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Innovation in Spectral Analysis Education: Integration of OBE, SPOC, and Ideopolitical Elements for Practical Exploration

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Abstract: In the context of contemporary chemical education, spectroscopic analysis courses face key challenges. Essential for fostering students' practical skills and problem-solving capabilities, these courses are vital across chemistry, materials science, and biopharmaceutical fields. Yet, predominant teaching methods overly focus on theoretical knowledge, sidelining practical skill development. This imbalance curtails the application of theory in real-world contexts. Additionally, traditional pedagogies often omit the integration of ideological and political education (IPE), failing to nurture students' sense of social responsibility and historical mission, thereby weakening their intrinsic motivation to learn. This article advocates for integrating Outcome-Based Education (OBE) principles and Small Private Online Courses (SPOCs), with a significant incorporation of IPE into professional teaching, to refine the pedagogy and practice of spectroscopic analysis. Aimed at improving teaching quality and enriching students' professional and social competencies, this model seeks to invigorate learning motivation and carve novel pathways in chemical talent development. It proposes an innovative approach to rebalance theoretical and practical learning, underscored by a commitment to societal values, thereby enhancing student engagement and proficiency in spectroscopic analysis within a more holistic educational framework.

1. Introduction

In the landscape of educational reform, the integration of Outcome-Based Education (OBE) and Small Private Online Courses (SPOCs), along with the incorporation of ideological and political education, offers innovative solutions to the challenges faced by traditional teaching methods. OBE, with its focus on students' learning outcomes, emphasizes the need for teaching activities and assessment systems that foster the comprehensive development of student abilities [1]. It aims at the ultimate effectiveness of education, where students are equipped to apply acquired knowledge and skills in real-life and professional contexts. Educators are required not only to set clear teaching

objectives but also to construct an environment that both stimulates students' motivation to learn and effectively evaluates their comprehensive abilities. SPOCs, as a form of educational technology, provide a personalized and flexible online learning experience, leveraging the resources of MOOCs while maintaining the interactivity of traditional classrooms [2, 3]. Through real-time feedback and online interaction, the learning process becomes more personalized and efficient. Thus, applying OBE and SPOCs to courses such as spectroscopic analysis effectively addresses the disconnection between theory and practice and the lack of personalized learning pathways in traditional teaching. Moreover, the integration of ideological and political education into course instruction is crucial. It enables students to develop a sense of social responsibility and historical mission alongside mastering professional skills, thereby igniting their intrinsic motivation for learning and deeply understanding the reasons and methods of learning, and for whom they are learning. This approach addresses the core issues faced by higher education in China: "whom to cultivate, how to cultivate, and for whom to cultivate." Research in higher education has achieved substantial results in the application of OBE or SPOC teaching methodologies, including practices in professional education and the integration of ideological and political systems. However, explorations into teaching and practice that intertwine multiple teaching philosophies with ideological and political elements remain relatively scarce. Therefore, based on the challenges identified in teaching spectroscopic analysis and the results of recent teaching practices by the authors and their research team, an attempt has been made to create a comprehensive and innovative efficient teaching loop model through the integration of OBE and SPOCs with a deep fusion of ideological and political education. This teaching model, guided by recent practices, has been found to effectively stimulate students' interest in learning and enhance teaching outcomes. It enables students to acquire essential professional knowledge and skills while fostering a strong sense of social responsibility and self-directed learning ability, laying a solid foundation for their future careers and societal involvement.

2. OBE and SPOC Integration with Ideological Education in Courses

2.1. Innovative Integration of Teaching Objectives and Course Design

Clarifying teaching objectives is essential for creating an effective, goal-oriented learning environment in the spectroscopic analysis course [4]. The integration of Outcome-Based Education (OBE) and Small Private Online Courses (SPOCs), along with ideological and political education, necessitates several key steps to define these objectives accurately. Initially, guided by the OBE framework, teaching objectives should focus on specific outcomes that students are expected to achieve upon course completion, such as enhanced capabilities in spectroscopic data collection, processing, and analysis. This implies that objectives include not only the acquisition of technical skills but also the development of critical thinking, problem-solving, and autonomous learning abilities. Incorporating the flexibility and personalized learning features of SPOCs, objectives should also cater to providing diverse learning pathways and accommodating the varied learning paces of students. For example, through online platforms, students are enabled to select learning materials based on their progress, while instructors can adjust the content and pace of teaching in response to student feedback. To further foster the enhancement of students' abilities, a SPOC course designed around a specific teaching case may employ various methods, such as video lectures, virtual laboratories, and project-based learning tasks, enabling students to master spectroscopic analysis techniques while also improving their ability to solve real-world problems through online discussions and teamwork.

Despite these methods, it has been observed that a portion of students lack intrinsic motivation, leading to lower participation enthusiasm, often being passively led by others in their group. Therefore, the establishment of teaching objectives must also consider the effective integration of

ideological and political education, ensuring that course content and activities reinforce students' understanding of the connection between technological advancement and social responsibility. By integrating current societal issues, such as environmental protection and new material development, students are encouraged to explore the application of spectroscopic analysis in addressing these issues, guiding them to contemplate and discuss how science and technology can serve broader societal needs.

