Curriculum and Teaching Methodology (2025)
Clausius Scientific Press, Canada

DOI: 10.23977/curtm.2025.080611
ISSN 2616-2261 Vol. 8 Num. 6

Construction and Practice of First-Class Course of Analytical Chemistry

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Keywords: First-Class Course, Analytical Chemistry, Course Construction

***Abstract*:** As an important carrier, course is a significant way to improve the quality of talents training. Based on the core idea of “placing the development of students in the focus”, Analytical Chemistry course in Anhui Normal University turns the architecture from “classroom, teacher, book” to “student, real case, application”. The various measures including teaching content optimization, the curriculum ideological and political education, discipline frontier, and innovation practice have been carried out within the whole teaching process, achieving the organic integration of students' knowledge, abilities and qualities. Through the construction of on- and off-line three-dimensional teaching resources, the course establishes the teaching model of “pre-class, in-class, and after-class”. Through the case teaching method, the course teaching team guides the students to adopt the learning form of independent exploration and cooperative communication, so as to actively acquire knowledge and cultivate abilities. After years of construction and practice in teaching content, method, evaluation, and the mean of education, Analytical Chemistry course not only efficiently improves the teaching effects, but also realizes the organic unity of the knowledge-transference, ability-improvement, and value-guidance.

1. Introduction

Course is the core element of teaching, education, and talent cultivation. The construction of a curriculum system is a powerful guarantee for strengthening talent cultivation, improving the teaching quality, and enhancing the schooling level. Analytical chemistry is the earliest developed branch of chemistry. It is the "eye" of science and technology, as well as industrial and agricultural production, which also plays a crucial role in the development of the national economy, the strengthening of national defense, the advancement of science and technology, and the development and comprehensive utilization of natural resources [1]. Analytical Chemistry is a professional basic course for all ordinary colleges and universities in chemistry and related disciplines. However, a phenomenon in teaching that "knowledge and skills are emphasized while ability cultivation and value guidance are neglected" is widespread. To address this issue and in response to the call from

the Education Department of China for the establishment of high-level, innovative and challenging "high-quality courses" [2], the Analytical Chemistry course at Anhui Normal University has been continuously undergoing reform and construction in multiple aspects such as teaching content, teaching methods, teaching means, as well as assessment and evaluation, on the basis of the school's positioning and the goal of cultivating professional talents.

2. Reform of teaching content

2.1. Optimizing course content with systematic organization

Analytical Chemistry course involves numerous analytical methods, formulas, and instruments, and its content is scattered, which may lead to a dull and boring teaching and learning process [3]. To enhance students' learning efficiency, the teaching content has been systematically classified and optimized: (1) Key and difficult content that requires detailed explanation, mainly including method principles, instruments, and qualitative and quantitative methods by analogical methods. For instance, in the four fundamental titration methods, the method principle of acid-base titration is emphasized through detailed teaching to enhance students' understanding of the titration curve and endpoint error, enabling them to apply the way of thinking of acid-base titration to the learning of method principles such as complexometric titration, redox titration, and precipitation titration. (2) Content for special topic introduction, mainly covering relatively systematic knowledge with lower learning requirements. For example, in the learning of complex substance separation, common types of separation methods and newly developed methods in recent years are introduced through special topics; to learn chromatography methods, the new development and other combined techniques such as gas chromatography-mass spectrometry and liquid chromatography-mass spectrometry are concentratedly introduced. (3) The content that students can learn and teach by themselves, mainly consisting of knowledge that is not too difficult and has already been covered in the prerequisite courses. The reconstruction of teaching content, not only resolves the problem of insufficient class hours for the classroom teaching, but also facilitates the students to achieve positive learning effects through different learning methods such as analogy learning, thematic learning, and self-teaching.

