learned in class to practical operation. Through the experiment, students can personally observe the chemical reaction, understand the experimental phenomenon, and verify the theoretical model, so as to deepen the understanding of the chemical principles, and cultivate the ability to solve practical problems.

Chemistry experiment course is the cradle of innovative thinking. In the process of the experiment, students need to design experimental schemes, analyze experimental data, and solve problems, all of which require innovative thinking and critical thinking. New engineering education advocates the spirit of innovation, and the chemistry experiment course is the place to cultivate these abilities, so that students can learn to find problems and solve their problems in practice, so as to promote the development of their innovative thinking.

The chemistry experiment course is the sharpening field of teamwork ability. Experiments often require multiple cooperation, and students learn communication, coordination and team cooperation in the division of labor and cooperation, which is very important for cultivating the necessary qualities of modern engineers. New engineering education emphasizes the spirit of teamwork, and the chemistry experiment course provides a good opportunity to practice this idea.

The chemistry experiment course is also a window of combining with the engineering practice. New engineering education requires that educational content is closely combined with engineering practice, and chemistry experiment courses can integrate more elements of practical engineering projects, so that students can contact with and solve real industrial problems in the process of experiment, and improve their application ability of engineering background knowledge.

Chemistry experiment course is the intersection point of information technology and traditional teaching. New engineering education advocates the use of modern technological means, such as virtual simulation technology, to enrich the experimental teaching means and expand the space and time dimension of teaching. Chemistry experiment course can improve the safety and convenience of the experiment through these technical means, and at the same time, let students have the opportunity to try more diversified experimental scenarios, so as to improve the effectiveness of experimental teaching.

The chemistry experiment course plays an irreplaceable role in the new engineering education. It is not only a platform for the transformation of knowledge to skills, but also a carrier of innovative thinking, teamwork and the practical engineering ability cultivation. Therefore, the key to improve the quality of chemistry education and cultivate high-quality chemical engineering talents is to reform the chemistry experiment curriculum and make it fit with the new engineering education concept. In the reform, we should pay attention to the practicality and challenge of experimental projects, implement the student-centered teaching mode, strengthen the integration of experiment and theory, improve the level of information teaching, and construct a diversified evaluation system, so as to fully meet the requirements of new engineering education.

3. Problems Existing in the Teaching of Current Chemistry Experiment Courses

3.1. Limitations of the Teaching Content

The current teaching content of chemistry experiment is often subject to the traditional teaching syllabus and teaching materials, which has serious limitations. First, the curriculum system is outdated, and many experimental projects follow the design of decades ago, which lack a close connection with the development of modern technology and engineering practice. As a result, students are often exposed to outdated chemical technologies and methods in the process of experiment, which cannot meet the requirements of new engineering education for cultivating talents with cutting-edge technology application ability. For example, traditional experimental projects may focus on basic chemical synthesis and analytical methods, with less content involved in experiments in new fields such as nanomaterials preparation, green chemistry, and biopharmaceuticals.

The experiment is too theoretical, focusing on verifying known chemical principles, rather than solving practical problems. This allows students to play more of the role of "operator" than "explorer" during the experiment. Such teaching methods often inhibit students' ability to think creatively and to solve complex problems, because they lack the opportunity to directly face and solve practical problems in experiments.

Moreover, the experimental project is out of touch with the actual engineering work, which leads to the phenomenon of "theory and practice" in the practical work of students after graduation. Experimental design often lacks the consideration of engineering background, and does not fully simulate the real industrial environment and challenges, making it difficult for students to directly transform what they learn in the experiment into skills in practical work.

Experimental courses generally lack the cultivation of students' ability to design experiments and carry out scientific research independently. In many cases, the experimental steps are preset, and students only need to operate in the set routine, which undoubtedly limits their space for independent thinking and innovation. In the new engineering background, students need to have more ability to design independent experiments and solve practical problems to cope with the uncertainties in the future work.

Therefore, the limitation of teaching content is an urgent problem to be solved in the current curriculum reform of chemistry experiment course. The reform should focus on the introduction of more experimental projects that are closely combined with the engineering practice, and encourage students to participate in the experimental design to cultivate their autonomy and creativity. By introducing the cutting-edge technology and updating the experimental content, the chemistry experiment course can more closely meet the training needs of the new engineering education for

compound talents. This will not only improve the practicality of the experiment, but also stimulate students' enthusiasm for chemistry, and lay a solid foundation for cultivating high-quality chemical engineering talents.

3.2. Singleness of Teaching Methods

In the traditional chemistry experiment teaching, the teaching method mainly adopts teaching and demonstration teaching. Teachers usually explain the principles and steps of the experiment first, and then conduct on-site operation demonstration, while the students operate according to the guidance of the teacher. However, such a teaching method focuses too much on the one-way transmission of knowledge, and ignores the active participation of students and the cultivation of innovative thinking, which runs counter to the student-centered and practice-oriented concept emphasized by the new engineering education.

