Original Article

Exploration of Project and Module-based Teaching Method in Pharmaceutical Microbiology Laboratory Courses for Undergraduate Pharmacy Students

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ABSTRACT

Background: Pharmaceutical microbiology is an important applied branch of microbiology and it's provided broad knowledge and understanding with regards to the principles, techniques and processes involved in pharmaceutical microbiological experiments. **Objectives:** To help students develop abilities related to laboratory techniques, data analysis, and systematic thought in biology, we have designed an exploratory program that employs project and the module-based teaching (PMBT) method. **Materials and Methods:** The PMBT experiments focus on the project of "Micro-organism limitation test of Shuanghuanglian oral preparation" and is divided into four modules. **Results:** The PMBT experiments guide students to experience an entire inquiry-based learning process by consistently conducting research projects, through which students gain an in-depth knowledge of the fundamentals of pharmaceutical microbial experiment skills. The PMBT experiments help student's gain thorough understanding and reveal profound insights into pharmaceutical microbiology. It will essentially provide ample emphasis on the vivid coverage of the procedures involved in isolation of antagonistic micro-organism and improve student's interest of study, the operational skills and scientific innovative abilities as well as enhance the quality of pharmaceutical microbiology education and teaching. Conducting the PMBT method in pharmaceutical microbiology experiments is beneficial to expanding students' scientific vision, improving their operational capacity and their exploratory ability.

Keywords: Pharmaceutical microbiology, Innovative learning, Project and module-based experiment, Experimental and practice teaching reform, Research.

INTRODUCTION

Microbiology is a professional basic course for all pharmacology majors. Microbiology and pharmacy have a close relationship, micro-organisms as the main source of drugs, its discovery and production of new antibiotics, biological enzymes, amino acids, etc. This course also provides the relevant knowledge and skill basis for the study of microbial pharmaceuticals, bioengineering pharmaceuticals, biochemistry, molecular biology, and other courses. Therefore, the microbiology course has an important position in the learning process of pharmacy majors.[1-3] As a basic course of pharmacy, the teaching effects of microbiology are directly related to the realization of the training objectives of pharmacy majors, as such special attention has been paid to the teaching practice and reform of microbiology by the university. We have made reference to the exploration of related institutions,[4-17] and carried out relevant teaching reform and practice in our "Excellent Engineer" class (pharmacy and pharmaceutical engineering majors), and have established a new teaching mode of microbiology laboratory courses for pharmacy majors based on the combination of basic skills training and project research. We have designed an exploratory program

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that employs project and module-based teaching (PMBT) method in pharmaceutical microbiology laboratory courses for undergraduate pharmacy students. The PMBT method is student-centered and focuses on guiding students to focus on issues of significant social importance or problems of real-world significance as a starting point, through active information gathering, knowledge acquisition, solution exploration, and cross-learning between multiple disciplines, so that students may explore and learn more deeply about problems faced in the real world and attempt to find solutions.

MATERIALS AND METHODS

Study participants

The study was conducted by Department of Pharmaceutical Microbiology, School of Life Science and Technology at China Pharmaceutical University. The participating students were 3-yr undergraduate students majoring in pharmacy and pharmaceutical engineering (Excellence Engineer Class). This project was conducted for 4 yr (2016 class to 2019 class). All of the procedures in this study were approved by the Ethics Committee of China Pharmaceutical University, and informed consent was obtained from the students. The students were assured that the results would be treated confidentially.

Experimental Content Integration

Pharmacological microbiology experiments generally include basic experiments and specialized experiments. Generally, due to the large number of students, the difficulty of management, and the limitation of instruments and equipment, most of the experiments offered are operational and verification experiments, which mainly include microscopy experiments, microbial staining and counting, medium preparation and sterilization, *in vitro* inhibition testing of drugs, antibiotic potency determination, etc. Although the content is insufficient, due to poor coherence, students reflect that the knowledge gained is limited, and they are unable to learn systematically and cannot master these techniques. In particular, some instruments, such as autoclave, ultra-clean bench, multi-point inoculator, bacterial collector, PCR instrument, etc., cannot be operated personally, which cannot satisfy students' desire for knowledge and often stifles the students' interest in learning and cannot achieve the purpose of the experimental teaching.

Based on the project of experiments related to microbial limit examination of oral preparations, a total of 4 modules as shown in Table 1 are set up, students learn medium preparation, bacterial plate counting, bacterial strain isolation and purification, bacterial staining, the usage of microscope, bacterial identification, and strain preservation. Through these experiments, students can better understand the experiment and achieve mastery of experimental skills.

