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Teaching Reform of Modern Instrument Analysis Course Under the Guidance of Ideological and Political Education

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Abstract:

Takes moral education as the fundamental task and ideological and political education as the teaching guidance, it aims at cultivating applied talents with both ability and morality. Modern instrumental analysis course reform focuses on the research of the multi-dimensional aspects of revising curriculum objectives, reconstructing teaching contents, designing teaching methods and perfecting evaluation systems by studying the course characteristics, educational reform needs and social needs, and explore ways to effectively fit ideological and political education, theoretical knowledge system, and practical teaching mode in the process of professional curriculum construction to stimulate students' interests in learning and change their learning attitudes, realize the collaborative education of value guidance, knowledge imparting and ability cultivation.

Keywords:

Application-oriented talents training
Curriculum ideological and political
Ability training
Multi-dimensional fusion

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1. Introduction

To embrace the new era and journey, cultivating practical and applied talents who can serve the construction of a modernized and powerful China and the great rejuvenation of the Chinese nation, while adapting to economic and social development with both moral and academic excellence, has become the main direction of teaching reform in various applied universities [1,2]. Modern instrumental analysis is a fundamental course for majors such as chemical engineering and food science, playing a crucial supporting role in talent cultivation goals and graduation requirements. Through this course, students can master the structure of modern instruments, the basic principles of qualitative and quantitative analysis, and corresponding scientific experiment methods. It cultivates students' scientific and rigorous thinking abilities, as well as their ability to analyze and solve practical problems using modern instrumental analysis techniques, laying a foundation for them to engage in food testing and other related scientific research work after graduation. In the context of building first-class national professional programs, the modern instrumental analysis teaching team at the School of Food and Biological Engineering, Qiqihar University, has undergone years of practical exploration. Combining professional talent cultivation characteristics and industry talent needs, they have highly integrated ideological and political education, curriculum knowledge systems, and practical teaching models, innovating and practicing the entire process of curriculum teaching from multiple dimensions. They have explored educational reform measures, effectively addressing issues in modern instrumental analysis teaching, and achieved a shift in students' thinking from passive learning to active learning, diligent learning, and proficient learning through guidance, gradually forming a unique teaching style [3–6].

2. Revising course objectives based on the OBE concept

Outcome-Based Education (OBE) is an educational philosophy that orients teaching design and implementation toward the final learning outcomes achieved by students through the educational process [7]. The setting, design, implementation, evaluation, and improvement of courses all depend on the accurate positioning of course objectives. For the cultivation of applied talents, the teaching objectives of the course not only come from textbooks but are more determined by students' future employment positions, namely, the requirements for employees. Based on the needs of social and industrial development, the modern instrumental analysis course follows the OBE concept of "student development as the center and output as the orientation." It revises course objectives by combining the school's educational positioning, engineering education professional certification standards, graduation requirements of professional training programs, and survey results from alumni and employers [8,9]. This supports the cultivation goals and graduation requirements of applied talents, providing direction for subsequent teaching method optimization, teaching content reconstruction, and teaching model reform.

2.1. Knowledge objectives

To cultivate students with firm ideals and beliefs, a sense of national responsibility, and a mission to serve the country through technology. To enhance their ability to understand and analyze things scientifically and dialectically. To foster a scientific spirit of seeking truth and pragmatism, professional ethics, and an innovative consciousness of replacing the old with the new. To develop good team collaboration skills.

(1) Supporting talent cultivation goals (targets achievable approximately five years after graduation): Students should have an international perspective, healthy physical and mental well-being, and good humanistic qualities. They should possess strong coordination, management, communication, competition, and cooperation abilities. They should be able to update their knowledge through continuing education or other learning channels, possess independent and lifelong learning abilities, and have the potential to grow into senior engineers.

(2) Supporting graduation requirement indicators: Students should establish correct values and have a sense of social responsibility. They should understand the professional nature and responsibilities of food engineers, and consciously abide by professional ethics and norms. They should be able to communicate, cooperate, and work with other team members in food engineering projects.

(3) Future employment position requirements for employees (compiled based on surveys of alumni and employers): Employees should have good professional ethics (professional qualities), strong communication and cooperation abilities, a certain degree of self-learning ability, and innovation ability, laying a foundation for sustainable development.

2.2. Optimizing teaching methods using "Backward Design"

The teaching model for each chapter of modern instrumental analysis traditionally followed the sequence of introducing the basic principles of the instrument → instrument structure → working principles of various components → influencing factors → practical applications. This approach emphasized the effectiveness of knowledge transmission by the teacher. Each chapter began with an abstract introduction to the basic principles of the instrument, followed by a lengthy explanation of the complex structure and the working principles of its components, and concluded with a brief overview of the instrument's application scope and examples [10]. Since students were not familiar with these instruments beforehand, they often struggled to understand and resorted to rote learning at the beginning of each new instrument's introduction. This could lead to a fear of difficulty and a subsequent loss of interest in the course. Such teaching methods resulted in low student initiative and participation during the entire learning process, hindering the achievement of the course's teaching objectives.

