

# Teaching Modification and Practice of Experiments in Fermentation Engineering

Xinchao Yang, Fang Wang, Yuehui Liu, Yuanxiu Wang, Naxin Sun, Chunjiang Ye\*

School of Biological Science and Technology, University of Jinan, Jinan 250022, China

\*Corresponding author: Chunjiang Ye (Email: chm\_yecj@ujn.edu.cn)

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**Abstract:** Microbiology and Fermentation Engineering is one of the very important specialized courses in biotechnology majors, which is in the core position, and it is a discipline with strong practicability and applicability. In addition, the course of Fermentation Engineering is characterized by large knowledge span, many difficult contents, fast scientific and technological updating, and strong practicability, etc. Therefore, the Experiment of Fermentation Engineering is the best way to improve the theoretical knowledge. Fermentation Engineering Experiment is a practical content necessary for the consolidation of theoretical knowledge. In the past, the teaching content is generally biased towards verification experiments, and lack of independent design experiments. Summarizing years of teaching experience, the author has summarized a set of teaching mode of “Fermentation Engineering Experiment” with students independent design as the main body and the textbook as the basis, including several aspects such as the design of teaching syllabus, the setting of teaching content, and the determination of assessment methods. In order to improve the quality of teaching, so as to cultivate high-quality application-oriented professionals.

**Keywords:** Fermentation Process, Pedagogical Change, Self-design, Self-development.

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## 1. Introduction

Fermentation Engineering is a course that is offered to all biopharmaceutical, biotechnology, and bioengineering majors[1]. The main contents of this course include: strain selection, medium preparation, seed expansion culture, batch fermentation kinetics, fermentation process control, aseptic technology, oxygen supply and demand, fermentation equipment, parameter detection and automatic control of biochemical processes, downstream engineering and product production examples. Teaching content includes elements of traditional and modern fermentation technology, and the characteristics of the biofermentation process are explained from an industrial point of view against the background of large-scale industrial production. The theoretical course Fermentation Engineering is a very important core course in biotechnology as well as in bioengineering, with strong applicability and practicability[2]. As a curriculum for biology majors, every theoretical course corresponds to an experimental course, and fermentation engineering is no exception, so the course “Fermentation Engineering Experiment” is an indispensable part of the theoretical course, through which students are trained to develop their experimental operation skills, and thus train their application techniques. As we all know, biological majors will eventually move towards industrialization, and this course of fermentation engineering is also a major key and a necessary path for the industrialization of biotechnology-based products[3]. At the same time, fermentation engineering experiments are rich in content, wide-ranging, operational as well as experimental, so how to make students master the most basic content of fermentation engineering within the limited class time, and improve their ability to analyze and solve problems in practice is a problem that college teachers need to seriously think about.

The current teaching mode of “Fermentation Engineering Experiment” in our school is the traditional teaching mode which is based on teachers and students, i.e., teachers prepare

the experiment before class and explain it in class, while students passively listen to the lecture and operate step by step with reference to the experiment instruction[4]. This traditional teaching method results in a lack of initiative on the part of the students, who only passively complete the experimental steps without thinking about the principles behind the experimental phenomena, and some of the students are not very involved or do not operate at all. Obviously, this teaching mode limits students' ability to discover and solve problems, and they only know one thing but not the other. In order to completely reverse the above passive situation, so that students can better master and apply the theoretical knowledge of fermentation engineering, the authors summarize years of teaching experience, and the teaching content, implementation methods, and teaching assessment and evaluation of repeated research and practice, forming a set of independent design of students as the main body of the textbook as the basis of the “Fermentation Engineering Experiment” Teaching Ideas and Experimental Methods[5].

## 2. Reform of Experimental Content and Improvement of Experimental Effect

As is well known, the Fermentation Laboratory is a specialised practical course that follows on from the Microbiology Laboratory, the Biochemistry Laboratory and the Enzyme Laboratory. While the basic skills of microbiology and biochemistry have been acquired in previous courses, the fermentation laboratory utilizes these basic skills to provide a holistic and comprehensive training of the fermentation process and to understand the entire fermentation process[6]. In the past, laboratory courses were designed to duplicate either the culture of strains in the experiment, the measurement of substances in the chemistry experiment, or even the measurement of enzymes in the enzyme experiment. As a result, there is a great deal of repetition, and once the experiment is repeated, students lose

the enjoyment of doing it, and it is not conducive to expanding their knowledge of the subject[7]. Therefore, we have considered modifying the experimental content of the fermentation procedure so that it does not duplicate the previous experiments, but also has the characteristics of the fermentation procedure.

