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Cultivating Scientific Research and Innovative Talents Based on Microbial Innovation Experiments

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***Abstract*—To stimulate students' enthusiasm for scientific research and innovation, and cultivate students' ability to discover, analyze and solve problems. Through the establishment of the "multi-level" teaching mode of microbial innovation experiment (validation experiment → comprehensive experiment → design experiment → innovative experiment → open experiment → innovation or entrepreneurship project → graduation thesis), the implementation process in teaching practice achieves the desired teaching effect. The implementation of this teaching mode fully mobilizes the students' interest and enthusiasm and stimulates students' sense of innovation. It is conducive to cultivating scientific research and innovative talents and has achieved good results.**

Keywords—Microbial Innovation Experiments; "Multi-Level" Teaching Mode; Scientific Research and Innovation; Teaching Reform

I. INTRODUCTION

Since the "19th National Congress of the Communist Party of China", the goal of building scientific research and innovative countries has become the core of national strategic development. The state is also paying more and more attention to the innovative and practical ability and entrepreneurial spirit of talents. For colleges and universities, innovative experimental teaching is one of the important methods to cultivate students' practical and innovative ability. It plays a great role in cultivating and conveying high-quality scientific research and innovative talents for the country [1]. Therefore, based on the needs of national development, the experimental teaching of the "Department of Pharmacy, School of Food and Medicine, Zhejiang Ocean University" relies on "Zhejiang Marine Biomedical Products Engineering Technology Research Center", "Zhejiang Marine Drug Research Center", "Marine Biomedicine Provincial Key Discipline", "Zhejiang Emerging Specialty Pharmacy Major" and other scientific research platforms, creating a multi-level experimental teaching model of validatory experiment → comprehensive experiment → design experiment → innovative experiment → open experiment → innovation or entrepreneurship project → graduate thesis. We derive corresponding scientific research projects, patents and scientific research papers, etc., focusing on cultivating students' sense of innovation to meet the needs of social development.

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II. THE NECESSITY OF MICROBIAL INNOVATION EXPERIMENT IN TEACHING REFORM

After many years of exploration, microbial experiments have established a unified teaching model of "basic experiment → comprehensive experiment → design experiment". It is from simple "microbial morphological identification" to complex "independent design experiments, screening organisms with biological activity in the environment". This series of experimental designs have greatly improved the hands-on practical ability of students. The basic experiment belongs to the regular learning part, focusing on the cultivation of students' experimental skills [2]. The comprehensive experiment aims to develop the integrity and systemicity of students' scientific thinking. Design experiments require students to innovate independently, innovate ideas, and improve students' comprehensive innovation ability.

Our microbiology lab is offered in the second semester of the undergraduate with 36 class hours. Microbiology involves a wide range of developments, rapid development and strong experimental application. In a limited class time, it is impossible to cover everything, so that students should master the essence of the course. For the purpose of teaching, we have revised the experimental outline based on sufficient research and careful summary, as shown in Table I. The establishment of experiments such as vessel dressing, medium preparation, aseptic processing, microbial inoculation technology, microbial culture, microscopic operation, microbial staining and microbial morphology observation, focusing on establishing a sterile concept for students, strengthening the perceptual knowledge of microorganisms, and mastering basic operations. The purpose of the reaction experiment is to let students understand the classical methods of microbial identification and grasp the important theories of microbial metabolism and reproduction. In the teaching of strain selection, microorganisms with high efficiency of pollution control are selected as target strains. The heavily polluted environment is used as a sampling site to teach students sample collection and microbial separation. Based on the treatment of heavy metals and refractory organic pollutants, high-efficiency functional bacteria are screened. On this basis, the preliminary study on the performance of the pollutants treated by the strains is carried out. This experiment not only allows students to learn

the methods of field sampling and review important knowledge points such as morphological observation and physiological and biochemical experiments, but also significantly enhances students' initiative and participation, and stimulates students' scientific research inspiration.