Backward design requires teachers to first clarify the desired final learning outcomes of the course and then design the teaching pathway and methods to achieve those outcomes. The starting point of teaching shifts from what the teacher wants to teach to what is necessary to achieve the peak outcomes, which is the opposite of traditional teaching design [7].

To enhance students' learning enthusiasm and subjective initiative, and to facilitate a shift from passive to active learning, the modern instrumental analysis

Table 1. Patterns among the chapters of modern instrumental analysis course

Theoretical knowledge	Intrinsic connections between various instruments	Examples
Basic principles	The relationship between the physical quantity of the substance to be measured and a certain signal strength; The physical quantity of the substance to be measured is a qualitative characteristic scale, and the signal strength is the basis for quantification	Spectral analysis: the relationship between wavelength and absorbance; Chromatographic analysis: the relationship between retention time and peak area
Instrument structure	Various instrument components are composed of several major parts: signal generator → converter or detector → signal processing device → recorder or computer digital output	UV-visible spectrophotometer: light source → monochromator → sample cell → detector → data processor (computer); Liquid chromatograph/amino acid analyzer: sample injector → chromatographic column → detector → data recording and processing system; Electronic nose/tongue: gas/taste sensor array → signal acquisition system → pattern recognition detection system → data processing system
Application	Qualitative analysis, Quantitative analysis	Atomic absorption/emission spectroscopy: quantitative analysis; Chromatographic analysis: can be qualitative and quantitative
Selection of analytical methods	Generally, instrumental analysis methods can be selected based on three points: 1. Sufficient understanding of the sample: requirements for accuracy and precision of the sample measurement, availability of sample volume, physicochemical properties of the sample matrix, etc.; 2. Adequate understanding of the detection instrument method: instrument accuracy, error, sensitivity, detection limit, concentration range, selectivity, etc.; 3. Other methodological characteristics: analysis speed, ease of operation, instrument cost, sample analysis cost, environmental cost, etc.	

teaching team at the college has optimized the teaching methods. The focus of the entire course is to address the "3W" questions: Why learn (Why), what to learn (What), and how to learn (How). At the beginning of each chapter, the purpose of learning the instrument and its application scope is introduced to motivate students' enthusiasm and initiative for learning new instruments. Then, teaching examples are used to explain the instrument's development history, analytical characteristics, advantages, and disadvantages, deepening students' understanding of the new instrument. Finally, the basic principles, structural components, working principles of various parts, analysis conditions, and selection of analysis methods are taught from easy to difficult. Generalizable patterns are summarized from individual chapters (see Tab 1), facilitating students' learning, understanding, and overall mastery of various analytical instruments, and achieving a transition from passive to active learning.

3. Reconstructing teaching content based on professional needs

3.1. Reconstruction of professional knowledge content

The traditional teaching content of modern instrumental analysis courses includes spectral analysis, chromatographic analysis, mass spectrometry, electrochemical analysis, etc. Among them, spectral analysis and chromatographic analysis are the main focus. However, the teaching methods still have issues such as a loose connection with the food profession and a lack of specificity, which makes it difficult to support the development of professional discipline, the achievement of talent cultivation goals, and graduation requirements.

In the context of building a national first-class professional program, to meet the needs of professional education and industry development, the modern instrumental analysis teaching team at the college has reconstructed the course's teaching content. This reconstruction balances traditional spectral analysis, mass spectrometry, and chromatographic analysis while incorporating knowledge of new technologies and instruments that have developed in recent years. By combining the teaching of instrument analysis specific to the food profession, the course strengthens the relevance between the curriculum and the food profession. The teaching duration on the basic principles and structure of the instruments is appropriately streamlined, and the application of various instrumental analysis methods in food analysis is elaborated more in detail. This is combined with practical food analysis and food safety cases to clarify the direction of students' course learning [6,11].

Additionally, comprehensive food safety experiments (such as determination of HCH and DDT residues in food, determination of benzoic acid and sorbic acid in food, determination of methanol and fuel oil content in Baijiu, HPLC determination of melamine content in infant formula, atomic absorption determination of lead content in puffed potato chips, detection of clenbuterol in pork, etc.) offered in the senior year help students consolidate the basic theoretical knowledge and application scope of instrumental analysis. These experiments also provide practical guidance for students to engage in food science research and inspection work after graduation [12]. The reconstructed course content more closely aligns with the revised course objectives, allowing students to fully understand the relevance of the course content to the food profession and its practicality for future work. This enables a shift from active learning to diligent learning.