Organization and arrangement of experiments

The experimental content and objectives are posted on the e-class teaching platform before the class starts, so that students can better understand what experimental content is available. With the understanding of the purpose, task and knowledge of each experiment and the required instruments and equipment, students start to consult the data, design the experimental plan, and establish the relevant research methods. During the whole experiment implementation process, the teacher mainly plays the role of guiding and answering questions, and the experiment is completely prepared by students independently, completing all the experimental operations and contents, recording the experimental

Table 1: The teaching arrangement of experimental modules.

Experimental modules	Experimental name	Tasks, knowledge points and experimental techniques
Module I (Basic microbial skills)	Preparation and sterilization of culture media	Culture medium preparation, dispensing and sterilization; wrapping and sterilization of test tubes, triangular flasks and Petri dishes.
Module II (Specific microbial skills)	Microbial limit inspection of Shuanghuanglian oral preparation; bacterial isolation and purification.	Plate coating method (include tilt-pour method and coating method), bacteria isolation method, inoculation method (inoculate bacterial culture to liquid slant, semi-solid medium and plate streak).
Module III (Basic microbial skills)	Identification of Bacteria with morphology, biochemical tests and molecular biological methods; bacterial UV mutagenesis.	Simple staining and Gram staining of bacteria and how to use of microscope-biochemical tests-PCR amplification of 16S rRNA gene and BLAST analysis-the effect of UV light on bacteria.
Module IV (Specific microbial skills)	Bacterial drug resistance testing and antibiotic potency determination.	K-B agar diffusion method for bacterial susceptibility testing, cylinder-plate method for antibiotic potency detection.

results and analyzing and discussing the experimental results in detail.

Because PMBT experiments are more extensive and comprehensive than traditional microbiology experiments, the experimental contents are too numerous and the experimental period too long, so students cannot complete them in a relatively short period of time. Therefore, time is an important guarantee for the development of these experiments, for this reason, our teaching experiment center has set up a special open laboratory, students may not be limited by the experimental hours and equipment, according to their own situation to make full use of their spare time, according to the experimental schedule of flexible arrangements for experiments. While in the traditional experimental teaching mode, it is difficult to have continuous time for students to conduct experiments, and such experiments with scientific research are difficult to complete. In order to avoid the chaotic situation in the open laboratory, when arranging students to conduct these experiments, a series of relevant systems have been formulated to ensure the safety of the laboratory and the normal operation of the experiments, such as designating a person responsible for each experiment, formulating a loan and return system for experimental instruments and equipment, a registration system for the use of experimental instruments and a responsible system for laboratory safety and hygiene, etc. At the same time, students are required to cultivate the habit of standardized experiments during the experiments and to ensure the neatness of the laboratory after the experiments are finished to ensure the smooth operation of the open laboratory system.

Implementation and assessment of experiments

Students establish a detailed experimental plan, including required drugs, experimental equipment, and detailed operational steps, by reviewing relevant literature and discussing within groups, and then discuss the feasibility of the experimental plan with the teacher, after the teacher confirms it, students strictly follow the experimental plan. In the experimental process, the observed experimental phenomena and experimental results are recorded in detail, and problems that cannot be explained in the experimental process are discussed and analyzed with the teacher in time to find out the causes of these problems, adjust the experimental program or take corresponding remedial measures to solve the problems in time. At the end of the experiment, students are required to record the experimental results faithfully, and conduct data processing and comprehensive analysis, and write an experimental report according to the format of the published paper.

The laboratory examination is a combination of laboratory report, operation examination and written examination. The lab report accounts for 70%, the operation part accounts for 20%, and the written exam accounts for 10%. The experimental report is required to be written in accordance with the format of the school journal after completing all the experiments, instead of submitting the experimental report as the traditional microbiology experiments; the operation part is mainly to examine the most basic microbiology operation skills of students, whether they have the concept of sterility, how to use the microscope, bacterial staining, medium preparation, bacterial inoculation, etc.; the written examination part is mainly aimed at examining whether students can carry out some simple experimental designs related to microbiology after passing this experiment combined with theoretical knowledge and in response to the knowledge points.

RESULTS

Effectiveness of PMBT experiment teaching

Trained students in literature review and experimental design

The PMBT experiment is a scientific research experiment in which students review the literature, design their own experimental protocols, and implement the experimental content on their own. Based on the experimental content, students first identify relevant literature by reviewing databases, such as China Journal Network, Elsevier, Springer Link, web of science, etc., and then read and compare the literature, in this way they improve their ability of literature review, summarization and induction. This training effectively develops students' ability to design experiments by proposing experimental protocols through literature reading, designing experiments, and discussing with teachers and their peers to improve their laboratory skills and overcome any problems they may face.

