Exploring the Reform of Value Oriented Educational Objectives Education in the Cell Biology Laboratory Course Based on the OBE Concept

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Abstract: Integrating value oriented educational objectiveseducation (IPE) elements into experimental teaching has become a prevailing trend in the reform of university laboratory courses, which in turn poses new challenges to the selection of instructional models for these courses. Cell Biology Experiment is a core practical course for life science majors; however, traditional teaching has long suffered from issues such as "emphasizing technical verification while undervaluing value guidance" and "rigid or forced integration of IPE content." Grounded in the Outcome-Based Education (OBE) framework, this paper proposes a reform pathway that "reverse-engineers" teaching reconfiguration through "competency-oriented outcomes," and establishes a tripartite instructional objective system encompassing "knowledge transmission—competency cultivation—value shaping." We explore a teaching reform model that embeds the IPE element of scientific spirit into Cell Biology Experiment. Specifically, using the experiment as a vehicle, we integrate the scientific-spirit IPE component into every stage of the experimental process, allowing students to fully experience the process of scientific inquiry and thereby develop scientific thinking and attitudes. Through backward design of experimental projects, mining "freely-diffusible" IPE integration points, and constructing a process-based multi-dimensional evaluation mechanism, we systematically incorporate IPE elements such as patriotic sentiment, scientific spirit, innovative thinking, and humanistic care into the entire experimental teaching workflow. Preliminary practice indicates that this model facilitates a progressive educational advancement from "experimental operator" to "scientific inquirer" and further to "responsible contributor" thereby providing a reference for the teaching reform of life science laboratory courses.

Keywords: OBE Concept; Cell Biology Experiment; Curriculum-Based Value Oriented Educational Objectiveseducation; Teaching Reform; Outcome-Based Orientation

1. Introduction

Since the beginning of the 21st century, higher education in China has transitioned from the stage of mass education to the stage of universal access, and has entered a new era focused on enhancing the quality of talent cultivation. Course objectives should adhere to the organic integration of knowledge, competencies, and comprehensive qualities. Teaching content should reflect both cutting-edge advancements and contemporary relevance. It is imperative to increase students' learning input and rationally increase their academic workload. As the core element of talent cultivation, curricula serve as a crucial instrument for deepening educational and teaching reforms and improving teaching quality, and constitute an important measure for implementing the guiding principles of the Conference on Undergraduate Education in Higher Education Institutions in the New Era [1]. As both a foundational and cutting-edge discipline in the life sciences, cell biology occupies a pivotal position in the knowledge framework of students majoring in biology-related fields [2–3]. The cell biology laboratory course is a practice-oriented curriculum that investigates biological phenomena and processes at the cellular level. By employing a variety of experimental techniques and methodologies, students learn to observe and analyze cellular structures, functions, and interactions, thereby

gaining an in-depth understanding of fundamental biological principles [4]. Most cell biology experiments are offered in the second year of university. By this stage, students have acquired certain practical-operation skills and capabilities. Instead of merely following demonstrations, they possess basic abilities for independent thinking and innovation, which enables them to receive training and practice in thinking and creative problem-solving. [5].

Cell biology experimentation acts as a "bridge" course connecting theory and practice, undertaking the vital mission of fostering students' hands-on proficiency, scientific reasoning, and innovative spirit. However, over the years, the teaching of this course has been pervasively plagued by a triple predicament: The First, Students' comprehensive competence is unsatisfactory. Laboratory courses are dominated by confirmatory experiments. Teachers demonstrate the procedures step-by-step, and students simply repeat what they have seen, engaging in little independent thinking. Experimental results can therefore be obtained easily.

Sector Ideological education in class is forced and far-fetched. Students find it hard to accept such education mentally and emotionally, so its effectiveness is self-evidently limited.

The third It is difficult to differentiate students' experimental performance. Evaluation mainly relies on laboratory reports. As long as reports are neatly written and present similar results, students tend to get comparable grades, which fails to reflect their real-world capabilities.

