Journal of Education and Educational Research
ISSN: 2957-9465 | Vol. 3, No. 1, 2023

Innovative Teaching Design and Exploration of Water Pollution Control Engineering Course based on the BOPPPS Model

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Abstract: The BOPPPS model is used to optimize the design of the teaching process in the classroom teaching of Water Pollution Control Engineering, in view of the problems of outdated knowledge system, low interaction between teachers and students, and disconnection between theory and practice. Based on connotation elaboration of the BOPPPS model, the application of the six teaching modules of "bridge-in, objective, pre-assessment, participatory-learning, post-assessment and summary" in the innovative teaching design of the Water Pollution Control Engineering course is explored, with a view to providing teachers with a more flexible and effective teaching method and students with a more interesting and efficient learning experience, as well as to providing useful reference for the innovative design of other related courses.

Keywords: BOPPPS Model; Connotation; Teaching Design; Water Pollution Control Engineering; Exploration.

1. Introduction

Water Pollution Control Engineering as the most core compulsory course for environmental science and engineering majors, aims to enable students to comprehensively master the basic theory, technology, methods and practice of water pollution control, cultivate students' ability to analyze and solve water environmental problems, improve students' practical hands-on ability to solve water environmental problems and innovation consciousness, and provide necessary knowledge and skill support for future environmental protection work [1]. However, in the actual teaching process of Water Pollution Control Engineering, there are problems such as outdated knowledge system, little interaction between teachers and students in class, and disconnection between theory and practice, which failed to stimulate students' learning interest and enthusiasm, resulting in poor learning effect of students on the course, which in turn affects the teaching effect of the course.

The BOPPPS model is a new classroom instructional design model created by the Canadian Teacher Skills Training Centre, which integrates six instructional modules, Bridge-in (B), Objective (O), Pre-assessment (P), Participatory-learning (P), Post-assessment (P) and Summary (S), throughout the teaching process. It is mainly used to help teachers design structured, targeted and effective classroom activities to improve students' learning [2]. Currently, the BOPPPS model has been widely adopted in many teaching and learning settings and domains, and there is a growing body of research showing that using the model to design and implement lessons can effectively improve student learning outcomes and satisfaction [3].

This paper aims to combine the teaching status of Water Pollution Control Engineering, apply the BOPPPS model to the teaching design of this course, comprehensively consider the course content, teaching methods, teaching evaluation and practice links, and build a student-centered teaching method that promotes learning through the interaction between teachers, students and teaching resources. Let the students be more active in the study of Water Pollution Control Engineering, so as to achieve better teaching effect.

2. Teaching Status of Water Pollution Control Engineering Course

The course Water Pollution Control Engineering is a professional course involving the field of environmental protection, and its beginning can be traced back to the period when China's environmental protection regulations were gradually improved. At present, this course is offered in many universities and research institutions in China, and it covers the sources, effects, monitoring, evaluation and control techniques of water pollution. During the decades of teaching development, the course has played an important role in the training of environmental protection professionals, but there are also many imperfections.

2.1. Outdated Knowledge System

Water pollution control engineering is a constantly developing field, and new technologies and methods involved are constantly emerging. However, the teaching of this course has the disadvantage of an outdated knowledge system, which is mainly reflected in the following aspects: (1) Lack of cutting-edge research results. With the continuous progress and development of science and technology, the research in the field of water pollution control engineering is also advancing, but some of the teaching materials and teaching content are still stuck in the past knowledge system, lack of cutting-edge research results and new technological advances; (2) Lack of new practical cases. Water pollution control engineering is a very practical course, but textbooks and teaching contents often lack new practical cases, which cannot reflect the current engineering practice and technical progress, affecting the cultivation of students' practical ability and application ability; (3) The framework of knowledge system is too solidified. Because the framework of the curriculum system is too solid, the teaching content is too rigid and the teaching method is too single, which is difficult to adapt to the rapid changes and development of modern society and cannot meet the diversified learning needs and

future development needs of students; (4) Bias to theoretical knowledge and ignore practical skills. Water pollution control engineering course teaching, often favor the mastery of theoretical knowledge, while ignoring the cultivation of practical skills, such a teaching mode is likely to lead to students only stay in the theoretical level, cannot really master the skills of practical operation; (5) Interdisciplinary integration is low. Water pollution control engineering involves a number of disciplines, such as ecology, chemistry, materials science, etc., but the traditional curriculum teaching lacks interdisciplinary cross-fertilization content, which is not conducive to the cultivation of students' comprehensive quality and innovation ability.

