

PBL Teaching Method of “Biology Experiment” Based on the OBE Concept

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Abstract—The biology experiment course is an essential introductory and compulsory course for biology majors in higher education. With the rapid development of biology research, improving the quality of classroom teaching and stimulating students' innovative and practical abilities is a critical issue that needs to be solved in biology experiment course. This article analyzes the problems in biology experiment course, summarizes experimental teaching experience, and designs teaching based on student learning outcomes, exploring innovative reform plans for course teaching. Adopting problem-based and project-based learning with the concept of Outcome-Based Education, we will attempt to reform the “Biology” curriculum and construct a student-centered and result-oriented teaching model. It is conducive to stimulating students' interest in learning, mobilizing their active participation in classroom learning, effectively improving their learning ability and sense of achievement, promoting the overall quality of students, and thus achieving the goal of improving the quality of biology teaching, laying a solid foundation for talent cultivation.

Keywords—Outcome-Based Education (OBE), biology experiment, Problem-Based Learning and Project-Based Learning (PBL), course teaching

I. INTRODUCTION

At present, higher education is also in the information age. The development of “Internet +” education has put forward higher requirements for the quality of personnel training of college graduates. Applying many new ideas and technologies in higher education has given higher education opportunities and challenges. OBE (Outcome-Based Education) was first proposed by Spady, a famous American education scholar, in 1981 [1]. It is a new educational model oriented towards students' learning outcomes and is the core of education professional certification. Its essence is to scientifically construct the curriculum education system so that it is closely related to the professional training goals of students. Unlike the simple knowledge imparted in the past, the OBE education concept pays more attention to cultivating students' abilities. This concept requires teachers first to

clarify the learning output of students and then guide students to complete the learning of knowledge through independent learning. Finally, teachers use students' learning output to give feedback, improve the original teaching method, and achieve mutual “run-ins” with students. PBL (Problem-Based Learning and Project-Based Learning) is a teaching method that allows students to cooperate to solve authentic problems by creating problems and project situations, centering on issues and projects [2, 3]. Compared with traditional teaching, it focuses more on student-centered and active learning. It is a more popular teaching method in dynamic teaching. After several years of practice and exploration, OBE and PBL education concepts have gradually been integrated into China's new era of education and teaching. The reform aligns with the training requirements of China's applied talents.

The biology experiment course is an introductory biology course combining theory and practice and is a professional foundation and compulsory course for ecology majors. It has the characteristics of introductory, essential, and comprehensive courses, and the course content involves zoology, botany, microbiology, cell biology, genetics, evolutionary biology, and ecology, covering almost all fields of biology [4]. The introduction of biology experiment courses at the undergraduate stage of colleges and universities is beneficial to promote students to understand the whole picture of life science, deeply comprehend the connotation of life, and lay an excellent professional foundation for the cultivation of talents in the field of ecology with “wide caliber and solid foundation.” However, there are many problems with the teaching content of the course, short class hours, and students' limited understanding of the importance of the course, which seriously affects the students' learning effect. To improve students' learning efficiency, improve students' ability to use knowledge in practice, and fully stimulate students' enthusiasm and subjective initiative in learning biology experiment courses, taking Northwestern Polytechnical University's undergraduate education in ecology as an example, colleges and universities can combine OBE and PBL education concepts. Introduce the teaching process of biology experiment course, improve its teaching mode, teaching

content and assessment system, to improve the teaching quality of biology experiment course.

II. PROBLEMS EXISTING IN THE TEACHING OF BIOLOGY EXPERIMENT COURSE

The biology course is the introductory course and main course of the ecology major, and the course content includes two parts: theory and experiment. This course reveals the basic concepts, principles, and laws of biology based on understanding biodiversity. The biology experiment course has the characteristics of extensive course content, many knowledge points, and a large amount of information. Therefore, most colleges and universities set up this course in the first semester of the first year. There are still many aspects to be improved in the actual teaching process.