2.2. Maintaining a close connection to practice while focusing on disciplinary frontiers

"Analytical Chemistry" is an experimental discipline that closely connects to social life and production practice. Based on the practice cases, students are able to use the course's professional knowledge to analyze and solve practical problems. For example, during the prevention and control of the novel coronavirus (COVID-19), the structural analysis, genome sequencing, nucleic acid testing, nucleic acid test kit, various therapeutic drugs of COVID-19, and disinfectants, etc. are all closely related to analytical chemistry. During the introduction and related chapters (such as fluorescence analysis method, electrophoresis, etc.) study process, teacher constantly introduces the role of analytical chemistry in the prevention and treatment of the COVID-19 epidemic, making students deeply realize the importance of analytical chemistry in solving practical problems in daily life. Through the timely expansion of the content related to the frontier and contemporary trends of the discipline, as well as the introduction of the analytical application of interdisciplinary scientific technologies, the students' thinking and perspectives have been broadened, and their learning interest has been enhanced.

2.3. Integrating theory with practice to enhance innovation capabilities

The "Analytical Chemistry" course covers a wide range of analytical methods and instruments. The theoretical teaching merely provides textual descriptions of the method principles and instrument structures, making it difficult for students to deeply understand and master the content and resulting in the low degree of achievement of teaching objectives [4, 5]. To address this issue, students are organized to visit the large-scale instrument center and related research laboratories of the university, and the instrument administrators are invited to introduce the principle, structure and functions of the instruments after class. This not only enables students to observe the actual instruments, understand their working principles and operation processes, but also stimulates their interest in learning and enthusiasm for participating in scientific research and innovation experiments.

At the same time, the course team teachers transform the latest research results into the experiments. Through various forms of projects such as the Innovation and Entrepreneurship Training Program, the Cultivation Plan for Excellent Undergraduate Graduation Theses, and Innovation Experiments, students can apply the basic theories and experimental operation skills into the scientific research and innovation process, achieving the cultivating students' ability of analysis and solving complex problems, the organic integration of knowledge and ability, and reflecting the high-level nature of the course.

3. Reform of Teaching Mode

3.1. Curricular and Extracurricular Three-Dimensional Teaching, Leveraging the Advantages of Information Technology Platforms

The "Analytical Chemistry" course team teachers integrate modern information technology with teaching comprehensively through various information technology platforms, such as Xuexitong, Rain Classroom, Tencent Meeting, etc. As shown in Figure 1, the three teaching stages of before class, during class, and after class are fully used to construct an integrated teaching process, ensuring that the teaching process is closely linked and progressively advanced step by step.

Before class, teachers design and delivery preview courseware or micro-lesson video materials on online platforms such as Rain Classroom, clearly describe the objectives, requirements, key points and difficulties of the new lesson, and guide students to independently study and understand the relevant content. Teachers propose discussion questions or exercises related to the new knowledge, guiding students to seek answers through shallow learning and thinking before class.

During class, the teaching is mainly adopted by teacher guidance and heuristic inquiry-based methods, focusing on the tackling of key and difficult content of the curriculum. Teachers design the teaching process based on the students' learning situations and pay attention to the individual learning outcomes of the students. Teachers design and post quizzes related to new knowledge via Rain Classroom to assess students' learning outcomes and enhance their learning interest. Meanwhile, students' thinking patterns for solving practical problems have been cultivated through the deep learning of the professional knowledge.

After class, teachers promptly summary mind maps and end-of-chapter test questions, facilitating students to systematically review and master the course content, helping students to assess their learning. Therefore, students' learning effects can be effectively improved through the closed-loop learning of pre-class guidance, in-class study, and after-class consolidation.

