The Research and Practice on Teaching Reform of the Comprehensive Experiment of Microbiology

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***Abstract*—Microbiology is an important foundation course for life sciences education which has intense theoretical and practical characteristics. However, the current experiment teaching system cannot meet the requirement of international engineering education accreditation well. To improve the teaching efficiency of microbiology experiment course, the current situation of this course for students studying bio-engineering is analyzed. Integrating requirements of engineering education accreditation and professional features, a comprehensive experimental project and experimental assessment mode were explored to cultivate students' motivation and innovation consciousness. It was proved in practice that teaching reform had posed a positive effects on cultivating the inter-disciplinary talents and meeting the need of the social development. Through the experimental scheme, the students effectively obtained the abilities to design and implement experiments, and to analyze and to solve problems. The teaching reform fulfilled the requirements of the professional accreditation standard in engineering education.**

***Index Terms*—Microbiology experiment course, comprehensive experiment, teaching reform.**

I. Introduction

Nowadays, it is of great importance to establish an accredited system for higher engineering education with international effective equivalence. Since China became a full member of "Washington Accord" from 2016, the quality of higher engineering education in China has been recognized by international community, which means China has officially adopted international engineering education evaluation system of talent cultivation whose core idea is student-centered, leaded by output and improved teaching quality through continuous improvement [1]. Thus, more attention should be paid to the improvement of the practical problem-solving ability of students. Students' innovative consciousness, such as the ability to use in-depth engineering principles for independent design and development, the ability to assume individual roles and to cooperate with others, etc., was emphasized. All these requirements also manifest the significance of experimental and practical teaching in colleges and universities.

As one of the key majors at Kunming University of Science and Technology, biological engineering is the characteristic majors in Yunnan Province, and it also stands as the fifth majors that have passed the international engineering education accreditation in China. The aim of biological engineering major is to cultivate the research and applied engineering technical personnel with professional knowledge as well as skills in modern biotechnology and engineering technology, so as to meet the social demand for bioengineering talents. Therefore, to strengthen the comprehensive ability to practice is an important point in biological engineering. Experimental course system helps to cultivate the comprehensive capacity and quality of the students (including innovative consciousness, scientific thinking ability and practicalability, etc.), and inhabits a significant role in the innovation of the college educational system. In order to satisfy the demands of cultivating high-quality talents, stimulate the interest in learning, develop scientific thinking, grasp the scientific experiment methods, and improve experience study process, the traditional teaching modes and contents should be reformed.

Nowadays, microbiology has become the basis of almost all of the life science related disciplines [2]. Microbiology experimental course covers basic concepts and experimental skills of microbiology with an emphasis on sterile technique, microscopy, isolation and cultivation of microorganisms, which can be expanded to all the life science courses as an important part in life science education. Therefore, microbiology experiment teaching effect is quite decisive for training students' basic experiment skills, as students can verify the theory foundation and basic experimental technique and develop independent operation experiment ability through course. Many colleges and universities have carried out the reform on the teaching of microbiology theory and experiment course to improve the teaching quality [3]-[8]. In recent years, our faculty focuses on the connotative development goal of stimulating the students' creative ability and improving the teaching quality, on the basis of building a microbiology course group. We have found many problems in previous microbiology and microbiology experimental teaching. In order to improve the teaching quality continuously, solve the problems founded during the teaching process of microbiology theory and experiment course and meet requirements of education certification, we analyzed the traditional microbiology experimental methods, the experiment content, and experiment assessment mechanism. A new student-centered teaching model was established through improving aspects as follows: promoting the in-depth implementation of comprehensive microbiology experiments, controlling the quality of preview reports strictly, enriching assessment forms, expanding assessment contents, and increasing the autonomous learning of microbiology.

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II. The Traditional Experiment Teaching System of Microbiology

A. The Teaching Content and Mode of Microbiology Experiment Course

Microbiology is among the most important professional foundation courses in the life sciences, which is quite theoretical and practical. In traditional teaching mode, the microbiology experimental course lacks systematic arrangement, and the experiment content of microbiology was old-fashioned, mainly focused on deepening and enhancing the understanding of the theoretical knowledge of the microbiological basis [9]. Experiment course mainly consisted of eight different confirmatory experiments, namely, preparation and sterilization of culture media; gram stain method; observation of microbial morphology; aseptic technique; counting the yeast using microscope; culture of microorganisms, and so on. Through these experimental studies, students can memorize the basic principles of relevant experiments, master the basic operation and use the relevant instruments and equipment under the guidance of teachers. However, there are many disadvantages in experiment teaching such as the insufficient experiment hours, the simple experimental types, and the single experiment projects. In order to ensure the experiment to be completed within a limited period of time, the preparation for the experiment, such as the culture medium, dye solution, reagents and the debugging of the experimental instrument, etc., were made in advance by full-time experimental teachers. The teaching method adopted was mainly that the teacher explained experiment principles and demonstrated the experiment, and then the students imitated and practiced. During the experimental teaching process, students were in the receptive and passive state. If these independent experiments were carried out one by one, each experiment would be a relatively simple and boring verification experiment, and the experimental settings were unable to be updated effectively. These traditional verification experiments were carried out in representation teaching mode. Since the experiment results were known, students were in a passive state and learning interest was hard to be stimulated during experiments. The problems encountered in the experiment course were not understood very well by students and the answers were not taught. It was a shortage in the interaction between teachers and students in the course of experiment. Meanwhile, there is a lack of correlation between experimental projects. One experimental project verifies a theoretical knowledge or strengthens an experimental skill, but it failed to develop the ability to solve practical problems with these technologies. The experimental course teaching was far behind the theory teaching and went against the improvement of comprehensive quality and practical ability of students. During experiment teaching, it is difficult to stimulate the enthusiasm and creativity of students. As such, an effective experimental teaching method should be explored to enhance the quality of experimental teaching.