A. *Traditional Teaching Mode*

Traditional biology experiment teaching generally adopts the teaching mode of teachers speaking and students listening. This model centers on teachers, teaching materials, and classrooms. All teaching activities are carried out in the classrooms, and students are in a passive learning state, which makes it difficult to stimulate and cultivate their learning interests and autonomous learning abilities. At the same time, courses often pursue students' grasp of fundamental theoretical knowledge too much while ignoring the expansion and application of professional expertise, and there are often problems of emphasizing theory and neglecting practice.

B. *Assessment and Evaluation Mechanisms Need to Be Improved*

An examination is a means to understand students' learning situations. Through the test, students can discover their deficiencies in time and make adjustments in subsequent studies. Schools often adopt the traditional "one-stop" examination mode at the undergraduate stage, that is, through a final closed-book examination to determine the final grade of students studying this course. Students often need to improve on many exam subjects in the first semester. It not only discourages students' enthusiasm for learning but also needs to meet the requirements of universities to cultivate innovative talents with independent abilities. Therefore, establishing a scientific and reasonable assessment system is one of the primary tasks of teaching reform.

III. OBE-ORIENTED PBL EXPERIMENTAL TEACHING DESIGN

Under the OBE teaching concept, the PBL teaching mode is applied to this course's teaching by introducing problems, project cooperation, and other forms. The OBE education concept particularly emphasizes taking students as the core and focusing on improving students' comprehensive abilities. Based on OBE, the professional talent training objectives and course output objectives are implemented according to different teaching contents, teaching methods, problem-based learning, and project-based collaborative teaching (project-based learning).

Different teaching methods, such as evaluation of teachers, evaluation questions, evaluation items, students' mutual evaluation, and other methods, are used to examine the teaching effect comprehensively.

The OBE education philosophy emphasizes that every student can gain a sense of accomplishment in course learning. It emphasizes personalized assessment, knowledge mastery, performance responsibility, and ability-based, enhancing their learning initiative [5]. Based on the OBE education concept, reverse design and forward implementation of the overall course teaching process, that is, training needs→teaching objectives→teaching process→teaching assessment→curriculum reform. According to different teaching contents, different teaching methods such as lecture method, problem-based learning, and project-based learning are implemented respectively, and the evaluation of teachers, evaluation problems, and evaluation items are adopted, student mutual evaluation and other evaluation methods to comprehensively examine the teaching effect.

Classroom theory teaching is mainly based on the question-and-exploration teaching mode, and the teaching content is processed and organized according to students' knowledge structure and cognitive level about biology-related knowledge. Connect with students' original cognitive structure, establish a tolerant teaching environment, fully tap students' ability to comprehensively analyze problems, and reasoning ability, so that students can quickly and effectively master more knowledge of biology, and cultivate students' ability to learn independently [6].

In terms of experimental practice teaching, it is mainly based on the project cooperative teaching mode, with students as the main body, adopts the "cooperative learning" teaching method of large concentration and small dispersion, and takes a relatively independent small project (or small topic) as the unit subject. Students are responsible for each project, from information collection, plan design, organization, and implementation to evaluation after completion. Through the implementation of each project, students are helped to understand and grasp the basic requirements of each link of the project and the vital and challenging points of the entire process. Teachers play the role of consulting, guiding, and solving complicated problems in the teaching process. Highlight the subject of teaching practice and cultivate students' essential innovation ability.

IV. PBL COURSE TEACHING PRACTICE BASED ON THE OBE CONCEPT

The OBE education philosophy emphasizes that every student can gain something, which requires teachers to abandon the traditional "one-word classroom" teaching mode and gradually changes from the teacher's "teaching" to the student's "learning." Using the teaching method of problem teaching method, transposition teaching method, case teaching method, and other teaching methods, combined with the advantages of contemporary network resources, fully mobilize the subjective initiative of students in learning so that

students can gain a sense of accomplishment in learning and realize the cultivation of the goal of students' autonomous learning ability.

