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The Practice and Exploration of BOPPPS Teaching Model Guided by Higher Thinking Ability in College Mathematics

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Abstract: *This paper takes the course of Probability and Statistics as an example, taking the training of students' higher-order thinking ability as the guidance, combining with the analysis of students' academic situation, the application of BOPPPS teaching model in the actual teaching has achieved good results.*

Keywords: *Higher-Order Thinking, BOPPPS Teaching Model, College Mathematics*

1. Introduction

The college mathematics course is the foundation course of all university engineering major. In the teaching and learning of college mathematics, teachers' lectures and discussions occupy the leading position in the classroom. The deepening of self-driven learning ability and the refinement of after-school use ability are indispensable conditions to achieve educational goals. The BOPPPS teaching model is designed to help students better understand the content of the course. Based on the application of this model, students can think actively, and explore and construct new knowledge structures by combining what they have learnt with what they already know. Thus students' higher-order thinking skill could be developed.

2. Higher-Order Thinking

The concept of "higher-order thinking" was first proposed by Plato. Plato pointed out that higher-order thinking is very different from the traditional way of thinking, the latter only involves memory, review and processing of basic knowledge, while the former involves in-depth exploration, analysis, evaluation and discovery of deeper concepts, so as to obtain richer knowledge [1]. Dewey believes that reflective thinking is a higher-order thinking mode, which can be summarized as "five steps of thinking": suggestive thinking, rational thinking, hypothetical thinking, deductive reasoning thinking and reasoning by action. In particular, he emphasized that exploring and solving problems is a key link in developing higher-order thinking skills, and a necessary step in achieving thinking improvement [2]. In addition, Smith outlined the main characteristics of higher-order thinking, which are high abstraction, logical rationalization and systematization of information integration [3]. The understanding of higher-order thinking in the field of education comes from Bloom's cognitive target taxonomy, which divides cognitive targets into six categories of "know, understand, apply, analyze, evaluate, and create", and regards "analyze, evaluate, and create" as higher-order thinking [4] . Professor Zhong Zhixian pointed out that higher-order thinking ability is a psychological activity or cognitive activity that occurs at a high cognitive level, which can be divided into four sub-abilities: critical thinking ability, problem solving ability, decision-making thinking ability and innovative thinking ability [5]. Higher-order thinking is also the fundamental pursuit of the goal of science education, and the concept of contemporary science education reform has upgraded from the teaching of low-order cognitive skills represented by traditional knowledge concepts to the cultivation of higher-order thinking capabilities such as scientific inquiry, reasoning and collaborative communication [6] .

3. Introduction of BOPPPS Teaching Model

BOPPPS teaching model was first proposed in the 1970s, which is a new student-centered teaching

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model and a new teaching model widely used by teachers in recent years. BOPPPS teaching model divides the teaching process into six modules.

1) Bridge in: introducing the learning content. In the pre-class introduction stage, teachers can propose some questions or topics related to the course content, relying on the situation to carry out teaching. The purpose is to arouse students' curiosity and interest in learning and to pave the way for the following teaching links.

2) Objective: clear learning objectives. For the cultivation of higher-order thinking, learning objectives should focus on the cultivation of students' core literacy, to cover knowledge, ability, literacy and other aspects. In addition to the core knowledge, teachers should also focus on cultivating students' autonomous learning ability, critical thinking ability and problem-solving ability. Thus the students' self-development ability can be trained.

3) Pretest: to test the effect of students' pre-study. The form of pre-test can be diverse, and teachers can determine the form of pre-test according to the learning content and the characteristics of students, such as tests online. The types of tests can be single-choice, multi-choice, fill in the blank, judgment and other objective questions. Through pre-test, teachers can initially understand the students' mastery of the pre-study content, and focus on the knowledge points with more wrong questions. Furthermore, teachers should make corresponding adjustments to the subsequent teaching, and pay more attention to the students with poor pre-test results.