This approach not only enhances students' technical proficiency but also cultivates their sense of social responsibility and historical mission, sparking intrinsic motivation and effectively addressing issues of student engagement. Such a teaching model meets the requirements of OBE and fully utilizes the advantages of SPOCs while providing robust support for students' comprehensive development through the integration of ideological and political education. This strategy not only elevates students' comprehensive abilities but also supports the holistic development of talents in the field of chemistry, serving as an important model for educational reform.

2.2. Optimization Strategies for Teaching Content and Methods

Beyond setting clear teaching objectives, optimizing teaching content and methods is crucial for enhancing the effectiveness of spectroscopic analysis courses. This necessitates that instructors ensure not only the coverage of theoretical knowledge but also the provision of ample practical opportunities. The optimization of teaching content and methods is manifested in several aspects:

1) Diversity and Richness of Teaching Content: Utilizing SPOC platforms, a variety of teaching resources are provided, including video lectures, real-time online experimental demonstrations, and the latest research findings and application cases related to spectroscopic analysis. This approach aids in not only grounding students in the fundamental knowledge of spectroscopic analysis but also, to a certain extent, sparking their interest in learning and increasing their motivation.

2) Innovation in Teaching Methods: Integrating the philosophy of OBE, project-based learning (PBL) and case study methods are employed to encourage students to learn and apply spectroscopic analysis knowledge in solving real-world problems. For instance, a drug detection case related to our research project was designed in a recent teaching session. In this case, students were assigned to a project aimed at detecting and analyzing the active ingredients and impurities of a certain pharmaceutical drug using High-Performance Liquid Chromatography-Mass Spectrometry (HPLC-MS) technology. At the project's onset, students were first acquainted with relevant theoretical knowledge, including the principles of HPLC-MS, sample preparation processes, and data analysis methods. Subsequently, under the guidance of instructors, they accessed virtual laboratories via the SPOC platform to conduct simulated experimental operations. During this process, students were required to design experimental plans and select appropriate chromatographic columns and mass spectrometry parameters to optimize separation efficiency and detection sensitivity. After collecting experimental data, students utilized professional software for data processing and analysis, identifying the active components and possible impurities in the drug. This process not only facilitated the application of spectroscopic analysis knowledge but also honed their experimental design and data processing skills. To enhance the case's authenticity, specific data were set as evidence. For example, students discovered an unknown peak in the drug sample, which, after database comparison and further mass spectrometry analysis, was inferred to be a degradation product of the drug with a molecular weight of M/Z 485.2. Through control experiments and literature review, students confirmed this inference and proposed suggestions for improving the drug's stability. This case deepened students' understanding of the application of spectroscopic technology in drug analysis and improved their problem-solving capabilities, showcasing the effectiveness of teaching content and method optimization.

3) Integration of Ideological and Political Education: The teaching process focuses not only on

cultivating professional skills but also on nurturing students' sense of social responsibility and professional ethics. Students are guided to contemplate how scientific and technological advancements serve societal and national development, understanding their contributions to society. For example, a research project on pesticide residue detection was introduced in the course. In this project, students not only utilized spectroscopic analysis techniques to detect and assess pesticide residues in agricultural products but also explored how to reduce their impact on the environment and human health by improving pesticide composition. Through this process, students could directly observe the application of chemical technology in ensuring food safety and promoting sustainable environmental development, thus deepening their understanding of how science and technology serve societal and national advancement. Moreover, the role of ideological and political education in this case is reflected in several aspects: firstly, it fosters a profound understanding among students of the relationship between science, technology, and societal development, helping them recognize the role they can play as chemistry professionals in addressing global issues such as food safety and environmental protection. Secondly, discussions on the ethical considerations in pesticide development strengthen students' professional ethics and sense of social responsibility. Lastly, the case also inspires students' patriotism and determination to contribute to human society, laying a solid foundation for the comprehensive development of chemistry professionals.

Through these measures, the assessment and feedback mechanism become an integral part of the learning process, not only assisting students in mastering core skills in spectroscopic analysis but also promoting a deep understanding of social responsibility and professional ethics. This comprehensive evaluation mechanism ensures the spectroscopic analysis course meets OBE objectives while effectively integrating the educational advantages of SPOCs and the core values of ideological and political education, providing directional support for the holistic development of students.

2.3. Innovative Practices in Assessment and Feedback Systems

The establishment of a multidimensional and interactive assessment and feedback system is indispensable in the teaching and practical application process of spectroscopic analysis courses, integrating the principles of Outcome-Based Education (OBE) and Small Private Online Courses (SPOCs), along with ideological and political education. This system not only evaluates students' mastery of knowledge and application of skills but also encompasses their thought processes, innovative capabilities, and understanding of social responsibility.