Therefore, taking into account the characteristics of the experimental course on fermentation processes, the teachers concerned, after much consultation and practice, devised a project in which students' autonomy in designing specific experiments was based on a given range of fermentation experimental projects. The results were as follows: (1) fermentation of yoghurt products; (2) exploration of fermentation techniques for glutinous rice wine; (3) fermentation experiments with nabe; and (4) fermentation techniques for beer[8]. The average number of hours for each experiment is 6 h, and the time can be coordinated by the students themselves according to their specific circumstances. By conducting the four fermentation experiments mentioned above, students will be able to gain a thorough understanding of the entire fermentation process, including the pre-treatment of fermentation materials, the measurement of fermentation parameters, and the optimization of fermentation conditions[9]. Through optimization and integration, the contents of fermentation process experiments are more reasonable and rich, highlighting the continuity and wholeness. The traditional experiments are mainly validation experiments. By changing the validation nature of traditional experiments into comprehensive experiments with a stronger design aspect, it is expected that students' innovation, creativity and the ability to use theoretical knowledge in a comprehensive manner will be fully mobilized.

### 3. Improving Teaching Methods

The traditional teaching method for Experiments in Fermentation is for the instructor to teach the purpose of the experiment, experimental principles, experimental materials, experimental methods and procedures in accordance with a laboratory guidebook or handout, and then to instruct the students to perform the experiment on-site[10]. The main subject of the experiment is the teacher, and the students are passive recipients, which is not effective in developing the ability to combine theory and practice with creativity and innovation. In order to motivate the students and enhance the development of creativity, the teachers in the teaching and research team have made a concerted effort to improve the quality of the teaching and research. After a long period of observation, and taking into account the characteristics of the Fermentation Process Experiment, a teaching model was developed in which the students' own design was the main focus, supplemented by the teacher's guidance. In addition, the total number of hours in the experiments is 24, and students coordinate their own time and plan the contents of the experiments as a whole according to their needs[11].

Following the same grouping pattern as before, each group of two students was divided into one, with a leader elected for each group. The teacher gave the requirements and scope of the experiment, and the students were given the opportunity to design their own experimental project[12]. Once the experimental project has been chosen, the students will look for relevant documents and references to develop a specific experimental plan, which will then be discussed by the two students in the group. Once the specific plan has been formulated, the experimental plan is revised by the laboratory

supervisor, who is required to have a relatively deeper understanding of the experimental principles, objectives and procedures of the experiment[13]. Once the experimental program has been finalized, students should identify the instruments and consumables they need, obtain them from the relevant teacher, and return them in a timely manner at the end of the experiment. In addition, students should familiarize themselves in advance with the use of instruments and equipment. Once the experiment has begun, it is up to the student to carry out the experiment in accordance with the design, and to keep a detailed record of the experiment, so as to identify any problems that arise after the experiment has been completed, and so as to make the experiment more complete.

### 4. Exploring Participatory Teaching Methods

In order to further develop students' thinking, the teachers of the teaching and research group decided to adopt a diversified approach to teaching and learning, which included the following: (1) experimental projects can be carried out on the basis of topics that have been the subject of a University Creative Year project undertaken by some of the students. (2) The experimental project could be based on a project undertaken by some students as part of their University Innovation Project. The students could learn about the content of the experiments and design the experimental methodology, and in addition to the teacher's guidance, the students could select students who have taken part in their University Innovation Project as the leader of the group, so that the leader could guide them through the process of the experiments. (3) Expanding on the scientific research projects of the teacher by consulting the relevant materials and designing the experimental program, with the relevant experimental supervisor performing the checks and balances, in order to develop the ability to design the experiments and to learn on one's own. (4) Students should be able to design their own experimental projects according to their own interests, provided that the scope of the experimental project is given and that the main focus is on solving practical problems.

