Building and Practice of BCD Teaching Mode Based on Scaffolding Instruction in Environmental Microbiology Experiment

Yu Pan, Zhiwei Song, Zinan Zhong

School of Environment and Chemical Engineering,
Heilongjiang University of Science and Technology,
Harbin 150022, Heilongjiang, China

Abstract
The course of environmental microbiology experiment is featured as more knowledge points, difficult to remember, and has requirements for the students' ability of experiment operating basic knowledge skills. Traditional infusion experimental teaching methods isolate the teaching content, and make students lack learning interest and the sense of responsibility, which are difficult to obtain satisfactory teaching effect. Therefore, stimulating learning enthusiasm and motivation, and enhancing the students' autonomous learning ability and innovation consciousness is an important developing direction of the current teaching reform in colleges and universities. This study has focused on the environmental microbiology experiment teaching according to the theory of scaffolding instruction, the teaching reform was carried out, and a BCD mode has been designed and built, which has guided the students to actively participate in teaching, and promoted innovative consciousness and scientific research ability. In this study, teaching objectives have been realized.
Key words: ENVIRONMENTAL MICROBIOLOGY EXPERIMENT, BCD MODE, SCAFFOLDING INSTRUCTION, TEACHING REFORM

1. Introduction

Higher education has brought the new opportunities of development in the new period. At the same time, it also faces new challenges to cultivate a new generation of college students with innovation ability [1]. Therefore, paying more attention to students' ability and quality promotion and cultivating innovative talents is the most important task of national higher education. Education teaching in colleges and universities aimed at cultivating students' innovative ability and practical ability of solving the problem is realized largely through the experimental teaching. The experimental teaching is not only the confirmation of the theory from classroom or making students master the basic experimental operation, but also playing a key role in training students' scientific research ability and exploring spirit and innovation consciousness.

Environmental microbiology is an important professional basic course of environmental engineering, which is opened prior to water pollution control engineering and solid waste disposal that are professional backbone courses. Environmental microbiology experiment is an important part

of the curriculum teaching system, its salient features are large amount of experiments, wide coverage, long period, strong comprehensiveness. However, at present, there are many disadvantages in the implementation of the traditional experimental teaching methods, which are summarized as the following five points: (1) The teaching contents are lack of independent design process, which are mainly to some observation and the verification experiments. (2) The experiments isolated among each other, the knowledge before and after the system integration and cannot be realized. (3) In order to finish the teaching task in class, the experimental teachers have to contract under all experimental design, preparation, cleaning up, only so-called "core operation" in the experiments will be left to students, which will make students lose responsibility and learning initiative. (4) in-class experiment teaching and the students of science and technology project are not close, although the students' enthusiasm to participate in extracurricular technological innovation activities, the basic experimental skills in the course of learning and training are not enough in place. (5) The experimental teaching evaluation is mainly in the way of experiment report, students often appear the phenomenon of mutual copying and perfunctory [2]. If these disadvantages are not eliminated, the experimental teaching will be unable to meet the need for further development of the students, the cultivation of innovation ability become empty talk.

Thus, the reform for environmental microbiology experimental teaching content and exploring new teaching mode is imperative. Scaffolding instruction is a new scientific teaching concept developed in recent years, the concept emphasizes students as the center, requests the students to make active learning instead of passive learning, requires teachers to transform their role from indoctrinating knowledge into students' autonomous learning guide, promoter of innovation, it advocates that learners should be provided with conceptual framework, which is used to help to construct the further understanding of the problem and decomposite the complex learning task, so that the learners' understanding will be brought in-depth step by step. Since the beginning of this century, scaffolding teaching mode has been applied in the teaching of colleges and universities worldwide, which have obtained remarkable achievements [3-5]. This study is to improve the students' scientific research innovation skills and stimulate the learning potential, the BCD experimental teaching new mode was constructed, the environmental microbial open experiment platform was established through the use of scaffolding instruction theory, which not only make the students actively participate in the experiment and improve the comprehensive ability to innovate, but also provide basic information for other experimental curriculum reform.

2. Methods

This study aims at students' innovative ability training, the teaching link was designed, a BCD model as the core of the experimental teaching reform was established guided by scaffolding instruction, research data were collected through literature review and questionnaires, the research was to understand other implementation situation of experimental teaching reform in other universities, the teaching mode was carried out and operated according to school and professional goals and the actual situation of the students. Seminars, students' and teachers' interviews were held regularly to understand the problems and the improvement method.

2.1 BCD mode establishing

Classification division and integration of the experimental teaching contents in environmental microbiology were completed. A new teaching mode called "BCD mode" was created to cultivate students' innovative thinking ability, the experimental projects in teaching content was divided into three big modules, namely as basic experiments (B), comprehensive experiments (C), designed experiments (D). B was considered as the scaffold of C, and C was considered as the scaffold of D in the aspect of macroscopic. In the implementation of each experimental teaching process, different forms of learning support were set up, which make students in the experimental course learn to participate in the implementation of the theoretical knowledge and experimental skills, fulfilling the double integration of experimental skill and experimental design.