OBE adheres to the principle of problem orientation and students as the main body. Under the current "Internet +" information technology conditions, it aligns with students' individualized and liberalized psychological characteristics, diversified learning methods such as mobile and fragmented learning, and facilitates students. Reasonable use of in-class time and extra-curricular fragmented time helps students effectively choose beneficial teaching resources and carefully design teaching content and teaching links so that students can organically integrate the knowledge structure and learning ability of the course during the course learning process to improve the effectiveness of learning [7].

A. Optimizing Course Objectives and Course Content

Based on the OBE education concept, the output goal of the "Biology Experiment" course should be to enable students to understand the law of evolution and development of biology from low to high, from simple to complex, and to understand the adaptation of animal and plant morphological structure and function through course learning. They are understanding the relationship between organisms and the environment, understanding biodiversity, mastering the laws of biological life activities, understanding modern animal biology's new achievements and progress, and the trend of interdisciplinary, infiltration, and comprehensive development [8].

Since the "Biology Experiment" course in our university has undergone several rounds of training program adjustments, the current class hours are only 16 class hours. How to make students become the main body in the limited class hours, the design of teaching content is particularly critical. The morphological structure and function of organisms are the focus of teaching, and the basic experiments of biochemistry and cell biology are also essential, which can often play a finishing touch. However, this part of the content is often difficult to achieve due to the limitation of class hours. How to make up for this deficiency? We try to adopt the PBL teaching mode, determine the teaching objectives, establish a learning community, design problems, and projects and organize their implementation, and finally evaluate and reflect on the problems and projects through the implementation of teaching links such as individual promotion, teacher-student promotion, and student-student promotion, Achieve course output goals.

Optimize the course content based on reforming the teaching mode of the biology course. First, teachers should let students understand that biology courses' content is closely related to their lives to stimulate their interest in learning. For example, when explaining the cell structure part, you can try to connect the cutting-edge scientific research results with the course content and guide students to understand the importance of cell structure as a basic knowledge; Protection and other application areas allow students to form the connection

between knowledge and application; when introducing prokaryotes, students can understand the role of yeast or lactic acid bacteria in the fermentation of bread, beer or yogurt [9].

Secondly, teachers can also guide students to discover critical scientific figures in the history of biological development and help students build a strong sense of professional pride and self-confidence, such as the achievements and contributions of Chinese scientists Yuan Longping and Tu Youyou in the history of biology in China and the world. Finally, teachers can introduce cutting-edge scientific and technological achievements into the classroom, broaden students' horizons, stimulate students' sense of the times to keep pace with the times and cultivate students' creative thinking and abilities. For example, when explaining the evidence of biological evolution, the content of the 2022 Nobel Prize in Physiology can be introduced, that is, the study of human evolution and the extinct human genome, to help students understand the biological evolution process and research significance; When looking at the morphological structure, you can introduce the latest research progress published in the journal *Science* by Northwestern Polytechnical University, that is, the morphological structure of velvet antler tissue and its occurrence process. Introducing cutting-edge scientific advances into classroom teaching can significantly enhance students' learning experience.

B. Problem-Based Teaching

The chapters on animal phyla have an essential evolutionary status in the animal kingdom, such as protozoa, coelenterate, platyhelminth, Annelida, arthropod, and chordate. Using the PBL teaching method, the teacher mainly explains the morphological structure and function of the animal phylum, while the diversity set questions for students to explain in about 3–5 minutes. Students participated in the classroom teaching process as both learning and teaching. For example, protostomes with a segmented body and appendages; why are arthropods the most diverse and widely distributed animals in the animal kingdom? The teacher started with the systematic evolution of animals, morphological structure and function, and the relationship with humans, and set up why there are so many types and broad distributions of insects. What kind of insects are around us? How to identify insects? What is the relationship between insect mouthparts and feeding habits? How do insects reproduce? How insects defend and protect themselves and a series of issues.