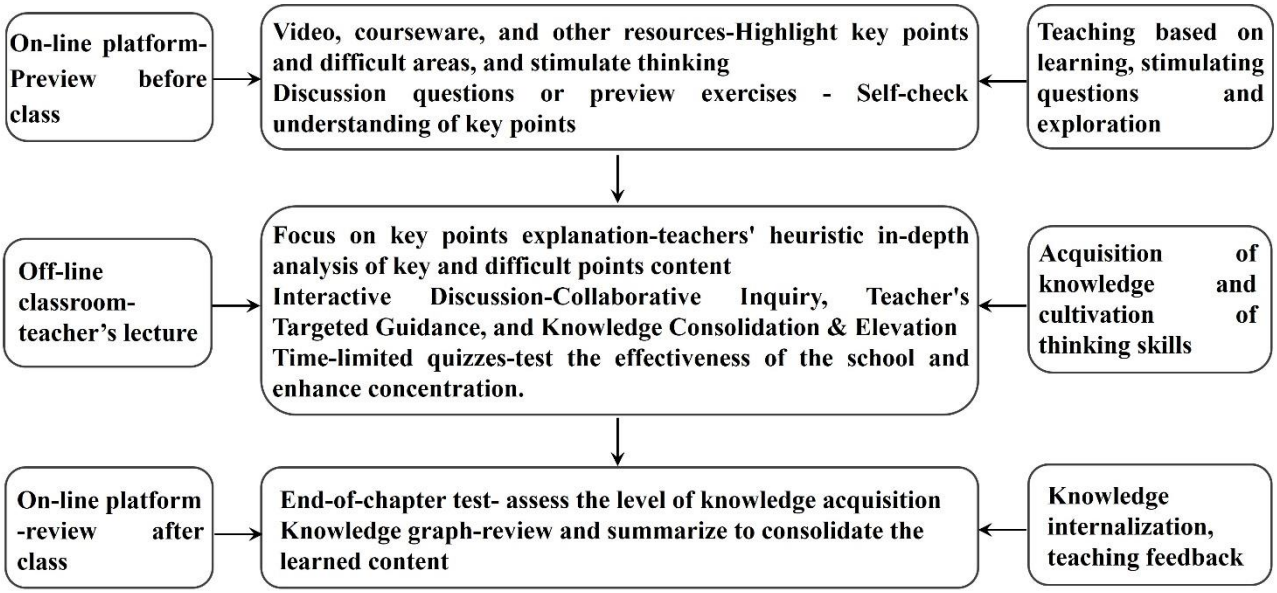

Figure 1: Curricular and extracurricular three-dimensional teaching design mentality.

3.2. Implement case-based teaching to enhance students' central role

Actual cases make the teaching content more concrete and typical [6]. The case-based teaching method has been used into the Analytical Chemistry course, enabling students to accurately understand theoretical knowledge. Teachers guide students to engage in inquiry-based and personalized learning, and prompt them to analyze, study, summarize, and conclude the cases, thereby improving their ability to analyze and solve problems. The case-based teaching method enables students to personally experience the application of knowledge, thereby stimulating their enthusiasm and internal motivation for learning. For example, during the learning of the principle of acid-base titration, by combining the social hot issue of protein content in milk, a case can be introduced: teacher guides students to analyzed the formation and the alterations of the titration curve; explains the law of quantitative change to qualitative change through the amount of titrant added and the color change of the indicator before and after the titration jump; derives the accurate titration conditions for weak acids by comparing the similarities and differences of titration curves of strong acids and weak acids. Based on this, the teacher then introduces the incident of melamine-contaminated milk powder, analyzes the problems existing in the acid-base titration method, and emphasizes the country's emergency response capabilities and the correct measures to deal with it. This not only enhances the students' sense of social responsibility, but also addresses the initial questions raised in the class. Finally, teacher sets thinking questions online for students to consolidate the knowledge they have learned (Figure 2).

For another example, teacher chose the determination of chemical oxygen demand in water samples as a case during the teaching of redox titration method. First of all, the students are divided into groups and required to search for relevant information through the Internet and electronic journals. Based on the nature of the water samples, they are then guided to analyze and select the potassium permanganate method or the potassium dichromate method that they have learned. Afterwards, students prepare PPT to comprehensively discuss the case-related questions proposed by the teacher (such as sample pre-treatment; titration acidity, temperature, and speed; method accuracy;

blank experiments, etc.). Finally, the teacher and the students jointly evaluate.