Teaching teaching is often teacher-centered, and students are only containers for passive knowledge acceptance, lacking space for active exploration and questioning. In such a teaching mode, it is difficult for students to put forward their own opinions, and the experimental process is more a process of verifying the knowledge of teachers, rather than a process of active learning and innovation. As a result, students lack of active thinking in the experimental process, lack of exercise in innovative thinking, and fail to cultivate the ability to solve problems.

Although the demonstration experimental teaching can allow students to directly observe the experimental operation, it puts too much emphasis on standardization and accuracy, so that students often only focus on the execution steps in the actual operation, but ignore the possible uncertainty in the experimental process, which limits students' practical innovation ability to a large extent. Students often do not know how to deal with small errors or accidents in experiments, which is not conducive to cultivating the ability to solve practical problems independently.

Moreover, the singleness of teaching methods is also reflected in the excessive reliance on traditional experimental operations and the lack of the integration of modern scientific and technological means. For example, virtual simulation techniques, data analysis tools and so on are underutilized in many experimental courses. These modern technological means can provide a safer and more economical experimental environment, simulate complex experimental situations, and help students better understand experimental phenomena and principles through data mining and analysis, and improve their data analysis ability, which is the skill advocated by new engineering education.

Therefore, the simplicity of teaching methods is another important problem in the current curriculum reform of chemistry experimentation. In order to cultivate students' practical ability and innovative spirit, teaching methods need to be changed from traditional teaching and demonstration to more rich and diversified ways, such as project-driven and problem-oriented teaching methods, so that students can learn and apply chemical knowledge in the process of solving practical problems. In addition, students should be encouraged to play their subjective initiative in the experiment, design their own experimental scheme, and explore the unknown, which will help to cultivate their independent thinking and innovative thinking.

At the same time, we should make full use of modern technological means, such as virtual simulation and big data analysis, to break the limitations of traditional experiments and provide a broader learning space. Teachers should become the guides and collaborators of students to learn, guide students to find and analyze problems in the experiment, and improve their critical thinking and problem-solving ability through experimental exploration. Through these reforms, teaching methods will shift from passive acceptance to active exploration, and from theoretical verification to practical application, so as to better adapt to the requirements of new engineering education for chemistry experimental courses.

4. Teaching Reform Strategy of Chemistry Experiment Course under the new Engineering Background

Under the impetus of new engineering education concept, chemical experiment course teaching reform strategy should revolve around course content update, teaching mode change, teaching resources integration and evaluation system reform of the four core aspects, to build a conforms to the new engineering education needs, and can cultivate innovative chemical engineering talent teaching system.

The renewal of curriculum content is the primary task of teaching reform. It requires the close combination of the experimental curriculum system with the development of modern science and technology, and the introduction of more experimental projects closely related to the engineering practice, such as green chemistry, nanomaterials synthesis, biopharmaceutical, etc., in order to enhance the practicality and challenge of experiments. These experimental projects should encourage students to use the theoretical knowledge they have learned to solve practical engineering problems and improve their ability to apply engineering background knowledge. At the same time, students should be encouraged to participate in the experimental design, and cultivate their ability to independently design experiments and scientific research, so as to adapt to the uncertainty brought about by the future scientific and technological development.

The transformation of teaching mode is another key point of reform. Student-centered, and project-driven and problem-oriented teaching methods should be implemented, so that students can actively learn and innovate in the process of solving practical problems. For example, the introduction of subject-based experimental projects, let students use chemical knowledge to seek solutions to specific problems. Encourage students to put forward their own experimental ideas, guide them to think independently, and cultivate critical thinking and innovative spirit. In addition, the deep integration of experimental teaching and theoretical teaching is essential, aiming to enable students to deepen the understanding of theoretical knowledge in the experiment, and to learn to apply theoretical knowledge in practical problems.

The integration of teaching resources requires the use of modern technological means, such as virtual simulation technology, to break the physical limitations of the experiment, provide diversified experimental scenarios, and increase the security and economy of the experiment. Through the mixed online and offline teaching mode, such as DIY experiment and competitive teaching, students' interest in learning can be stimulated and the learning effect is improved. In addition, teachers can introduce real-world data and cases into their teaching, so that students can improve

their ability to analyze data and solve practical problems in dealing with practical problems.

The reform of the evaluation system is also an important component. Under the background of new engineering, the evaluation system should go beyond the single assessment of experimental skills and turn to the comprehensive evaluation of students' innovative thinking, teamwork ability and the ability to solve practical problems. For example, group projects can be set up for students to show their teamwork spirit in the cooperation, and to examine their ability to use knowledge to solve problems through the project results. In addition, the regular training and presentation of innovative thinking, as well as the reflective evaluation of the experimental process, can also effectively promote the development of students' innovative thinking.