B. The Course Evaluation of Microbiology Experiment

The experiment teaching system of microbiology curriculum in our university was independent of the theory teaching curriculum. The traditional examination assessment system of the microbiology experiments was mainly depended on the experiment reports and ordinary achievement at the ratio of 70% and 30%, respectively. As the experiment contents consisted of different confirmatory experiments, the experimental results were the same, which leaded to the poor quantifiable assessment result and the unfair assessment results. This system could not fully reflect the real level of students' experimental operation skills, as the ordinary achievement was scored by their attendances and other behaviors in class. As long as the students arrive on time, all of them can got high grades. Experimental report was the main basis of final grade and the proportion of report assessment grade was too large. In addition, the examination assessment system excludes the experiment preparation and experiment design, etc. A few students could get high score by writing or copying an experimental report carefully after class, but they had not conducted experiments seriously, which tended to bring the students to spend most of the energy in writing experiment report, despising the consciousness of study and active participation in the process of practical operation. This is unconducive to the cultivation of the student' practice ability. During the experimental process, many students did not care about whether they have mastered the operational skills and thought about the reasons of experimental failures, or even did not check the experimental results after the experiment. Most students forgot what they have done in experiment courses soon. Thus, it is necessary to establish a scientific and reasonable assessment method to correct students' experimental attitude and to cultivate students' meticulous workstyle. This kind of assessment would assume an important role in the process of mastering microbiology experimental skills and cultivating high-quality talents.

III. The Teaching Reform of Microbiology Experimental Course

A. Setting Up the Comprehensive, Researchful Experimental Teaching System of Microbiology Experiment Course

Experimental teaching is characterized by a large quantity of contents and sound comprehensiveness and specialty, which plays a unique role that cannot be replaced with other teaching links in training students' practical ability, research ability and innovation ability. Basic experiments place more emphasis on deeper understanding of key knowledge points and basic training of engineering practices, and the key point is to train students' ability to operate and use basic equipment and tools. According to the knowledge structure and inner laws of microbiology, we combined experiment courses with theoretical courses to form integrated curriculum system of microbiology experiments, under the principal lines of the separation, purification, culture, classification and identification of microorganism. The combination of theory and experiments can make students not only do experiments with knowledge they have gained, but also have deeper understanding of the basic principles by observing experiment phenomena. On the basis of cultivating scheme

and teaching program of microbiology experimental course, we reformed the experiment system to strengthen basic training, highlight innovation and improve comprehensive quality.

Applied scientific research projects is integrated into the experimental teaching process of basic microbiology to stimulate students' enthusiasm and initiative in scientific research and exploration, so that they could master the basic skills of microbiology much better. In microbiology experiment course, students were required to master the four basic techniques of microbiology, namely, microscope technology (including dyeing and preparation technology), aseptic operation technology, separation and purification technology, and pure culture technology. In the experiment designing, the traditional eight experiments were organized together in an orderly way to form a new large comprehensive innovation experiment: isolation and purification of enzyme-producing (such as amylase, lipase protease, etc.) microorganisms and it's identification of 16S rRNA genes. During the experimental process, students are requested to work independently to finish the things as follows with teachers' help, including samples collection, culture media preparation, strains separation, PCR amplification, cloning, sequencing, and the identification of the strains, etc. Two students made up a group and chose their topic by themselves. Through consulting literature material and analysing theoretical knowledge learned in the classroom, they needed to design the technical route of the comprehensive experiment, finished the operation of the whole microbial experiment and write the experiment report by themselves. In theory, each student or group could got the different enzyme production strains. In other words, the experimental results were different, which approach resolved the problem in which verification experiment results was single and repeated. Thus, it would be easier to stimulate students' learning enthusiasm while the experimental process and experimental results were interlocked. At the same time, the exploratory experiment could provide students with an independent scientific research experience and formal research training opportunities. In the experiment, the teacher played a guiding role, to enlighten the thinking, review the experiment scheme, check the key links of the experiment, and organize students to analyze and discuss the results. With all these effort, the experimental process would become systematic and continuous, in which students become the subjects of experimental courses and their interest and enthusiasm for learning would be greatly stimulated.