2.2 Teaching methods reform

Teaching methods were modified guided by the scaffolding instruction. In the experimental teaching, the teachers were the leading factor and the students were the main

body, discussion-based, heuristic and problem leading teaching methods were mainly adopted, the students were given opportunities to share their experimental ideas and experiences through regular seminars.

2.3 Open experimental platform building

The open experiment platform of environmental microbiology was established. Time open was to facilitate students in extracurricular experiments. Opening space ensured that the students had plenty of experimental reagents, experimental equipment and experimental sites. Open the guidance of teachers, the experimental theory problems faced in the experiments at any time would be solved of guided by teachers. Knowledge was opened, that is, for each classmate or each group, the experimental results and experiences were timely summarized and communicated.

2.4 Diversified evaluation system

A diversified evaluation system and comprehensive evaluation of students were established, which could really reflect the teaching idea of "students centered".

3. Practice and Exploration

3.1 Scaffold building in BCD mode

In the scaffold building process, a new teaching plan of the environmental microbiology experiment course was designed to integrate the teaching content, and comprehensive experiments and designed experiments were added.

In basic experimental part (18 class hours), skills training scaffold and sample demo scaffold were built as the primary supports. Detailed experimental scheme, demonstrated the important operative technique in the form of live demo, which made students firmly grasp the related basic microbiological experimental skills in the process of important basic theory verification to lay a solid foundation. Some basic teaching items were included in this part, such as bacteria counting method, gram staining, separation line technology, etc.

In comprehensive experimental part (12 class hours), problem guided scaffold was set up as the main support. Some experiments were arranged for repeat training of basic skills, such as isolation and identification of azo dye biodegrading bacteria and other functional bacterial [6,7], this kind of experiment involves multiple basic single items: disinfection and sterilization, plate streaking and separation, the strain separation and identification, dyeing and film production, species preservation. In this process, inspiring, questions asking and guidance from teachers were required, which led the student learn and discuss actively, feel each link of experiment with concentrated attention. It both strengthened the basic operation skills, and exercised the ability of comprehensive analysis, improving the overall quality in the framework.

In design experimental part (6 class hours), suggested scaffold and ability scaffold were built as the primary supports, targeting at the cultivation of innovative ability. In this process, four to six students were made up as a team to customize a research content, complete the tasks of literature consulting, project design, experimental preparation and operation, interactive discussion, thus completing the knowledge construction. Some designed experiments were arranged for training innovative and experimental skills, such as designed experiments of bacterial physiological and biochemical properties. Using this experiment as an example, scaffold building in BCD mode was illustrated as Figure 1.

3.2 Pitching in the supporting points and independent exploration

Some appropriate entry points were selected, introducing students to a certain problem situation. In the special situation, students could experience problems, which stimulated their independent inquiry consciousness. When the inceptive guidance and help from teachers reduced gradually along with the teaching process, the students were encouraged to start their own play. Finally, the students could try to explore independently without teachers' guidance.

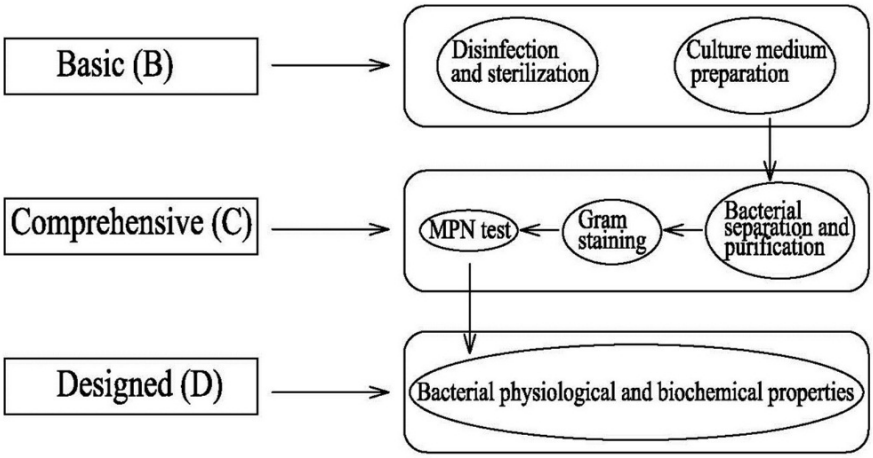


Figure 1. The original image Systematic illustration of the experiment of bacterial physiological and biochemical properties

3.3 Cooperative learning

Group consultation and discussion were arranged to excavate the potential of each student and exert the interaction, complement each other, mutual function of learning teams, making the student set up the team cooperation consciousness and improve together in the process of discussion and cooperation.