The OBE (Outcome-Based Education) framework offers methodological guidance for addressing the aforementioned challenges. OBE emphasizes a reverse-design approach, starting from the expected learning outcomes that students are to achieve, and subsequently aligning instructional activities, allocating teaching resources, and establishing assessment mechanisms. Its core tenets are "student-centeredness, outcome-orientation, and continuous improvement" [6]. Curriculum-based ideological and political education should embed the cultivation of students' correct values into the whole process of education. It should proceed step by step and reshape students' value orientations imperceptibly. As required by Outcome-Based Education (OBE), the curriculum should focus on students' competence development. Its content should cover competency dimensions such as students' devotion to the country, scientific spirit, professional ethics and ethics literacy. Curriculum-based ideological and political education enables these intangible learning outcomes to be achieved in practice.

Based on the above, this paper attempts to construct a reform framework of "OBE-oriented goal design — organic integration of value oriented educational objectives elements into the process — multi-dimensional evaluation to verify outcome achievement" and explores potential pathways for transforming the Cell Biology laboratory course from a "skill-verification" model toward a "value-empowerment" paradigm.

2. Reform Logic: Driving Pedagogical Restructuring through Expected Outcome

2.1 A Paradigm Shift from Content-Oriented to Outcome-Oriented Approaches

"The traditional teaching model has been predominantly adopted in the cell biology laboratory course: students attend classes according to the scheduled timetable, teachers lecture while demonstrating the experimental procedures, and students subsequently repeat the experiment following the teacher's demonstration. Most of these exercises are confirmatory (verification) experiments. After class, students submit corresponding experimental reports, which are then subjected to standardized grading and assessment by the instructors. Although this approach ensures a high success rate for the experiments, it does little to stimulate students' initiative and considerably constrains their critical thinking.

In previous laboratory courses, the procedure essentially followed a fixed sequence: experimental content, experimental methods, and experimental results—that is, students proceeded step by step according to the textbook, from the experiment title onward, allowing them to complete the experiments mechanically without the need for independent thought. Some experiments were even conducted in groups of three or four, which often led to situations where only one or two students did the work while the others merely watched. The results were then copied onto the lab reports, and as a result, most students received similar grades. Under this model, students had only a vague understanding of the teaching objectives, and it was impossible

to determine whether their abilities and overall competencies had actually improved. Moreover, the evaluation methods did not necessarily align with the intended learning outcomes.

The OBE philosophy calls for “backward design”: first define the three-dimensional learning outcomes of knowledge, competence and literacy that students are expected to achieve upon completing the course, and then design experimental projects, select teaching methods and formulate evaluation criteria accordingly. In order to cultivate students' innovative abilities, the cell biology laboratory course has undergone substantial reform. Some of the original confirmatory experiments were converted into comprehensive experiments, while others were redesigned as project-based design experiments, with only one or two confirmatory experiments retained. This reform has successfully achieved innovation in both form and content. Before each experiment, students are notified to formulate their own experimental plans, which encourages them to proactively search for relevant information. This approach fosters students' ability to learn independently and enables them to apply modern information tools and platforms on their own initiative. Furthermore, relevant experimental methods from scientific research have been organically integrated into the entire process of experimental teaching [7].