3.2. Identification and design of ideological and political elements and educational functions in the curriculum

To strengthen the integration of modern instrumental analysis course teaching with ideological and political education, the study focuses on the course training objectives. By exploring the course's historical development, typical stories, prominent figures, and their roles in societal hotspots and food public safety incidents, we fully tap into the ideological and political elements and inherent educational functions embedded in the course. This approach integrates ideological and political education content into professional course teaching, realizing the goal of fostering morality and cultivating talent.

3.2.1. Nurturing patriotism and enthusiasm for serving the country through science and technology

The study highlights the dedicated and selfless spirit of scientists through case studies of individuals who have made significant historical contributions to the development of modern instrumental analysis. This helps cultivate students' patriotism and enthusiasm for serving the country through science and technology. For example, Gao Hong, the founder of modern instrumental analysis in China, authored the first "Instrumental Analysis" textbook in China. After obtaining his PhD from the University of Illinois in 1947, he resolutely returned to China to establish the precedent of instrumental analysis, developing the oscillography analysis method and opening up a new field in analytical chemistry.

3.2.2. Cultivating the scientific spirit of scaling scientific heights and innovation consciousness

The history of instrumental analysis, spanning over 100 years, has produced more than 30 Nobel Prize winners. Their achievements, such as the discovery of X-rays, the invention of mass spectrometry for isotope determination, distribution chromatography, high-resolution electronic spectroscopy, and the establishment of biological macromolecule mass spectrometry, all reflect scientists' desire to explore the unknown world, their pursuit of truth, and their unwavering scientific spirit in facing difficulties, embracing failures, and persevering in scientific research. Through case-based teaching and discussion, we focus on exploration and technological innovation as entry points for ideological and political education, cultivating students' scientific spirit and innovation consciousness in overcoming difficulties and scaling scientific heights.

3.2.3. Establishing a correct sense of social responsibility and mission

By incorporating hot topics in social life and food public safety cases, such as the melamine incident in infant formula, the "gutter oil" incident, the Sudan Red incident, the clenbuterol incident, frequent school cafeteria food safety incidents, and the European horsemeat scandal, students are made aware of the importance of correct and rational use of modern instruments to detect toxic and hazardous substances in food and prevent public safety incidents. This helps students establish a sense of social responsibility and mission. Starting from the social background of safety incidents, the study reveals the deficiencies of inspection and detection technologies for components such as protein and pigments in food at that time. Emphasizing the necessity of continuously developing new inspection and detection technologies cultivates students' sense of mission and responsibility. Finally, from the perspectives of professional talent training characteristics, future career requirements, and professional accomplishment development, the study assists students in establishing correct professional ethics and values, enhancing their potential for career development.

4. Innovating teaching models to achieve learning progression

The CDIO (Conceive, Design, Implement, Operate) engineering education model is a new educational paradigm that can compensate for the deficiencies of higher engineering education. Its development aims to provide students with an educational framework for conceiving, designing, implementing, and operating real products or research structures. The traditional education model primarily focuses on teacher instruction and knowledge transmission, often overlooking the cultivation of students' abilities. By integrating the CDIO engineering education model with theoretical courses, course teaching can be transformed from mere knowledge imparting to enabling students to actively learn engineering knowledge and acquire engineering practical abilities. This enhances teamwork awareness and practical skills, facilitating a transition from diligent learning to proficient learning.

Taking advantage of engineering education professional accreditation, and aiming to cultivate high-quality applied talents, the study integrates value guidance, knowledge transmission, and ability cultivation into the teaching methods. The modern instrumental analysis teaching team incorporates the CDIO engineering education model into the teaching process (**Figure 1**). Specifically, teachers utilize actual ideological and political cases or created problem scenarios related to social hotspots and public food safety as starting points. Students are assigned to groups and tasked with applying their theoretical knowledge of instrumental analysis to conceive research tasks, design experimental testing schemes, implement group discussions to select the best option and operate instruments to verify the feasibility of the overall plan. This immersive approach allows students to engage in the entire simulation process from project conception to design, implementation, and operation. The design aspects of the experimental projects closely resemble the work environments students will encounter in their future careers. Additionally, students' project implementation results can be used to evaluate their mastery of course knowledge and their ability to comprehensively select appropriate analytical methods based on the characteristics and application scope of various instrumental analysis techniques. Through the process of analyzing problems, solving challenges, and implementing projects, students enhance their scientific literacy, sense of responsibility, and innovative consciousness, cultivating rigorous thinking, strong communication skills, and team collaboration abilities.