In order to implement the above reform strategies, the change in the role of teachers is equally important. Teachers should change from the transmitter of knowledge to the guide and collaborator of students' learning, encourage students to ask questions in class, and guide them to explore, question and innovate. Teachers should strengthen exchanges and cooperation, share teaching experience and reform results, and jointly improve the quality of experimental teaching. At the same time, schools should provide continuous teacher training to help teachers adapt to the requirements of teaching reform in the new engineering background.

5. Conclusion

Through the implementation of the above reform measures, the chemistry experiment course will no longer be just a place to verify the theoretical knowledge, but become an important platform to cultivate students' practical ability, innovative thinking and team spirit. This will help to improve the competitiveness of chemical engineering education in China, cultivate high-quality chemical talents who can cope with the challenges of future science and technology, and promote the modernization process of chemical education. The teaching reform of chemistry experimental courses under the background of new engineering is an important part of the strategy of higher education to meet the social needs and serve the innovation-driven development, and has far-reaching significance for the development of national science and technology and the construction of talent team.

References

[1] Andrés Garcés,Luis Fernando Sánchez-Barba.An alternative educational approach for an Inorganic Chemistry laboratory course in Industrial and Chemical Engineering[J].Chemistry Education Research & Practice, 2011, 12(1):101-113.DOI:10.1039/C1RP90013G.

[2] Dwivedi R K , Dwivedi S , Mishra A K .USE OF APPLET IN AN ENGINEERING CHEMISTRY COURSE[J].[2024-07-28].

[3] Sanderson K .Chemistry course corrections tackle bias[J].Nature, 2023, 615(7951):359-361.DOI:10.1038/d41586-023-00644-7.

[4] Schuppisser C , Mulliri K .Drug Discovery Summit:14th Swiss Course on Medicinal Chemistry[J].ChemMedChem, 2024(4): 19.

[5] Ciulli A , O'Connor S ,Chun-Wa ChungIngo V. HartungAndrea TestaDanette L. DanielsLaura H. Heitman.The 17th EFMC Short Course on Medicinal Chemistry on Small Molecule Protein Degraders[J].ChemMedChem, 2023, 18(20):n/a-n/a.

[6] Bargiela P , Fernandez V , Morgan D ,et al.Surface chemistry of ion beam modified native titania/Ti interfaces examined using X-ray photoelectron spectroscopy[J].Results in Surfaces and Interfaces, 2024, 15.DOI:10.1016/j.rsurfi.2024.100231.

[7] Bendi A , Mittal C , Chauhan V ,et al.Strategic One-Pot Synthesis of 1,2,3-Triazole-Based Dihydropyrimidinone Hybrids Using Magnetic CuFe2O4NPS as Heterogeneous Catalyst and Their DFT, Molecular Docking Studies[J].Journal of Molecular and Engineering Materials, 2024, 12(01n02).DOI:10.1142/S2251237324500035.

[8] Malinina E A , Myshletsov I I , Buzanov G A ,et al.A New Approach to the Synthesis of Nanocrystalline Cobalt Boride in the Course of the Thermal Decomposition of Cobalt Complexes [Co(DMF)[J].Molecules (Basel, Switzerland), 2023, 28(1).DOI:10.3390/molecules28010453.

[9] Lin b, Wang Q, Qi z, et al. . Cucurbit [8] uril-mediated multi-color fluorescence system for time-dependent information encryption [J] . Chinese science: Chemistry, 2023,66(4) : 1111-1119.

[10] Jasin J , Ng H T , Atmosukarto I ,et al.The implementation of chatbot-mediated immediacy for synchronous communication in an online chemistry course[J].Education and Information Technologies, 2023:1 - 26.DOI:10.1007/s10639-023-11602-1.

[11] Stippell E , Akimov A V , Prezhdo O V .PySyComp: A Symbolic Python Library for the Undergraduate Quantum Chemistry Course[J].Journal of Chemical Education, 2023, 100(10):4077-4084.DOI:10.1021/acs.jchemed.2c00974.

[12] Kisunzu J K .A Multidimensional Journal Club Activity for an Undergraduate Advanced Organic Chemistry Course[J]. Journal of Chemical Education, 2023, 100(4):1687-1692.DOI:10.1021/acs.jchemed.2c00883.

[13] Holton M B A J ,emailprotected, Emailprotected E M ,et al.The Impact of Modality Choice on Final Exam Success and Retention in a Concurrent Preparatory Chemistry Course[J]. Journal of Chemical Education, 2023, 100(12):4585-4596. DOI:10.1021/acs.jchemed.3c00365.

[14] Senapati M B S , Senapati S ,Subhadip Senapati Subhadip SenapatiDepartment of Chemistry, Prayoga Institute of Education Research, Bengaluru, Karnataka , IndiaMore by Subhadip Senapati,et al.Investigating the Impact of Combining Structured Peer Work with a Flipped Organic Chemistry Course for High School Students[J].Journal of Chemical Education, 2023(12):100.