Using the experiment of bacterial physiological and biochemical properties as an example, the effect of scaffold building in BCD teaching mode on the training and improvement of the students was demonstrated in Table 1.

Table 1. Effect of BCD mode on the experiment of bacterial physiological and biochemical properties

Experimental items	Existed problems before reform	Improved effect after BCD mode
Disinfection and sterilization	Single, pertinence was weak, and disconnect to related experiments	The purpose and meaning of the experiment was more clear
Culture medium preparation	The role of the medium prepared to the later experiments was slight	High interest and motivated in learning, points were applicable
separation and purification	Coherence among the experimental items was poor	Dominant strain were obtained, learning interest was improved
Gram staining	Complicated to operate and poor resolution of bacteria	Clear dyeing results and the initiative was improved
MPN test	Complicated procedures and poor Operated system	Repetitive operation was reduced, comprehensive application ability was raised

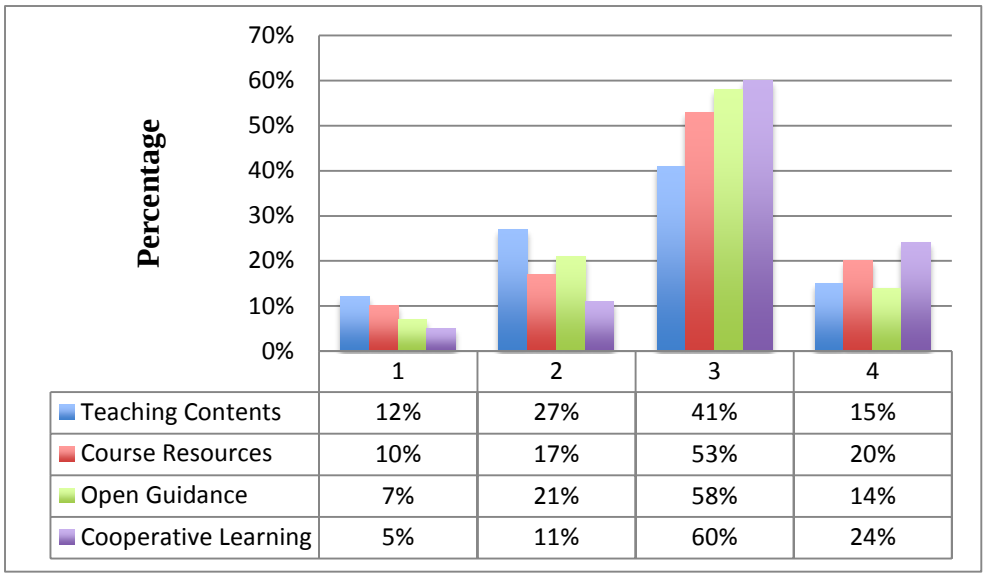
3.4 Effect evaluation

Academic oral test accounted for 30% of the total grade, Specific experimental operation skills accounted for 30% of the total grade, experimental research paper accounted for 20% of the total grade, and students' mutual evaluation accounted for 20% of the total grade. In ordinary assessment, a complete set of "the book of environmental microbiology experimental report" was designed according to the experimental content, which have evaluation standards for each experiment, the achievement of each experiment was assessed based on the results of the students' peacetime preparation, operation, experiment, experimental attitude and experiment report situation. When all the

experiments had been finished, the ordinary grades were summarized. In experimental skills test, After the experimental class, a comprehensive experimental skills quizzes was carried out, which was to assess students' experimental skills of independent dyeing production, microscopy, aseptic operation, etc. According to the situation of its operating, the final results were given on the spot. In the step of students' mutual assessment, everyone in the completion of design experiments had to show their results in the form of wall newspaper and accept the questions from other team members and the results evaluation, scores are given, the result accounts for 20% of the total grade. This kind of students' assessment mode have stimulated the students' learning interest and enthusiasm.

3.5 Satisfactory survey

After the teaching reform implementation of the course, a satisfaction survey analysis was conducted among 90 students. Four aspects were selected, which included the rationality of the course content setting, curriculum resources richness, teacher guidance and group discussion of students. There were four levels: very dissatisfied, not too satisfied, satisfied, very satisfied (represented as 1-2-3-4). The survey time chose the environmental microbiology experiment study, statistical data was 90, and the questionnaire recovery rate was 100%. The satisfaction survey statistics was shown in figure 2. For the item of the contents of the course, very dissatisfied, not satisfied, satisfied and very satisfied were accounted for 15%, 27%, 45% and 15% respectively. For the degree of rich resources very dissatisfied, not satisfied, satisfied and very satisfied were accounted for 13%, 17%, 51% and 13% respectively. For the interaction guidance, very dissatisfied, not satisfied, satisfied and very satisfaction were accounted for 7%, 23%, 57% and 7% respectively. For the link of student group discussion, very dissatisfied, not satisfied with, satisfied and very satisfied were accounted for 5%, 11%, 60% and 11% respectively.