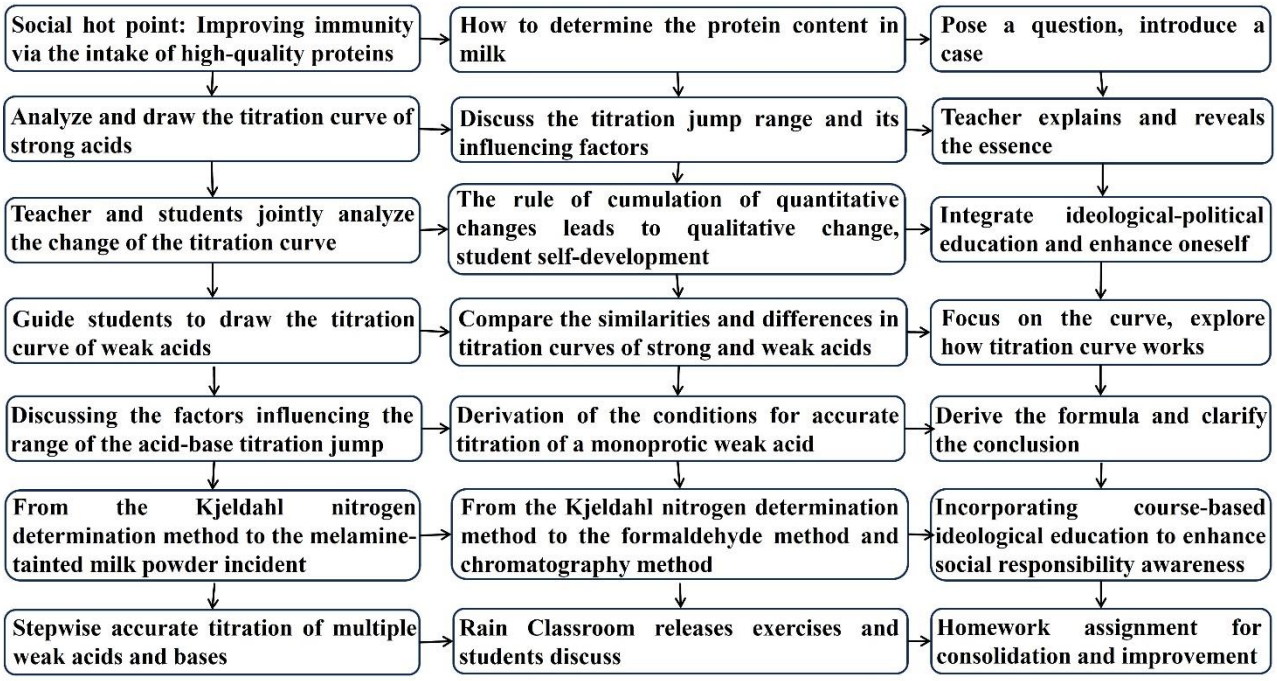

Figure 2: Teaching case: detection of protein in milk powder-principle of acid-base titration.

By integrating specific cases into the teaching process, the students' enthusiasm, initiative and creativity in learning have been fully mobilized and the students' activities of thinking and discussion have been encouraged, achieving the two-way interaction between the leadership role of teachers and the dominant position of students. At the same time, teachers guide students to apply theoretical knowledge to comprehensively analyze real case, which not only deepens their understanding but also cultivates their ability of flexible application of the theoretical knowledge.

3.3. Thematic Discussion Teaching, Enhancing the Difficulty of Course Learning

The "Analytical Chemistry" course features a variety of analytical methods, significant differences in principles, and wide application scope. Many students believe that the course content is numerous, scattered and lack of coherence, which makes it difficult for them to understand. In response to this situation, based on small-class teaching, certain contents (with universal laws, strong systematicness and application, or social hot topics) were proposed as the themes for the learning. Subsequently, the students conduct independent literature research and analysis before class. During the class, they present their reports, have in-depth discussions, participate in debates, and summarize and reflect on the course content in various forms at different stages to complete a specific research project. Based on the premise of increasing burden, we aim to cultivate students' self-directed learning abilities, logical thinking skills, critical thinking capabilities, and collaborative skills. Through the method of thematic discussion teaching, we appropriately increase the difficulty of the course learning to cultivate students' abilities of autonomous learning, logical thinking, critical thinking and collaboration.