B. Reforming the Examination of Microbiology Experiment Course

The reformation of examination method was a critical part of the teaching reformation. A good evaluation system is not only an objective and truly reflection of learners individual learning, but it can also help to find their own problems. Then, targeted learning would be made actively, and it will eventually lead to the achievement of the teaching goal [10]. The evaluation system should pay more attention to students' operation skills, the ability to make an integrated use of knowledge and independent innovation, the ability to analyze and solve problems [11]. Therefore, the evaluation method will definitely combine experimental results with the experimental operation process closely. The test scores of microbiology experiment used to be mainly depended on the experiment report. In order to evaluate students' scores more objectively and accurately, a new examination and assessment method of microbiology experimental course was established. The new examination evaluation system was made up of two parts, namely, process assessment (70%) and experimental operation evaluation (30%), respectively. First, the process assessment achievement was quantitatively scored by pre-lab reports (20%), daily performance (experimental attendance, preparation, record, discipline, attitude, etc. 10%) and experiment report (40%). Pre-lab reports should include the experimental details, technical route, supplies, any information you feel necessary such as a basic outline of approach, and if necessary, tables should be made to record the information. The experimental reports included experimental principles, steps, results, analysis and discussion, etc., and students should write in the same standardized way as scientific research reports. The other part was the experimental operation evaluation which included oral and practical tests. The content of operational examination was mainly around the requirements of experiment teaching outline, including the basic experimental operation method and fallible knowledge in the process of teaching. The concrete content is composed of microscope specification operation, gram staining of bacteria, tablet coated, aseptic operation, such as plate streaking and inoculation of an agar slant, microorganism microscopic counting method, different types of microbial colony morphology identification, etc. In the lab test site, the teacher should place experimental equipment and facilities in advance in different areas. Students could take out the exam question from the examination bank, and then the student should answer the questions and in dependently complete the whole experiment process by teacher supervision. Once problems occurred in the assessment process, the teacher would give the correction immediately, whilst the student would be given an appropriate scoring. Therefore, the students could activate with the experiment positively, and fully mobilize the enthusiasm of hands-on experiments. It should be noted that examination bank was an important component of resource construction in assessment contents.

C. The Effect of Microbiology Experiment Curriculum Reform

It's necessary for students to change their traditional mind from "I am required" to "I require", so as to realize their multilayered educational goal. Through the reform of teaching methods, we can promote the expected learning output and construct a reasonable learning output evaluation system. The basic operation skills of microbiology experiment could be consolidated, the students' learning attitude could be corrected, and their dominant role in the teaching implementation would be strengthened. With all these effort, the students could change their mind and shift their attention from the theoretical knowledge to the experimental operation. After the establishment of experimental content and assessment method, students would took an active part in microbiology experimental course. In

order to improve their own abilities, many students took the initiative to consult literature, volunteered to do experiments in the laboratory, and assisted teachers in preparing experiment. Some students were actively involved in the teachers' scientific research subject, improved their scientific research ability and practical ability, and developed a good study habit. We found that the students' comprehensive abilities, such as independent operation, knowledge application, experimental design and innovation, have been greatly improved. The scientific quality of students in consult literature and design experiments were cultivated effectively, and all these laid down a good foundation for the future graduation project, work practice and scientific research. We have conducted a questionnaire survey after the teaching reform and the results showed that quite a few students thought microbiology experiment was their favorite experiment at the university (data not show here). Despite more time and effort spent, students thought they learned a lot. Through this new comprehensive experiment course, the students could master basic skills and methods for analyzing and solving practical problems, establish a combination system of theory and technology, obtain the ability to make process design, complete the course objectives, and meet the requirements of the engineering education professional certification.

IV. Conclusion

Education is a system engineering, and student-oriented cultivation of scientific research and innovation talents is a process that needs to be explored, updated and continuously developed. This paper makes an exploration to a student-centered experimental teaching mode where teachers inhabited a guiding role. Teachers focused on cultivating students' ability to analyze and solve problems, carried out engineering training for students, and cultivated students' engineering practice ability, so that it could help students to lay a solid foundation for solving complex engineering problems. Our teaching reform showed that the introduction of comprehensive and researchful projects which was closely related to production practice on the basis of strengthening basic skills training in microbiology experimental teaching could improve the comprehensive quality of students and stimulate their learning interest and innovation ability in a better way. In the future, we need to focus on the construction of experimental courses, and improve the scientific research level and teaching level of teachers constantly, so as to maintain the sustainable development of microbiology experimental courses at a high level and strive to cultivate more and better innovative talents for microbiology scientific research in China.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

JY and LL conceived and designed the study. JY, SD and LL performed the project and wrote the paper; all authors had approved the final version.

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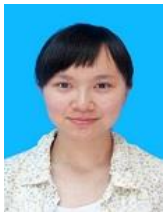

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