2.2. Low Teacher-student Classroom Interaction

In the teaching of Water Pollution Control Engineering course, active participation of students in classroom teaching is particularly important, however, in actual teaching there is little or even no interaction between teachers and students in the classroom. It is mainly reflected in the following aspects: (1) Teachers dominate the classroom. In the traditional teaching classroom of Water Pollution Control Engineering, the teacher is often the dominant person, who simply instills knowledge, and the students just passively listen to the lecture, lacking interactive communication with the teacher; (2) Lack of student questioning. Lack of student initiative and participation, little questioning or communication with the teacher in class, short time for students to speak and think, which fails to give full play to their learning potential; (3) Lack of interaction in classroom teaching. Single form of teaching, lack of interest and interaction, which makes it difficult to attract students' attention and stimulate their enthusiasm and motivation for learning; (4) Lack of personalized teaching. Lack of understanding of students in teaching and failure of teachers to develop different teaching plans and methods to meet the learning needs and interests of different students; (5) Lack of cooperative learning opportunities. Classroom instruction lacks cooperative learning opportunities in small groups to promote the development of cooperation, communication, and collaboration skills among students. In addition, teachers rarely understand students' learning through course feedback on a regular basis, failing to identify problems and make adjustments in a timely manner, and the effectiveness of course teaching is often only reflected in post-class assignments or final exams. All these problems lead to a lack of vitality and interactivity in classroom teaching, which limits students' learning effectiveness and interest and reduces the effectiveness of classroom teaching.

2.3. Disconnect Between Theory and Practice

Water Pollution Control Engineering is a course aiming at train students to master water pollution control technology, understand water pollution control laws and regulations and practice the use of related engineering technology. However, in the teaching process of this course, there is a disconnect between theory and practice, mainly in the following aspects: (1) Teaching content lack of practical cases. Water Pollution Control Engineering course mainly involves theoretical knowledge, such as the sources of water pollution, types, treatment technology, etc., but this theoretical knowledge often lacks the support of practical cases, it is difficult for students to truly understand and master the practical application of this knowledge; (2) Lack of relevant theoretical support for practical links. Although practical links are an essential part of the teaching of Water Pollution Control Engineering course, they often lack relevant theoretical support, which makes it difficult for students to combine theoretical knowledge with practical operation due to the lack of guidance and support in practice; (3) Less practical opportunities. Water Pollution Control Engineering course needs to rely on laboratory or sewage plant for practical operations, but some schools have outdated and backward laboratory equipment, which cannot meet the requirements of modern water pollution control engineering, and practical operations in sewage plants are mostly based on walking around, which makes it difficult for students to learn the latest technology and methods in practice.

3. The Connotation of BOPPPS Teaching Model

As a problem-solving and practice-based teaching method, the basic components of the BOPPPS teaching model include six modules: bridge-in, objective, pre-assessment, participatory-learning, post-assessment and summary, and the connotations of each teaching module are as follows:

a. Bridge-in: Before the course begins, the teacher stimulates students' interest in learning and introduces them to the topic by creating engaging scenes and situations. The introduction session should be lively and close to reality, through questions, stories, pictures, videos, etc., to attract students' attention and mobilize their thinking.

b. Objective: In this session, teachers need to clarify the objectives of the course before the course begins, tell students what learning outcomes to be achieved in this session, give students a clear expectation and goal for the course, provide guidance for the selection of teaching content and teaching methods, and enhance motivation and learning effectiveness.

c. Pre-assessment: Pre-assessment of students through questions, tests, etc., to determine students' existing knowledge and ability levels, to understand students' learning needs, and to help teachers make targeted adjustments to teaching content and teaching methods so that classroom teaching content and methods can better meet students' needs.

d. Participatory-learning: Encourage students to actively participate in classroom teaching and establish a good teacher-student interaction. Teachers should involve students in the classroom and use diverse teaching methods, such as group discussions, experiments, case studies, etc., to encourage students to cooperate, communicate and discuss with each other to improve classroom effectiveness and learning outcomes.

e. Post-assessment: According to the learning objectives and teaching contents, design appropriate assessment tools, such as tests, assignments, essays, projects, etc., assign the assessment tools to students to complete a specified period of time, collect the data obtained from students' completion of the assessment tools, provide feedback to students on their performance based on the assessment results, and offer suggestions for improvement.

f. Summary: At the end of classroom teaching, teachers should summarize the session so that students can have an overall understanding of what they have learned, consolidate what they have learned, and improve the learning effect. At the same time, it can also help teachers better understand students' learning and learning reflection, so as to guide the

subsequent teaching work.