4. Pedagogical Approaches

4.1. Integrating Ideological-Political Education into Courses and Enhancing the Educational Function of Professional Courses

While strengthening the imparting of basic professional knowledge, it is also very important to leverage the educational function of professional courses [7]. By combining the characteristics of Analytical Chemistry, teachers actively dig out the relevant ideological-political elements, design and explore ideological-political cases for Analytical Chemistry course based on the content modules including current affairs hotspots, scientific literacy, regional development, national rise, philosophical issues, role models of the times, and student growth. As shown in Figure 3, teachers naturally incorporate ideological-political elements into the course teaching, to stimulate students' interest in learning, cultivate their patriotism and sense of mission, and guide them to establish correct worldviews and values.

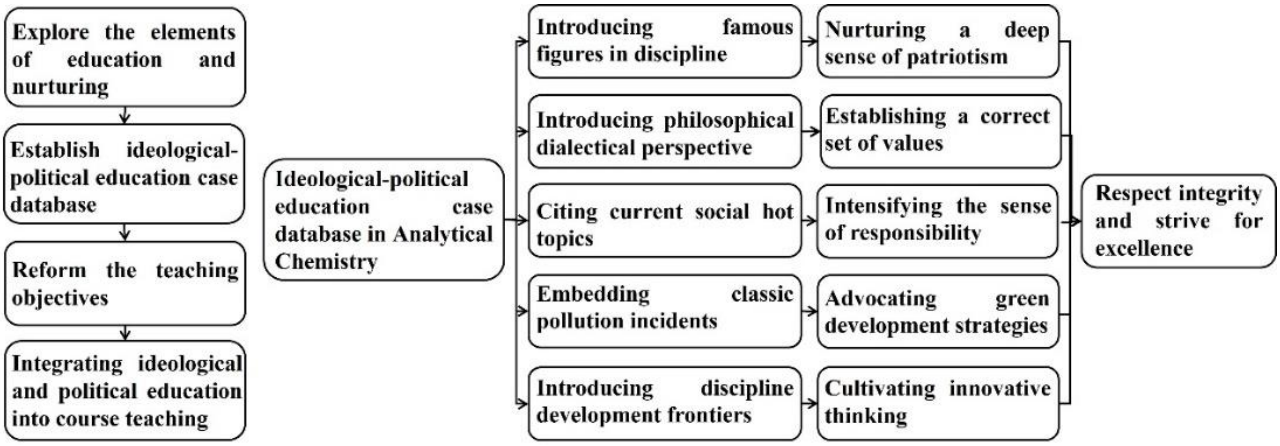

Figure 3: Construction of the curriculum ideological and political education system.

For example, in the Introduction section, based on the understanding of the research conducted by the Wuhan Institute of Virology of the Chinese Academy of Sciences on the components, structure, and amounts of the novel coronavirus, students understand that this is the structural analysis in analytical chemistry. Screening whether a person is infected with the novel coronavirus through nucleic acid testing falls under qualitative analysis. The currently most commonly used method for detecting the COVID-19 is real-time fluorescent RT-PCR technology, which is a typical quantitative analysis. Moreover, in this case, teacher introduces other analytical methods and techniques for the detection of COVID-19, inspiring students to embrace the ideal of contributing to the nation through science and technology and the mission-driven responsibility that no one else can shoulder.

4.2. Conduct innovative experiments and deeply experience the professional education function

The implementation of innovative experiments not only cultivates and enhances students' innovative awareness and ability, but also enables them to deeply experience the educational function of research. By the combination of the research projects with students' interests, Analytical Chemistry course team teachers encourage and guide students to carry out the innovative experiments. Through the entire process of learning and training including investigating literature materials, designing research plans, conducting experiments, analyzing data, summarizing and writing research report, students can feel different educational effects in each stage. For example, one needs to be patient and meticulous when observing the experimental phenomena; one should ensure accuracy when

recording experimental data; one needs to think deeply and persevere in making efforts once facing difficulties; one must strictly adhere to academic ethics when writing the thesis, they must strictly abide by academic ethics, etc.