Improves students' hands-on skills and interest in research

The PMBT experiment is not a simple integration of several basic microbiology skills experiments, it is a continuous research-based experiment, integrating multiple knowledge points and involving the use of a variety of instruments, which requires students to do more hands-on learning in order to master the use of instruments; there are also some experimental principles, such as UV mutagenesis or UV sterilization principals,

such as the following question; why UV does not work on *Bacillus*; the principle of PCR for gene amplification. This kind of experimental teaching method has greatly stimulated students' enthusiasm to participate in research. According to the feedback from the school's Academic Affairs Office, the proportion of students participating in open experiments in classes with comprehensive experiments has increased from about 20% to 86%, and the proportion of students participating in university innovation and entrepreneurship projects has increased significantly. In addition, the proportion of the major's graduate study has also increased. In 2019, there were 32 students in the "Excellent Engineer" class, except for 4 students who were employed and 10 students who were guaranteed graduate study, all other students were admitted as graduate students to famous University or institute like Shanghai Institute of Pharmaceutical Sciences, Chinese Academy of Sciences, School of Pharmacy, Peking University, Zhejiang University, West China College of Pharmacy and other famous research institutes at home and abroad, such as Drexel University in the United States and the University of Edinburgh in the United Kingdom.

Enhanced the teamwork spirit of students

The implementation of this PMBT experiment requires the cooperation of students. For example, in preparation of culture medium, a student has to do the weighing of different medium components, while another student has to dissolve and adjust the pH value, and according to the different physical properties, different concentrations of agar have to be added, and then the medium will be divided and sterilized. In this process, not only the self-consciousness and enthusiasm of each student are effectively brought into play, but also teamwork is strengthened. The joy of this victory will increase the memorability of the experiment through the joint efforts of all of students to finally achieve the success of the experiment.

Improving the teaching quality of microbiology courses

Microbiology is originally a very practical course, through the conducting the experiments, students have a further perceptual understanding of the theoretical knowledge, so that the theory is connected with practice, and improving the teaching effect of microbiology courses. Under the traditional teaching mode, due to the excessive number of students, some students indiscriminately do not perform experiments seriously, and consider the experimental class irrelevant to their studies, which leads to unsatisfactory results in the final experimental assessment and written assessment, even to the extent that some students cannot obtain single colonies, after the PMBT experiments, as they are often exposed to these basic experiments, they can master the basic skills well, and 100% of students master the basic microbiological skills such as the use of microscope, bacterial staining, medium preparation, isolation and culture of bacteria, and also mastered the knowledge of pharmacological microbiology, such as *in vitro* antibacterial assay of drugs, etc.; the written examination is mainly to assess the main points of the test and experimental design, the passing rate in the traditional mode is generally about 40% (13 people were completely correct in 2016, 32 people in total), after the PMBT experiment, the passing rate increases to about 90% (in 2019, 29 people were correct, a total of 32 people).

CONCLUSION

The PMBT method has been conducted for 4 sessions in our university. The experiment is a coherent and large research-oriented experiment centered on pharmacological micro-organisms, using basic knowledge and skills of micro-organisms, involving relevant knowledge of pharmacological micro-organisms, such as determination of antibacterial activity and *in vitro* antibacterial tests of drugs. The PMBT experiments enable students to improve their knowledge in literature review, experimental design, independent operation, and comprehensive application of their knowledge, and lay a good foundation for future graduation design or scientific research in graduate school. Students demonstrated positive educational outcomes such as scientific knowledge acquisition and expanding scientific vision, improving operational capacity and exploratory ability. These results suggest that PMBT approach may help to contextualize scientific research in future curricula.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

ABBREVIATIONS

PMBT: Project and the module-based teaching; **PCR:** Polymerase chain reaction; **UV:** Ultraviolet.

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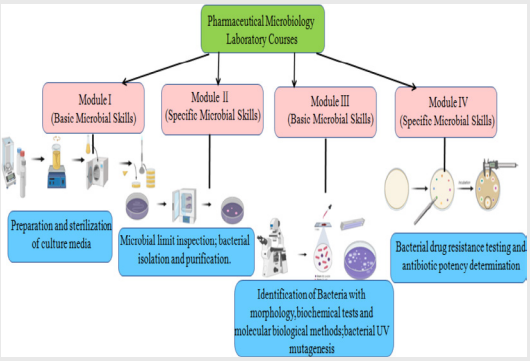
PICTORIAL ABSTRACT



SUMMARY

In the present study, PMBT approach is described for use in Pharmaceutical Microbiology Laboratory Courses for undergraduate pharmacy students. The PMBT experiments enable students to improve their knowledge in literature review, experimental design, independent operation, and comprehensive application of their knowledge, and lay a good foundation for future graduation design or scientific research in graduate school. Students demonstrated positive educational outcomes such as scientific knowledge acquisition and expanding scientific vision, improving operational capacity and exploratory ability. These results suggest that PMBT approach may help to contextualize scientific research in future curricula.

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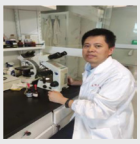

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