TABLE I. EXPERIMENTAL PROJECTS OF MICROBIOLOGY COURSE

Project name	Content summary	Experimental Hours
Microbial classification	Fungi, bacteria, actinomycetes , Gram-positive/ negative bacteria,	4
Microscopic technique and microbial morphology observation	Microstructure, principle and method of operation; Morphological observation of fungi, bacteria, and actinomycetes	4
Aseptic processing and microbial inoculation techniques	Medium preparation, sterilization, microbial aseptic technique inoculation and plate separation technology	8
Efficient functional bacteria isolation and screening	Isolation, identification and preservation of microorganisms; treatment of pollutants by microorganisms, evaluation of biological activity of microorganisms	20

III. EXPLORATION AND PRACTICE OF MULTI-LEVEL TEACHING MODE

A. Streamlining the experimental section to enhance the scientific integrity and coherence of experimental teaching.

A common problem in microbiology experiment teaching is that the proportion of confirmatory experiments is too large, and there are few design and innovation experiments. When students are engaged in scientific research projects, they will expose the shortcomings of weak scientific research ideas. Therefore, in the experimental teaching, we must consciously cultivate students' systematic thinking. We optimize and adjust the experimental content and sequence, and divide it into two sections: the basic skills training section and the open innovative experimental section. The first section includes the use of the microscope and the observation of the basic morphology of the bacteria, Gram stain, actinomycetes and yeast (4 lessons), and the morphology observation of the mold (4 lessons), preparation of medium and sterilization technology (8 lessons). Students are required to master the basic principles and methods of microbial experimental operation, learn to analyze experimental phenomena and propose improvement measures, developing solid basic experimental skills and good operational habits. The second module includes comprehensive and design experiments (20 lessons). The main content is the detection, separation and purification of environmental microorganisms, the influence of physical and chemical factors on the growth of microorganisms, and evaluation of the biological activity of microbial metabolites. Students are required to design experiments and conduct free grouping. Students should review the literature before experiment and operate independently. In this module, students can comprehensively apply the experimental techniques they have learned, which is conducive to fostering independent thinking and innovation, and enhancing the coherence and integrity of students' scientific thinking.

B. Cultivating students' autonomy and subjective initiative, strengthening pre-experiment preparation and improving creativity.

Cultivating innovative talents should guide students to study independently and think positively [3]. Pre-study is an important part of experimental teaching. Through pre-study, students can deepen their understanding of experimental principles, procedures and operational methods, and exercise independent thinking skills. At the same time, through the pre-study situation, the teacher can give specific answers to the difficulties existing in the pre-study process so as to present a good teaching effect by effectively using the experimental class. Experimental teaching should also highlight the student's subjective status and increase the chances of students' hands-on experiments, so that students' learning status changes from “want me to learn” to “I want to learn”. Through open design experiments, students set up their own teams, design experimental sessions, and enhance students' initiative.

C. Combining scientific research topics, introducing life-related projects, enhancing experimental practicality, and promoting students' overall improvement.

Strong youths lead to a strong country. In order to meet the training requirements of young talents, our institute opens up innovative experimental modules and consciously introduces scientific research projects or interesting topics, such as “Isolation and Identification of Marine Microorganisms in Sediment of Zhoushan Culture Area”, "Screening of Symbiotic Microorganisms Inhibiting the Growth of *Vibrio Anguillarum* from *Enteromorpha*", "Discovery of Marine Microbes Factors to Inhibit the Activity of Aquaculture Pathogenic Bacteria". Students choose their own comprehensive experimental projects; three or four people freely combine, consult literature, design experiments, and self-implementation. Finally, students are required to submit a patent application, research paper or final report. At the same time, students are encouraged to report the results of the open experiment as the subject of the innovation and entrepreneurship project and the thesis topic. The combination of patent application, graduation thesis and innovative projects not only deeply studies and expands the content of the experimental course, but also exercises the students' comprehensive ability [4].