5. Evaluation Model Reform

Analytical Chemistry course team takes process evaluation as the core to build a diversified course assessment system and design a comprehensive evaluation system that can examine students' knowledge, abilities and qualities, overcoming the disadvantages of the traditional assessment method of "grading solely based on one exam". The diversified course assessment includes attendance, class discussions, homework, group activities and overall classroom performance. That is to say, all the aspects during the course and after their completion are part of the assessment content. This will put students under certain pressure, thereby motivating them to study harder and successfully complete the course.

In addition, teachers appropriately increase the number of unit tests and project research plans to assess students' mastery of the learned knowledge and enhance their ability to solve practical problems, respectively. In the summative evaluation stage, besides the assessing of students' basic knowledge and theories, more attention has been placed on cultivating their ability to apply knowledge comprehensively. In this way, based on the scientific increasing the burden, students are evaluated from multiple aspects and dimensions, thereby ensuring the comprehensiveness and rationality of the course assessment.

6. Enhancement of Teachers' Professional Competence in the Course Team

6.1. Three-level Management System and Specialized Course Scheduling Model

Analytical Chemistry course team has established a three-level management system consisting of "team leader - course leader - teaching group", where the team leader is responsible for the selection of course materials, revision of teaching outlines, and arrangement of teaching discussions, thereby improving the operational quality and efficiency of the team. The course team, after carefully considering the teaching content and difficulty level, gradually carried out the teaching process step-by-step from easy to difficult, which also conforming to the growth pattern of teachers and effectively ensuring the quality of teaching.

6.2. The doctoralization and Internationalization of the Teaching Team

To enhance the quality of teaching, the Analytical Chemistry course teaching team has made plans to enable the teachers to pursue higher degrees and engage in international exchanges and cooperation. Among the 16 teachers in the teaching team, there are 10 professors, 3 associate professors, and 3 lecturers. All the teachers hold doctoral degrees, and 11 teachers have overseas research experience. Such a well-structured and highly qualified teaching staff is rare in our university and also uncommon among similar-level normal universities in the surrounding areas. The improvement of teachers' educational qualifications, academic degrees and professional titles has facilitated the integration of teaching and research, laying a solid foundation for enhancing teaching quality.

6.3. Senior-Junior Faculty Pairing Mechanism, Persistent Words-and-Deeds Promoting Growth

Teaching team has established a mentorship system for young teachers. Through various measures such as attending courses taught by excellent teachers, participating in lesson plan presentation and demonstration lesson, and taking part in teaching skills competitions, etc., teaching team continuously implements the senior-junior faculty pairing program, rapidly enhancing the teaching abilities of young teachers. And different means including collective lesson planning, demonstration lessons, observation and evaluation of lessons, experimental preparations, online course learning, and teaching research discussions have been conducted to improve the teaching quality of the team of teachers. Meanwhile, according to the requirement of “professor serves the front-line undergraduate teaching”, professors with good teaching abilities and high professional proficiency take the podium for undergraduate classes, highlighting the central position of teaching.

7. Conclusion

Based on the core elements of the "student-centered" educational philosophy, Analytical Chemistry course teaching team combines the University's positioning, professional talent cultivation goals, course characteristics, and the requirements of the times to carry out teaching reforms and practices from multiple dimensions such as teaching content, teaching methods, teaching evaluation, and educational approaches. The teaching team has turned the framework centered on "classroom, teacher, and textbook" into one centered on "student, real case, and application", constructing a "pre-class, in-class, and after-class" teaching process. These measures not only facilitate students' learning and mastery of theoretical knowledge, but also enable them to cultivate the ability to integrate professional knowledge and apply it to the practical problem-solving in production and daily life, as well as stimulate their innovative thinking.

The curriculum construction is a long-term and regular task. Based on the standard of "high-level, innovative and challenging", we will continuously carry out the construction of the "Analytical Chemistry" course to further enhance the educational effect of the course through strengthening the construction of the depth and breadth of teaching content, the improvement of quality and operability of teaching case design, the integration of course ideological education and course teaching, the complementary construction of classroom teaching and online resources, and the deepening the application of digital technologies.

Acknowledgements

This work was financially supported by Anhui Province Undergraduate Higher Education Teaching Reform Project (2022jyxm559).

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