For cell biology laboratory courses, the expected outcomes should not be limited to "mastering microscope operation techniques" or "completing cell culture procedures," but should be extended to the ability to independently design experimental protocols and analyze data (competency dimension). For instance, in cell culture experiments, innovation is manifested by transforming simple cell counting into a trypan blue exclusion assay, with emphasis on determining cell viability and biochemical indicator detection, ensuring that the experimental teaching system remains comprehensive and targeted, and enabling result analysis with relevant biological software. Students should also be able to comprehend research ethics and academic norms (attribute dimension). Before class, the instructor randomly assigns each experimental project to groups; during online sessions, new research topics are promptly disseminated to students to guide independent inquiry-based learning. Prior to student hands-on operations, explanations are provided regarding experimental principles, objectives, materials and apparatus, procedural steps, and precautions. Students may collect domestic and international literature to determine experimental preparation plans—such as what types of experimental materials need to be gathered and through what channels relevant information can be obtained—and each student is encouraged to personally participate in the entire process from reagent preparation and pre-experimental operations to the explanation of experiment-related content. These tasks not only consolidate students' fundamental theoretical knowledge but also drive their comprehensive practical application and innovative thinking expansion, aligning with the progressive pattern of cognitive development. By completing practically meaningful tasks, students are motivated to actively mobilize their existing knowledge and experience, proactively explore uncharted territories, and thereby achieve deep internalization of knowledge and advanced competency enhancement [8]. Additionally, students should be able to integrate personal development into the national life science enterprise (value dimension).

2.2 The "Implicit Value Oriented Educational Objectiveseducation" Advantages of Cell Biology Laboratory Courses

Faced with a world and diverse ideas in constant flux, modern-day college students are confronted with numerous unknowns and confusion. Teachers should help students establish a correct outlook on the world, life and values, assist them in enjoying a fulfilling college life, and foster them to become qualified builders and successors of socialism. Laboratory courses have certain advantages over theoretical courses in terms of cultivating students' character and values. First, experiments involve hands-on operations, which allow instructors to require students to be rigorous and standardized in their procedures. There are also data to be recorded, which teaches students the importance of being factual and seeking scientific truth. In addition, group work in experiments enables students to develop teamwork and communication skills. During the experimental process, students must pay attention to safety; when laboratory animals are involved, they should be aware of animal ethics, cherish life, and treat animals with care. All of these elements serve as excellent material for values

education.

Therefore, the cell biology laboratory course provides a comprehensive platform for ideological and moral education, making it relatively easy to achieve the educational objectives. Since students carry out the experiments themselves and engage in hands-on practice, they genuinely experience the joy of scientific inquiry throughout the process. This experiential approach makes it easier to transform external inculcation into internalized, self-generated understanding.

With value oriented educational objectives, many courses in the field of life science have carried out relevant teaching activities. In particular, for the integration of cell biology and ideological-political education, we organically incorporate ideological-political elements into course content to achieve the ideological-political teaching effect of "moistening things silently like spring rain [9].

While predominantly oriented toward educational objectives and incorporating diverse implementation strategies for curriculum-based IPE—including the integration of core socialist values—previous approaches have not extended to the inclusion of biographical accounts of ethnic Chinese scientists as an extension of laboratory coursework [10]. The research trajectories and life experiences of ethnic Chinese scientists offer a greater sense of familiarity and cultural proximity, thereby rendering specialized knowledge more vivid and engaging, and more effectively eliciting students' patriotic sentiments. Exemplary cases include Zhai Zhonghe (nuclear reconstitution), Shi Yigong (structural biology), and Kuang Tingyun (photosynthesis), among others.

3. Reform Pathway: Three-Dimensional Restructuring of Objectives, Content, and Assessment

3.1 Objective Restructuring: Constructing a "Trinity" Outcome System

Based on the Outcome-Based Education (OBE) philosophy, the course objectives are expanded from the traditional two-dimensional framework of "knowledge and skills" to a three-dimensional system encompassing "knowledge — competence — literacy", as shown in Table 1.

Table 1. The Trinity Outcome System

Dimension	Specific Outcome Description	Corresponding value oriented educational objectivesorientation
Knowledge	Mastery of core experimental techniques, including cell culture, microscopic observation, and subcellular fractionation, along with their underlying principles	Scientific spirit, pursuit of truth
Competence	Ability to independently design experimental protocols, analyze aberrant results, write standardized reports; capability for teamwork and division of labo	Innovative thinking, teamwork and collaboration
Literacy	Adherence to laboratory safety and academic integrity; awareness of the societal applications of life sciences; sense of mission to serve the nation through science and technology	Patriotic commitment, sense of responsibility, humanistic care

The clarification of these objectives provides an "anchor point" for the subsequent selection of teaching content and the reform of assessment methods.