In the case of a beer fermentation experiment, for example, if three bottles are used, a group of three students could be selected, and all students would need to participate in searching for information, then discussing and finalizing the experimental plan, and then working in groups[14]. For example, one student could be responsible for collecting supplies and checking that the equipment used in the experiment is working properly to ensure that the experiment is carried out smoothly. For example, one student can be in charge of collecting supplies and checking that the instruments used in the experiment work properly to ensure that the experiment is carried out smoothly. Another student can prepare for the experiment by searching for a suitable experimental plan and being aware of any problems that may be encountered during the experiment. If there is a problem that cannot be solved, the student can first consult his or her classmates, and if no solution can be found, the student can seek help from the teacher. Of course, it is important that the teacher prepares the experiment in advance, informs the students of any problems that may arise, and answers any questions that they may have during the experiment. Through repeated communication, students are empowered to solve and analyze problems, and learn how to access

documents[15]. In conclusion, the teaching method, in contrast to traditional teaching methods, stimulates students' enthusiasm for experimentation and thoroughly integrates theory and practice, resulting in an outstanding teaching effect that is worthy of extension to other experimental courses.

There are also some experiments, such as the operation of large laboratory equipment. For example, if there is only one 600 L fermenter, then this can be done collaboratively by the whole class, and every student needs to be involved, so that a small number of students are not doing it and a large number of students are not watching it. This can be done by dividing the class into groups of four and making sure that each student has reviewed the information and understands the principles of the experiment before they are put into groups. For example, one group should be responsible for planning the experiment, one group should be responsible for performing the experiment, one group should be responsible for finalizing the experiment and ensuring the safety and security of the experiment, and the last group can be responsible for the observation of the experiment at a later stage. Each student should keep a detailed record of the experiment and write a report. Ensure that the experiment is complete.

## 5. Changes in the Assessment Methods of Experiments in Fermentation Processes

The previous assessment system for the fermentation laboratory course consisted of regular grades, laboratory reports and a quiz at the end of the course, which made it difficult to bridge the gap between the students and did not truly reflect their mastery of the experiments, thus defeating the purpose of the laboratory course[16]. Therefore, the teachers of the teaching and research group summarized their previous experience and developed a new assessment system based on the new experimental programme. The evaluation system consists of the following elements: (1) 20% for regular grades, including attendance and management of experimental consumables; (2) 20% for experimental design, including selection of experimental topics (10%) and design of experimental program (10%); (3) 30% for experimental operation, including the power of practical operation during the implementation of experimental projects (15%) and the power of problem solving (15%) when encountering problems in the course of experiments; (4) the power of practical operation and the power of problem solving (15%). (5) Experimental operation (30%): this includes the power of practical operation during the implementation of the experimental project (15%), as well as the power to solve problems encountered in the course of the experiment (15%); (6) Experimental debriefing and experimental report (30%): the debriefing can be done by one person in the group, or in a PPT presentation. Experimental reports will be submitted in paper form and grades will be given by the teachers and researchers in the teaching and research department. The group presentations allow for a thorough examination of the students' knowledge of the fermentation process, while at the same time providing an opportunity for them to express themselves. In practice, this method of experimentation, which is based on the students' own design, provides a comprehensive test of their ability to combine theory and practice, and is important for the development of their ability to identify and solve problems.

## 6. Conclusion

The teaching method of "Experiments in Fermentation Processes" has been changed to cultivate students' ability to combine theoretical knowledge with practical strength. At the same time, the teaching content, teaching method and evaluation system were improved, and better teaching results were achieved. This is reflected in the following two ways: (1) Self-design has enhanced students' ability to consult documents, strengthened communication between students, enabled them to use their knowledge in a holistic and systematic way, and, most importantly, enhanced their ability to solve practical problems and helped to develop a sense of creativity in their minds. (2) While traditional teaching methods encounter fewer problems, self-designed experiments encounter many problems, forcing teachers and students to face them together, and to seek advice from the literature and engage in in-depth discussions to enhance their problem-solving skills. In conclusion, self-designed experiments are more effective than passive, duck-feeding experiments, as they allow students to truly appreciate that theory is guided by practice, and thus make their learning of theory more relevant.

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