Divide the students into several study groups to form a learning community. Each learning community assigns a question. The teacher sends the question to the students two weeks before class and asks them to read the teaching material first and discuss how to analyze the question and from which aspects to explain it. Questions, under the organization of the team leader, the team members work together to search for relevant materials in the library and the Internet around the problem, obtain answers to the questions, and make small PPT courseware. After the teacher briefly introduces the status

and evolution characteristics of arthropods in the animal kingdom, the learning community will lecture on classroom issues and discuss and evaluate after the explanation.

C. Project-Based Collaborative Teaching

An experimental teaching model to cultivate undergraduates' creative ability has been established through reform measures such as optimizing teaching content, focusing on practical details, strengthening process management, and scientifically evaluating teaching effects. On this basis, the PBL teaching model is applied to practical teaching, optimizes the teaching content, and improves the teaching effect [10]. For example, in experimental content and course practice, some small topics (projects) are carefully designed, such as the investigation and analysis of the current situation of birds in the Qinling Mountains, the current situation of captive mammals in Xi'an Zoo and animal welfare, the diversity of birds in Xi'an, the diversity of insects on campus, the loess plateau plant diversity. Each learning community chooses a small project. The team members work together in a division of labor, consult relevant materials, and design project implementation plans according to the provided research content. In addition to completing the necessary internship tasks, they also need to complete the investigation and writing of the project, make PPTs, and report the completion of the project in class.

D. Completing Curriculum System

The complete biology curriculum system includes two parts: theoretical courses and practical courses. Experimental courses can guide students to improve their professional skills and comprehensive ability. Therefore, to improve the biology curriculum system, it is indispensable to add a result-oriented biology experiment course, which meets the requirements of the "creativity-innovation-entrepreneurship" education system for new engineering talents [11].

In order to cultivate diversified and innovative talents, teachers can gradually guide students to form an excellent experimental order and strengthen the experimental awareness of the safe operation of instruments in the process of teaching practical courses; help students form a good habit of establishing correct experimental methods by consulting literature, Cultivate students' comprehensive ability to design experiments, collect and analyze data, and finally write exploratory, experimental reports. Through experimental teaching, the student's ability to think independently and solve problems is exercised, thus satisfying the result-oriented educational concept and the primary demand of the market for talents.

E. Optimizing Evaluation Mechanism

Traditional biology courses use two methods of theoretical examination and experimental operation to assess students. The examination content focuses more on the understanding and mastery of theoretical knowledge points and basic experimental skills but less assessment of students' ability to live and learn. The OBE education

concept focuses more on examining the course learning process and pays attention to student's ability to use knowledge flexibly to solve practical problems. Therefore, creating a course assessment and evaluation system oriented to students' learning output and implementing it is crucial to ensure the quality of course teaching and promote the continuous construction of courses.

The reformed biology course evaluation system emphasizes the process-based evaluation of theoretical and practical courses and establishes a comprehensive method combining formative and result evaluation. This assessment method abandons the traditional evaluation mode that uses test scores as a single evaluation index and pays more attention to the dominant position of students in the learning process.

V. CONCLUSION

The reform of personnel training mode, improving education and teaching methods, and innovating educational concepts in colleges and universities are all eternal subjects in higher education. Actively exploring the OBE education concept and gradually implementing the three educational concepts of "student-centered", "result-oriented", and "continuous improvement" require the joint participation and efforts of teachers and students. Practical application of the PBL teaching method in the course construction of "Biology Experiment", setting up questions and projects according to the knowledge structure and characteristics of the course, is conducive to fully mobilize the enthusiasm, initiative, and participation of students in learning and improving students' comprehensive understanding of knowledge. Using ability, independent learning ability, and teamwork spirit can achieve the output goal of the course and achieve the desired teaching effect.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Xinxin Cui and Chenguang Feng conducted the research and wrote the paper; Jianxiao Song and Juan He analyzed the data; Yingmei Peng and Tong Lin reviewed and edited the paper; all authors had approved the final version.

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