3.2 Content Restructuring: Experimental Project Redesign and the "Free Diffusion" of Value Oriented Educational Objectiveseducation

3.2.1 Introduction of inquiry-based experimental modules

The proportion of purely confirmatory experiments has been reduced, and "problem-oriented" comprehensive experiments have been introduced. For example, in the experiment "Morphological Observation of Apoptosis," rather than directly providing the identification method, students are offered a range of detection techniques (e.g., Hoechst staining, Annexin V-FITC labeling) and are required to independently select and justify their choice of protocol based on the experimental objectives. This design aligns with the OBE (Outcome-Based Education) requirement for "capability in solving complex problems."

3.2.2 "Free-Diffusion" Integration of value oriented educational objectiveselements

Drawing on the concept of "free-diffusion" integration [11], value oriented educational objectiveselements are embedded naturally throughout the entire experimental process, much like salt dissolving in water:

Experimental introduction phase: Groundbreaking achievements by Chinese

scientists in the field of cell biology (e.g., the contributions of Shi Yigong's team to the structural analysis of the spliceosome) are introduced as background, fostering national pride and research aspirations. Academician Shi Yigong has applied structural biology to investigate the molecular mechanisms of apoptosis and Alzheimer's disease, founded Westlake University, and mentored the outstanding student, Academician Yan Ning. Professor Yan Ning primarily researches the structure and mechanisms of transmembrane transport proteins; she has now returned to Shenzhen to establish the Medical Academy, striving to build a world-class research institution.

Experimental operation phase: Emphasis is placed on standardized procedures and the authenticity of data recording, instilling academic integrity and a rigorous, truth-seeking scientific spirit. Group experiments cultivate collaborative awareness and clear division of responsibilities.

Abnormal result analysis phase: When experiments fail or results deviate from expectations, students are guided to rationally analyze the causes rather than arbitrarily alter data, thereby fostering frustration tolerance and critical thinking.

Experimental report and discussion phase: Social issues related to the experimental content (e.g. ethical boundaries of cell therapy technologies, regulated use of gene editing) are introduced, and students are organized to engage in debates, incorporating engineering ethics and humanistic concerns.

This integration approach is characterized by being "contextualized, process-oriented, and experiential"—value oriented educational objectiveseducation is no longer an isolated teaching segment, but rather issues that students naturally encounter and reflect upon throughout the course of their experimental work.

3.3 Evaluation Redesign: Establishing a "Goal-Attainment-Oriented" Diversified Assessment System

Traditional experimental evaluation, which relies primarily on lab reports, fails to reflect the development of competencies and the internalization of values. The reformed assessment system should adhere to the following principles: diversification of assessment methods, competency-oriented assessment content, and continuous assessment processes.

Process-Oriented Assessment (Formative Assessment): this includes preparatory work, such as students' ability to clarify experimental logic and design protocols based on provided materials; operational proficiency, i.e., mastery of critical steps and details during experimentation; teamwork and division of labor among group members; and completeness of data recording. This category shall account for no less than 40% of the final grade.

Outcome-Oriented Assessment (Summative Assessment): students are required to complete lab reports in a standardized format, correctly describe experimental phenomena, and analyze results. Additionally, a dedicated section titled "Problem Analysis and Improvement Suggestions" is added to the reports to evaluate students' reflective thinking and transferable skills. This also includes original records and research reports on experimental data analysis. When evaluating these reports, instructors shall assess basic structural completeness while placing particular emphasis on the students' analysis and discussion of experimental results.

Competency-/Literacy-Oriented Assessment (Affective/Dispositional Assessment): The achievement of value oriented educational objectiveseducation (value-based) goals is indirectly measured through post-experiment reflective essays, peer-evaluation metrics related to sense of responsibility, and observational records of safety and ethical conduct.