5. Improving the evaluation system with an outcome-oriented approach

To better evaluate students' learning achievements, a comprehensive assessment of both the learning process and learning abilities is conducted (**Figure 2**). This approach emphasizes the importance of assessing not only the outcomes but also the journey students take to achieve those outcomes, ensuring that the evaluation is challenging and encourages continuous improvement [14].

The evaluation system for the Modern Instrumental

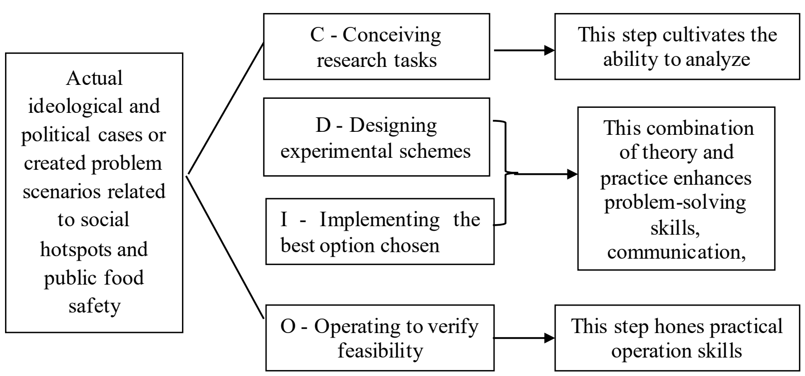

Figure 1. Integration of the CDIO model into modern instrumental analysis courses.

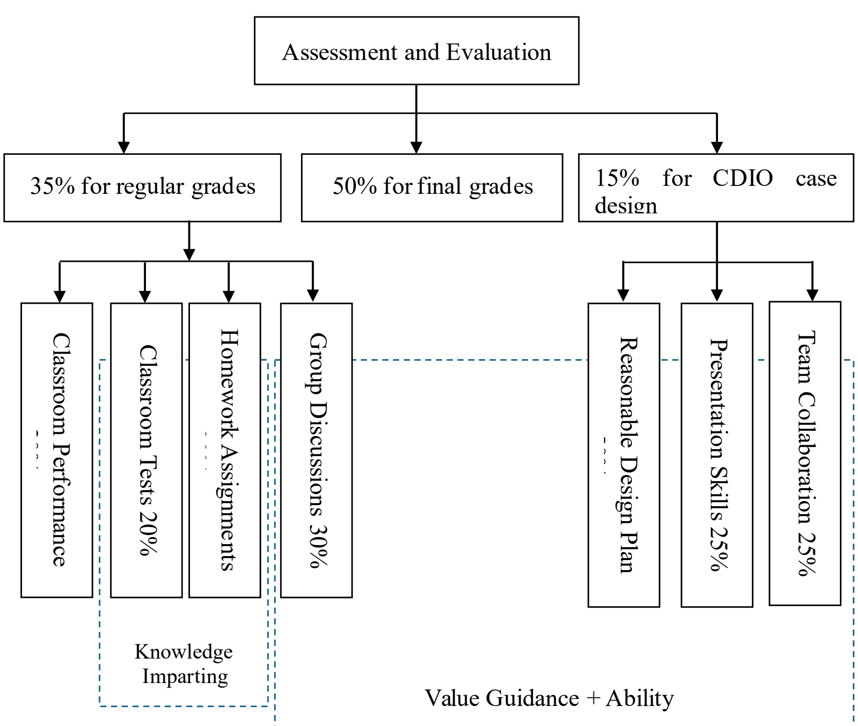

Figure 2. Multi-dimensional evaluation system for modern instrumental analysis course performance.

Analysis course includes regular grades, which are primarily based on coursework assessments such as attendance and classroom performance. Classroom performance mainly examines whether students can actively participate in the course, demonstrating engagement, independent thinking, and insights. The CDIO project assessments focus on students' presentation skills and team collaboration abilities during discussions. Additionally, self-study ability and learning attitude are also evaluated to reflect students' initiative and dedication to learning.

6. Conclusion

Taking the modern instrumental analysis course as an example, under the background of national first-class professional construction and engineering education professional certification, this paper adopts a series of reform measures from the aspects of implementing the OBE concept, reverse design, forward implementation, and multiple evaluations. By integrating ideological and political elements with teaching content, and combining engineering practice education mode with traditional teaching mode, a teaching system that meets the requirements of knowledge, ability, and quality cultivation is constructed. The curriculum system and education mode are further updated, the advanced nature of the curriculum is improved, the innovativeness of the curriculum is highlighted, the cutting-edge and applicability of the teaching content are enhanced, and the connotative development of disciplines and the improvement of student training quality are promoted.

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Disclosure statement

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