4) Participatory learning: This module is the main part of classroom teaching. Teachers play a leading role in this link and are the guides and promoters of students' learning. Teachers should fully mobilize the enthusiasm and participation of students on the basis of respecting their individual differences. For example, teachers can guide students to carry out inquiry learning activities such as project-based, case-based, group discussion, etc., and encourage students to think deeply and use the knowledge learned to analyze problems and propose solutions, so as to cultivate students' logical thinking ability and problem-solving ability.

5) Post assessment: The teacher tests whether the teaching goal is achieved effectively. Teachers can carry out post-tests by homework, tests, random selection of people to answer questions and so on. Therefore teachers can make a comprehensive evaluation of the students' knowledge mastery and problem-solving ability, and get timely teaching feedback. In order to consolidate and strengthen weak knowledge, teachers can provide personalized guidance and learning programs for different students.

6) Summary: Students summarize what they have learned after class. They can summarize and induce the learning situation by means of mind map and self-evaluation table. Students can share their learning experience. On the other hand, teachers should combine the student's learning effect, summarize and reflect on the whole teaching process, so as to guide the next course.

4. The Implementation of BOPPPS Teaching Model in College Mathematics Curriculum

Probability and statistics is an important basic mathematics course in colleges and universities. Through the study of the basic theory and knowledge of this course, students get basic training from three aspects which are theory, method and ability, and have a preliminary understanding and recognition of the unique thinking mode, wide application and rich practical background of probability and statistics. In the course design, the author introduces the BOPPPS teaching model into the probability and statistics course, in order to cultivate students' core ability and higher-order thinking ability as the goal, arouse students' enthusiasm and initiative to participate in the teaching process.

1) Before class. Based on Cloud Class platform, the teacher establishes the resource database in the platform, uploads the PPT document, the preview material or the case video, etc. The teacher uploads the file about the knowledge goal of the course, including the goal of the basic concepts and basic calculations in the course learning, and releases the task list of the pre-class preview. Students independently watch the PPT document, textbook or case video uploaded by the teacher before class to prepare for the preview, and complete the task list issued by the teacher to complete the task before class within the specified time. The task of the preview can be a group discussion or a summary formed by individuals, and as the content presented in the class, thus further clarifying the learning goals for the students. Students can ask the questions online to teacher they encountered in the preview. On the one hand, the teacher collates the data on the students' completion for the pre-class preview, on the other hand, answers the questions raised by students in the pre-class.

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2) In class. In the implementation stage of the classroom, there are mainly the following links. The first is pre-test and clear objectives of the course. According to the data on the pre-class situation, the teacher carries out pre-test and forms pre-evaluation. In this course, pretest is still carried out by means of Cloud Class platform, mainly in the form of selection and judgment. After the pre-test, according to the data of Cloud Class statistics, the teacher should focus on the knowledge points with high error rate. And the teacher further clarify the learning objectives of this course. For the main link of classroom teaching, teacher may use a variety of teaching methods to strengthen the focus and solve the difficulties. Students can be mobilized to participate in the classroom and become the main body of learning by means of classroom display, group discussion and peer-learning. On the other hand, students should be encouraged to think positively and dare to express their opinions. In particular, students with high participation and active thinking should be recognized timely from teacher. And scores should be added appropriately to stimulate the emotions of student participation. Finally, the key points of learning can be re-tested by means of classroom questions, classroom exercises and other ways. After completing the test, the teacher and the students jointly summarize and comment which can promote the distillation of the students' thinking.

3) After class. The teacher can assign the homework on the Cloud Class platform, including writing assignments and online test assignments. After the completion by the students, the teacher should review and approve the homework uploaded by the students. And they can also evaluate the homework between groups or conduct self-evaluation. In addition, teacher may issue expanded resources on the Cloud Class platform, such as online learning materials, extracurricular reading materials, etc., so that students can study independently after class. On the other hand, teacher should strengthen the process management. For example, with the help of the data analysis function of the Cloud Class platform, the teacher informs regularly the learning situation and gives feedback to students. And the power of the example can be strengthed.