	1	2	3	4
Teaching Contents	12%	27%	41%	15%
Course Resources	10%	17%	53%	20%
Open Guidance	7%	21%	58%	14%
Cooperative Learning	5%	11%	60%	24%

Figure 2. The satisfaction survey of students in the learning process

It can be seen from the results of the survey that most of the students are satisfied and very satisfied with the teaching reform of environmental microbiology experimental course, meanwhile, some dissatisfied situation also existed. Focus on this part of the interview survey analysis, one main reason was the poor theoretical foundation and innovative ability of this part of students, they could not follow the teaching arrangements of environmental microbiology experiments, in which their poor basic knowledge of theory was mainly manifested in the grasp of the basic knowledge slowly, they could not keep up with the rhythm of the curriculum, and it was difficult for them to transform from the basic, comprehensive experiments to design experiments. Moreover, their basic knowledge and operation methods have not been reach the designated position, innovation ability was limited, which make them not well integrate into

the communication with the teachers and students.

4. Conclusions

The teaching reform of the course of environmental microbiology experiment was based on the theory of scaffolding instruction, which set up the specific scaffolding supports for students and transformed the students into the main body of learning, accelerated the change of students' and teachers' roles in teaching process, shortening the time from basic theory cultivation to the innovative practice. Microbiology experimental teaching methods have been systematic improved, which transformed the teaching implementation from "teacher-centered" to "student-centered", the scaffolding instruction was adopted in the experimental teaching, students' learning enthusiasm and motivation is fully mobilized. According to the experimental teachers point, students will construct relevant knowledge abilities based on their own experiences, teaching emphasis and difficulties and specification of experimental operation can be clearly grasped in the class. From basic experiments to comprehensive experiment and designed experiments, the teacher's role at the primary level of "the center", from detail explanation, demonstration, operation in each basic experiment to fewer but better details in the comprehensive experiments explaining, letting the students acquire more personalized education in such aspects as thinking mode, experimental operation. In the whole experimental teaching process, teachers only provide necessary experimental conditions, the independent innovation and practical ability of students were improved obviously.

Environmental microbiology experimental teaching content have been optimized. Any microbiological experiments should require the basis of the classic methods, therefore, basic skill training is still the focus of microbiological experimental course. Development from basic experiments to the comprehensive experiments has connected the original isolated, discontinuous experiments to an organic whole, improving the students' abilities of observation, analysis and problem solving. When the students have mastered the basic experiment skills and analytical ability, they can link in the designed experiments, students' literature, design experiment plan, prepare the material, to carry out the experiment. This is the pattern of a trilogy in our microbiology experimental teaching. BCD (basic, comprehensive and designed) mode as the core support system for the experimental teaching reform was built to change the oneness and independent verification experimental situation, which will develop to the direction of innovative design, the systematic integrity and comprehensive practice, and also provide basic information for other experimental curriculum reform.

Acknowledgements

This work was supported by the Education Science "twelfth five-year" plan young project of Heilongjiang province (No. GJD1214064), and the Youth Talent Developing Foundation of Heilongjiang University of Science and Technology (No. Q20130102).

References

1. Chen H., Nan X., Ding X., Hu X., Sheng Q. (2012) Establishment and practice of inquiry teaching mode in microbiology. *Biology teaching in university*, 2(4), p.p. 23-26.
2. Zhang J., Lei G., Zhou S., Peng H. (2012) An initial discussion on the reform of microbiology experiment teaching. *Biology teaching in university*, 2(4), p.p. 41-43.
3. Hong L. (2014) The exploration of modular teaching pattern for microbiology experiment in peking university. *Microbiology*, 41(4), p.p. 744-747.
4. Qiu L., Wang W., Duan L. (2013) A study of systematic and comprehensive experimental teaching for microbiology. *Higher education of sciences*, 111(5),p.p. 87-90.
5. Lv A., Hu X. (2013) Discussion and practice of four-stage progressive teaching in microbiological experiment. *Journal of microbiology*, 33(4),p.p. 98-101.
6. Pan Y., Li N., Mu J., Zhou R., Xu Y., Cui D., Wang Y., Zhao M. (2015) Biogenic magnetic nanoparticles from *Burkholderia* sp. YN01 exhibiting intrinsic peroxidase-like activity and their applications. *Applied Microbiology and Biotechnology*, 99(2), p.p. 703-715.
7. Cui D., Li G., Zhao D., Gu X., Wang C., Zhao M. (2012) Microbial communitystructures in mixed bacterial consortia for azo dye treatment under aerobic and anaerobic conditions. *Journal of Hazardous Materials*, 221-222(6), p.p. 185-192.