The six modules of the BOPPPS teaching model are not isolated from each other, but are organically integrated together (as shown in Figure 1). First, Bridge-in module and Objective module are interrelated. Teachers should include some relevant information in the introduction session to make students interested in the content to be learned, and then clarify the learning objectives in the Objective session to give students a clear understanding of the content to be learned. Secondly, the Objective module and the Pre-assessment module are interrelated. After clarifying the learning objectives, the teacher can start pre-assessment for students in a more targeted way. Again, the Pre-assessment module is interrelated with the Participatory-learning module. In the Pre-assessment session, the teacher understands students' knowledge and learning needs, and then adopts appropriate teaching methods and strategies to meet students' needs in the Participatory-learning session, so that students can participate more actively in the class. Then, the Participatory-learning module is interrelated with the post-assessment module. In the Participatory session, students enhance their motivation and interest in learning by participating in classroom interaction, communication, and discussion, and then better demonstrate their learning outcomes in the post-assessment session. Finally, the Post-assessment module is interrelated with the Summary module. In the Post-assessment session, students show their learning outcomes and understanding levels, and teachers can deepen students' understanding and mastery of knowledge in the Summary session in response to their performance in order to consolidate students' learning results. At the same time, the implementation of each downstream session can give feedback on whether the upstream session is set up reasonably, and then guide the optimization and adjustment in the subsequent teaching design to form a fruitful and innovative teaching system.

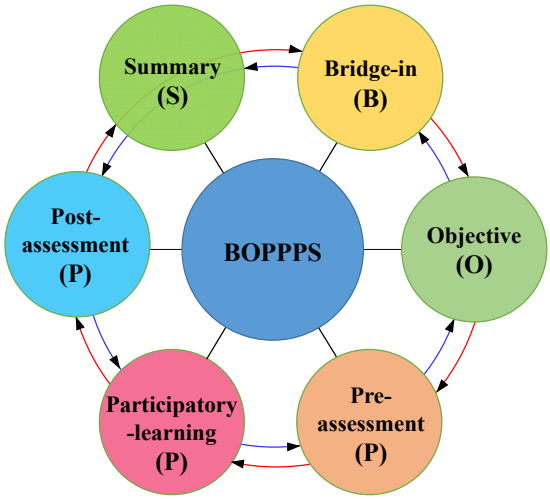


Figure 1. Organic integration of BOPPPS teaching model

Therefore, the six modules of the BOPPPS teaching model are organically integrated, and teachers should focus on the correlation between each link in the actual teaching process to make the teaching process into a coherent, complete and organic whole, which helps improving students' learning effect and interest in learning.

4. Application of BOPPPS Model

The course Water Pollution Control Engineering contains a wide range of contents and involves many knowledge points. In this paper, we will take the section of "Adsorption", which must be taught in the course, as an example, and adopt the BOPPPS model to design the teaching process.

4.1. Bridge-in

A short video is used to introduce several new adsorbent materials that can quickly achieve sewage purification, including modified activated carbon, graphene, nano-silver particles, magnetic adsorbent materials, biomass adsorbents, etc. Students can visually and efficiently see the water purification effect of adsorbents through the short video. Then, data and graphs are used to show students the application space and market prospect of adsorbents in the field of water treatment to stimulate students' interest in learning this section.

4.2. Objective

The content to be taught in this section includes several aspects of adsorption principles, adsorbents, adsorption processes and equipment, regeneration methods of adsorbents, and the application of adsorption in wastewater treatment. Specific learning objectives include: (1) To understand the concept and basic principles of adsorption (including adsorption equilibrium and adsorption isotherm, adsorption rate, adsorption influencing factors, etc.); (2) To recognize the commonly used types of adsorbents; (3) To master the classical adsorption processes and types of equipment; (4) To master the common physical, chemical and biological methods that can be used to regenerate adsorbents; (5) To understand the application of adsorption methods in wastewater treatment and cutting-edge technologies. According to these learning objectives, students can clearly focus on their learning during the course of the lecture and avoid the phenomenon of "grabbing one eyebrow by the other".

4.3. Pre-assessment

This section uses a teacher-question-and-student-response approach to find out how many students know about the topic of "adsorption". Questions may include: (1) What do you think is the "adsorption method"? (2) Have you ever been exposed to "adsorption" in a previous physics, chemistry, or other course? (3) What are some common scenarios where adsorption is used in daily life? Students' answers will provide an initial understanding of their learning or cognitive base, which can be used to target subsequent lessons.