Taking the knowledge point of conditional probability in probability and statistics as an example, table 1 shows the teaching design process.

Table 1: Case of teaching design process.

BOPPPPS	Learning content	Students	Teachers
B	 introduction of examples of interpol arresting suspects	positive thinking of students	inspiring students to think
O	determining the learning goal of conditional probability	preliminary understanding of the learning tasks for this lesson	clear objectives (including knowledge, ability, and emotional goals)
P	review the concept and calculation formula of classical probability	recalling learned knowledge and feeling the difference between old knowledge and new knowledge	guide students to recall existing knowledge, and inspire students to think about the difference and connection between old and new knowledge
P	the concept and calculation of conditional probability, to solve the practical problems introduced	Students can discuss freely, and complete the analysis and answer the questions, and deeply understand the meaning of conditional probability.	guide students to correctly understand the concept and calculation of conditional probability
P	other application cases	solving problems and forming knowledge structure	analyze and explain according to the students' mastery of knowledge
S	summarize the content of this lesson	summarize the new knowledge, deeply understand the essential meaning of conditional probability	expand, induct, summarize, reflect

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5. Teaching Reflection

BOPPPS teaching model is a student-centered teaching design framework, emphasizing student participation and feedback in the teaching process. Combining with the concept of deep learning, it can promote the overall development of students and the cultivation of core literacy. However, in the process of implementation, there are also shortcomings. Especially for large class classes, such as the number of 90~100 or so, there will be some students whose participation is not enough. For example, in group activities, individual group members do not actively participate and enjoy the learning results of other members. This makes the expected learning effect can not be well achieved. Therefore, BOPPPS teaching model puts forward higher requirements for teachers' professional quality. Teachers should have a full analysis of students' learning before the start of the class, and have a deep grasp of the characteristics of the curriculum, and have adequate preparation for the design of the curriculum and the implementation of teaching. At the same time, the teaching strategies and the corresponding teaching design should be optimized and adjusted according to the characteristics of curriculum and students.

In response to the above issues, the author has adopted the principle of "diversified teaching methods and advanced evaluation system" in actual teaching. In terms of teaching methods, the author has focused on three major modules: pre class guidance, in class mutual learning, and post class research. Before class, students complete the construction of preparatory knowledge through online learning, as well as reading and searching for relevant literature, to form preliminary cognition; In the classroom, the teacher matches classroom teaching based on the learning effectiveness of students' prepared knowledge. Students are guided to think about the differences in learning effectiveness and cognition before class, and students are organized to think critically and discuss; After classroom teaching, students are encouraged to independently ask questions and seek solutions based on their actual lives, complete project-based assignments, and apply the knowledge they have learned. In the evaluation system, both process evaluation and outcome evaluation are equally emphasized, forming a double helix between evaluation and content, and forming a multidimensional evaluation system based on different teaching stages, different aspects inside and outside the classroom, and different subjects of teachers and students. Clearly define goals in the process of pre class preparation, classroom learning, homework, group learning, and computer practice, and design evaluation methods based on the goals. For students with low classroom participation, corresponding measures should be provided through individual heart to heart talks and other means. At the beginning of the school year, it is important to clarify the importance of classroom participation activities. In group activities, while cultivating students' teamwork ability, it is also necessary to distinguish individual differences, consider students' personalized needs, and make appropriate adjustments during the teaching process.

6. Summary

The teaching design framework of BOPPPS has a common direction with cultivating students' higher-order thinking abilities. And the author's teaching attempt shows that it is applicable in the subject of probability and statistics, which achieved good results. It will make more mathematics classes truly integrate into the students' learning needs and reflect the learning value, so as to improve the students' learning ability, and truly help the students' comprehensive quality improvement and future development.

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