Initially, online automated quizzes are designed to target key concepts and skills of the course, enabling students to promptly assess their learning status. The data analysis feature of SPOC platforms allows for instructors to receive instant feedback on students' progress and comprehension, facilitating the adjustment of teaching plans accordingly. Furthermore, Project-Based Learning (PBL), a crucial element of OBE instruction, requires students to apply spectroscopic analysis in addressing real-world problems. Beyond evaluations based on project outcomes, process evaluations are conducted, focusing on students' collaboration, problem-solving, and innovation within projects [5]. Through group discussions and feedback sessions, targeted suggestions are provided by instructors and peers, assisting students in advancing their subsequent learning. For instance, a case study integrated with research work has been successfully implemented, significantly enhancing the evaluation and feedback mechanism. The case involved analyzing the structural characteristics of a novel composite material using spectroscopic techniques. Students were divided into several groups, each responsible for different stages of the experiment, including sample preparation, spectroscopic data collection, and data processing and analysis. Online quizzes and real-time feedback provided through SPOC platforms enabled students to gauge their theoretical knowledge and practical skills immediately. Upon project completion, each group was required to submit a comprehensive report,

documenting the entire experimental process and results analysis, and discussing findings and suggesting potential improvements. To further strengthen the feedback's impact, online defense sessions were organized, inviting faculty members to review students' research outcomes. This not only increased students' research experience but also provided valuable learning opportunities through faculty feedback.

Through this case, students deepened their understanding and application of spectroscopic analysis, enhancing their teamwork, problem-solving abilities, and research literacy. The case, significantly stimulating students' interest in learning and research enthusiasm, was compiled into the course materials as a benchmark project. Regarding the integration of ideological and political education, case analyses related to significant national science and technology projects were designed, enabling students to explore the application of spectroscopic analysis in national development. The evaluation of these case analyses assessed not only students' technical analysis capabilities but also their understanding and reflection on the relationship between science, technology, and societal development.

Interactive feedback, crucial for reinforcing the evaluation mechanism, was facilitated through online interactions, peer evaluations, and regular online consultation hours, offering immediate feedback on students' progress. This feedback, originating from both teachers and peers, fostered a collaborative learning environment. These measures made the assessment and feedback mechanism an integral part of the learning process, not only aiding in mastering core skills in spectroscopic analysis but also promoting a profound understanding of social responsibility and professional ethics. This comprehensive evaluation mechanism ensures that the spectroscopic analysis course aligns with OBE objectives while effectively integrating the educational advantages of SPOCs and the core values of ideological and political education, providing directional support for the holistic development of students.

3. Reflections on Teaching and Practice

Although feedback indicates that integrating Outcome-Based Education (OBE) and Small Private Online Courses (SPOCs) with ideological and political education (IPE) significantly enhances students' professional skills, social responsibility, and motivation in spectroscopic analysis courses, several challenges have been encountered during implementation. These include teachers' adaptability to new teaching models and information technology application, students' adaptation to self-directed learning, particularly in fostering motivation and self-management skills, and issues related to resources and technical support for SPOC platform development and teaching material updates.

To address these challenges, preliminary strategies have been adopted: firstly, teacher training and workshops have been conducted to improve understanding of OBE and SPOC concepts and IT application skills; secondly, designing engaging online content and interactive learning activities has been emphasized to enhance student interest and autonomy in learning; thirdly, technical support and resource updates have been prioritized to ensure the stable operation of SPOC platforms and the timeliness and relevance of teaching materials. These strategies have gradually overcome challenges, facilitating innovation and reform in teaching models.

Furthermore, to enhance teaching quality and student capabilities, deeper integration of OBE and SPOCs, along with innovation in teaching content and methods, is necessary. Practical teaching methods such as case analysis and project-driven learning are recommended to strengthen students' practical and problem-solving skills. Establishing a comprehensive student feedback mechanism is essential to ensure a student-centered teaching process is continuously optimized. Enhancing students' self-directed learning and critical thinking abilities, encouraging participation in teaching content

innovation, and fostering an interactive and co-creative learning environment are crucial for improving teaching quality and student competencies.

4. Conclusions

Based on our teaching practices in recent years, findings indicate that the integration of Outcome-Based Education (OBE) and Small Private Online Courses (SPOCs) into the spectroscopic analysis curriculum has significantly enhanced students' comprehensive abilities, encompassing technical skills, critical thinking, problem-solving, and self-directed learning. This pedagogical approach not only deepened students' understanding and application of spectroscopic analysis techniques but also accommodated diverse learning needs through varied learning paths and personalized pacing, thereby improving teaching effectiveness and student satisfaction. Furthermore, the close integration of ideological and political education with professional studies has enabled students to gain a deeper comprehension of the link between technological progress and social responsibility, enhancing their commitment to serving societal and national development. Consequently, the incorporation of OBE and SPOC concepts, combined with ideological and political education in the spectroscopic analysis course, has not only elevated students' comprehensive capabilities but also provided strong support for the holistic development of talents in the chemistry field. This approach holds significant demonstrative value and long-term implications for educational reform, offering a robust model for enhancing higher education quality.

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