The clarification of evaluation criteria itself serves as a form of "assessment for learning" (or "assessment-as-learning") —by making explicit to students what constitutes good performance, it guides the adjustment of their behaviors and value orientations.

4. Practical Reflection and Key Issues

4.1 Teacher Competence as a Bottleneck to Reform Implementation

The experimental teaching reform under the OBE (Outcome-Based Education) framework imposes higher demands on instructors: they are expected not only to be proficient in experimental techniques, but also to possess curriculum design capabilities (backward design of teaching objectives and activities), the ability to integrate value oriented educational objectiveseducation (embedding value-oriented

elements naturally rather than artificially), and diversified assessment competencies. During course implementation, the teacher's "scaffolding" role should be gradually diminished: in the "knowledge internalization and skill foundation" stage, teachers establish a solid operational and cognitive foundation for students through concise theoretical explanations and standardized demonstrations; in the "technology integration and problem-solving" stage, the teacher's role shifts to that of a collaborative facilitator. Currently, most experimental course instructors are research personnel serving in a concurrent capacity, with insufficient professional training in instructional design. It is recommended that teacher teaching competence be enhanced through measures such as building teaching teams, collaborative lesson planning, and sharing case study repositories.

4.2 Methodological Breakthroughs Urgently Needed in Assessing Value Oriented Educational Objectiveseducation Outcomes

Compared to the assessment of knowledge and skills, the evaluation of achieved value oriented educational objectiveseducation objectives represents a current challenge in reform. The internalization of values is characterized by latency and implicitness, making it difficult to measure accurately through a single test or questionnaire. Existing approaches predominantly employ a combined pathway of "process-oriented behavioral observation + student reflective self-assessment + qualitative teacher judgment." Although of certain reference value, the reliability and validity of these methods still require further verification. In the future, AI-assisted learning behavior analysis technologies may be leveraged to track student performance data in areas such as collaboration and rule compliance, thereby providing a more objective basis for competency evaluation.

5. Conclusion

Through the cell biology laboratory course, students are able to gain a better understanding of the difficult concepts encountered in theoretical studies. The hands-on practice in experiments enhances their practical operational skills. The design of experimental protocols stimulates their innovative thinking. Group work in experiments fosters their team spirit. The processing and analysis of experimental data cultivates their ability to solve problems. Furthermore, the use of bioinformatics software improves their comprehensive competencies.

The value oriented educational objectiveseducation reform and exploration of the cell biology laboratory course based on the OBE (Outcome-Based Education) concept represent an important educational reform task. Measures such as designing training objectives for value oriented educational objectiveseducation within the course, improving the evaluation system, optimizing the design of value oriented educational objectiveselements, and providing teaching design cases can significantly enhance the teaching quality of the laboratory course and students' comprehensive qualities. The OBE concept requires teachers to adjust teaching content and methods in a timely manner according to students' learning outcomes. However, in actual practice, it is difficult for teachers to obtain a real-time, comprehensive understanding of each student's learning progress and difficulties, making it challenging to achieve precise dynamic adjustments.

The reform of cell biology laboratory teaching essentially addresses the questions of "what kind of people to cultivate" and "how to cultivate them." The OBE concept provides a "beginning-with-the-end-in-mind" design methodology, while value oriented educational objectiveseducation within the course infuses "outcomes" with value-based soul. Their integration is not a simple superimposition but a deep synergy across three levels: goal setting, content organization, and evaluation implementation. Through experimental teaching reforms, students' hands-on operational skills have been enhanced, their scientific literacy has been strengthened, and they have developed the aspiration to serve the country through science and technology, ultimately becoming responsible professionals in the life sciences. In future teaching, we will continue to explore and practice the value oriented educational objectiveseducation reform of the organic chemistry laboratory course based on the OBE concept, utilizing modern educational technology means to strengthen monitoring and feedback of the teaching process, thereby contributing to the cultivation of high-quality talents with patriotic sentiment and comprehensive abilities.

Acknowledgments

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