D. Taking the experimental assessment as an introduction, guiding students to focus on innovation ability in thinking.

The traditional microbial experiment assessment only pays attention to the results of the experimental report and ignores the experimental operation of the students. We should comprehensively test the experimental preparation, experimental operation, and experimental report to score the students as a whole. The establishment of this diversified evaluation mechanism has enhanced students' participation in the microbial innovation experiment curriculum, and has increased the multi-faceted examination of practical hands-on ability, comprehensive quality ability and innovative thinking, which are conducive to the overall development of students [5].

IV. The Effectiveness of This Reform at This Stage

The microbial innovation experiment was established by the Department of Pharmacy, Zhejiang Ocean University, through the implementation of a multi-level experimental teaching mode, adheres to the teaching philosophy of "introducing scientific research into teaching, promoting teaching with scientific research, all for students, for all students, for students of all", and cultivates high-quality scientific research and innovative talents for the society. In recent years, the innovation achievements of the college have been outstanding. The number of students participating in the National College Student Challenge Cup Innovation Competition, Patent Application, Zhejiang University Students' Science and Technology Innovation, Entrepreneurship Competition, and New Miao Talent Program has increased significantly, and the enthusiasm for participating in scientific research projects has been greatly improved. The implementation of the multi-level teaching mode has greatly improved the students' ability to innovate, and played an important role in the future of further study and social progress.

The purpose of the experiment is clear and unique, but the experimental conditions are optional and diversified. Therefore, students can achieve the purpose of experiment through different ways and methods, hence fundamentally changing the traditional teaching mode of thousands of people. It is conducive to the cultivation of innovative talents and embodies the people-oriented teaching thought. However, to prevent the quality of the experimental results as the sole criterion for judging the results, the experimental process and results analysis should be emphasized. We should encourage students to continually try new methods, allow failures, and focus on results analysis and experience summaries. During the experimental operation, students are required to develop a good habit of making experimental records. The reagent preparation method, instrument status, experimental phenomena, test data, etc. must be recorded in detail. The microbial experiment is rich and colorful. It is recommended that students use image technology to take pictures of the morphology, growth, sampling location, and experimental results of the microorganisms, which not only vividly retains the original records, but also enhances students' sense of accomplishment.

V. Conclusion

The purpose of conducting design experiments is to cultivate students' independent thinking ability, rigorous scientific attitude, and unyielding work style, team spirit of mutual cooperation, and innovative consciousness that is brave to develop. The practice-oriented design experiment emphasizes flexibility and individuality. Students are the main body, designing and completing experiments independently, and evaluating the experimental results. Teachers serve students from all aspects of experimental teaching management. Microbiology focuses on establishing a scientific and complete system of thinking for students, transforming book knowledge into the ability to solve practical problems. For the design experiments in the syllabus, we strive to guide students to choose their own topics according to their personal interests. The topics are diversified and the content is close to production, life practice and research hotspots. For the application of microorganisms, students should choose the subjects that they care most and are most interested in, such as the detection and evaluation of mineral water from different manufacturers who drink daily; choose different living places such as dormitory, campus, classroom, etc., monitor fungi, bacteria and actinomycetes, and the total number of molds aiming to understand the relationship between the environmental conditions of the entire campus and microorganisms; the evaluation of the antimicrobial activity of microorganisms. These experimental projects are closely related to life and production, fully mobilizing the enthusiasm of students, and at the same time strengthening their awareness of environmental sanitation.

The fundamental guiding ideology of microbial innovation experiment teaching reform is to explore and innovate, improve the overall quality of students, and cultivate scientific research talents with innovative spirit, consciousness and ability. The implementation and promotion of the multi-level teaching mode has cultivated students' innovative thinking to a certain extent, and the innovation results are outstanding. This teaching reform needs to be further improved, increasing the design of experimental topics, enhancing the interest of open experiments, increasing the intensity of innovation and entrepreneurship competitions, graduation thesis, patent applications and other results, and encouraging more students to integrate experimental results into research projects. We should get innovative results that can both train students' ability and benefit the industry and society. At the same time, this teaching reform model should be promoted to other majors and disciplines to drive forward interdisciplinary and common development [6].

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