4.4. Participatory-learning

"Participation" is the most critical part of the BOPPPS model, and the effect of participation will directly affect students' learning outcomes [6]. In order to stimulate students' participation, a "classroom experiment" was introduced under the premise of safety and time control (as shown in Figure 2). The specific implementation process is as follows: before the start of the "adsorption method", students are informed to collect one to three kinds of materials that can be used as adsorbents in daily life in their dormitories or study groups. During the class, after the teacher introduces the section on "adsorbents", each group is asked to send a representative to present the basic information and characteristics of the adsorbent materials collected by their group. In order to verify the adsorption effect, the teacher prepared a batch of conical flasks containing 100 mL of methylene blue solution in advance and added the adsorbent materials selected by each

group and shaken them for a period of time, so that students could compare the effect of different adsorbent materials on color removal and summarize the factors affecting the adsorption effect in terms of adsorbent, adsorbent and operating conditions. On this basis, the teacher dissects the physical or chemical mechanism of adsorption with the help of kinetic and isothermal models to give students a clearer knowledge of the mechanism of occurrence of adsorption.

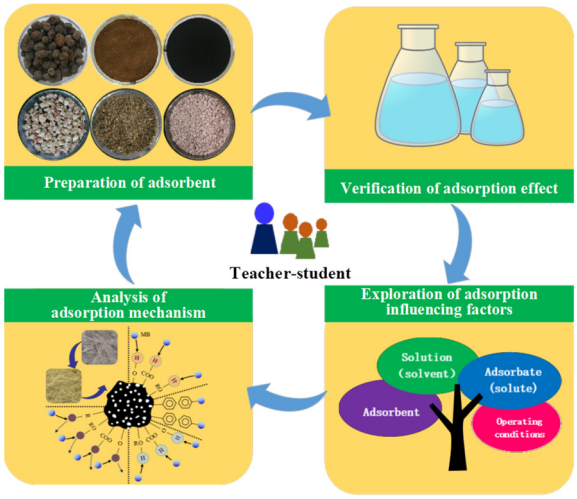


Figure 2. Basic process of "classroom mini-experiment"

After a small classroom experiment and discussion, students were asked to analyze the reasons for the differences in adsorption effectiveness of the selected materials and to propose solutions for improving the adsorption effectiveness. The teacher will provide a targeted review of each group's proposal, during which the more cutting-edge adsorbent materials, such as graphene, biochar, and nanomaterials, will be introduced to the group, and the effectiveness of the improved adsorbent materials as filter media in biological filter and as catalysts in advanced oxidation systems will be demonstrated to expand students' knowledge of the application areas of adsorbent materials, not only limited to the propriety functions of adsorbents as taught in the textbook .

4.5. Post-assessment

At the end of the study, the learning effect is tested by using post-lesson exercises. This section mainly uses terminology explanation, short answer, calculation and experimental scheme design for post-learning assessment. The terminology explanation mainly assesses the understanding of the important concepts appearing in this section, including adsorption, chemisorption, adsorption equilibrium, regeneration and other concepts; short-answer questions mainly include a brief description of the influencing factors of adsorption, the main processes of adsorption operation, and whether adsorption is applicable to urban wastewater treatment plants; calculation questions mainly test the degree of students' mastery of the formulae for calculating pollutant removal rate and adsorption amount; finally, students were asked to design an experimental scheme based on what they had learned, and the topic chosen was how to prepare common waste fruit peels in life into adsorbent materials. Through the above-mentioned tests, we can understand the real learning situation of students and provide feedback for the improvement and optimization of the subsequent teaching process.

4.6. Summary

In the summary session, the instructor should first confirm that the learning objectives have been achieved; second, to reinforce key elements, in which students review the key points of the learning process that will help deepen their memory and improve their application skills; again, to summarize the gains of this course, in which students can share useful information, skills or knowledge learned in this course and be encouraged to think about how they can apply what they have learned to their real life or work; finally, a plan for the next step of learning should be presented. In short, in the summary session, teachers need to summarize and outline the course content, and review the course content with learners, reinforce the key points, summarize the gains and determine the next learning plan, so that learners can better absorb and apply what they have learned.

5. Conclusion

The course Water Pollution Control Engineering plays an important role in the training of environmental science and engineering majors. In order to improve its teaching effect, an innovative teaching design is tried based on the BOPPPS model. Through the introduction and analysis of the BOPPPS model and the teaching practice of the course, we propose an innovative teaching plan that integrates bridge-in, objective, pre-assessment, participation-learning, post-assessment and summary. Through the use of BOPPPS model, it provides a new way of thinking and method for the teaching of Water Pollution Control Engineering course, which can help teachers to design the course better and improve the teaching effect. In addition, the proposed innovative teaching design focuses on students' participation and practice, which can stimulate students' learning interest, improve students' learning motivation and learning effect, and positively promote students' comprehensive quality improvement.

Acknowledgments

This work was financially supported by Sichuan Province 2021-2023 Higher Education Talent Training Quality and Teaching Reform Project (JG2021-1409): Construction and practical exploration of the system for cultivating students' innovation ability in environmental courses under the concept of Internet Plus education.

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