Application of BOPPPS teaching model in online and offline blended teaching of college Public Basic Mathematics

Xiang Zeng†
Guilin University of Technology, College of Science, Guilin, 541004, China

Abstract

As The Times advances, innovating teaching methods, optimizing teaching resources and building online and offline blended teaching environment have become the top priority. Therefore, this paper constructs a BOPPPS model based on active introduction, problem formation, pre-evaluation, participatory learning, evaluation feedback and summary, which aims to help students deeply understand and master the key knowledge of the course and helps teachers effectively improve the teaching effect of the course. The BOPPPS model integrates the education information technology and undergraduate teaching, establishes the closed-loop feedback framework of teaching and learning and gives full play to the main role of students in teaching, which at the same time, provides students with a learning atmosphere of independent inquiry, cooperative learning, knowledge exchange and critical reflection, and achieves good results in teaching practice. The results show that after applying BOPPPS teaching model in the college public basic mathematics course, the scores of students have been primarily more than 90 points, and at the same time, the proportion of students with scores of 80-90 points has been significantly increased, and the percentage of students failing has dropped dramatically. This indicates that the BOPPPS teaching method can significantly increase the proportion of students with high scores, perfect the learning effect, reduce the failure rate, and improve students’ learning enthusiasm and ability to master knowledge.

Keywords: BOPPPS teaching model; Teaching effect; The main role of students; Blended teaching; Teaching practice

AMS 2020 codes: 97U50
1 Introduction

The requirements for well-rounded human resources are increasing in the new era [1-3]. With the deep integration of modern information technology and education teaching, the online and offline hybrid teaching mode has been widely used in many disciplines, and hybrid teaching will become a quality education method [4-5]. The BOPPPS teaching model, created in 1976, is based on constructivist and communicative approaches, advocates a student-centered approach, and is a teaching model adopted by many institutions in recent years to train young teachers [6-9]. With the increasing prevalence of classroom reform, the BOPPPS teaching model, as an emerging teaching model, has received increasing attention from educational scholars in China and abroad as an effective tool that can assist teachers in dismantling and analyzing the teaching process, identifying teaching blind spots, and improving teaching effectiveness [10-12]. University mathematics courses are also continuously experimenting with online and offline hybrid teaching models based on Internet platforms to change the way students acquire knowledge, extend learning time, expand learning space, and thus achieve deep learning [13-14]. The implementation of online and offline hybrid teaching mode of university mathematics implies a change to the traditional teaching mode, and based on this new teaching mode, how to make a more scientific teaching design is still a topic faced by many university mathematics teachers [15-16]. Although the concept of blended learning is relatively broad, the definition of “a mixture of online and offline teaching” has gained more consensus. The rapid development of information technology, especially the continuous construction of various platforms and their online open courses at home and abroad, has given new connotations to online teaching and learning, and the goals, resources, models, strategies, and assessments of blended teaching and learning have evolved and innovated [17-20].

The literature uses the BOPPPS instructional model to achieve instructional goals, such as: bridging, objectives, pre-assessment, participatory learning, post-assessment, and summation, consisting of six elements. The teaching model is practical and operational, providing teachers with a complete framework of theoretical guidance covering all aspects and a structured and rationalized arrangement of classroom instruction. In the practice of the BOPPPS teaching model, the teaching process should be designed to achieve the teaching objectives, using rich participatory teaching methods and the interaction with students necessary to achieve the teaching objectives. In response to the characteristics of BOPPPS model, the reform of teaching process should strengthen the student-centered teaching concept, strengthen the construction of teacher training system, strengthen the education evaluation system, and promote the healthy development of higher education. The literature reflects that online and offline hybrid teaching is a current mainstream teaching model. Meanwhile, the online and offline hybrid first-class course is also one of the five types of first-class courses led by the Ministry of Education. For such courses, the relevant documents require their teaching design to be scientific and reasonable, overall planning around goal achievement, teaching content, organization and implementation and multiple evaluation needs, reasonable design of teaching strategies, teaching methods, teaching processes, teaching evaluation, etc.; teaching organization and implementation highlighting student-centeredness, innovative teaching and learning modes according to students’ cognitive rules and acceptance characteristics, teaching according to their aptitude, promoting communication and interaction between teachers and students, resource sharing and knowledge generation, timely teaching feedback and significant teaching effects. However, due to the inherent inadequacy of its teaching design, the teaching process has led to the phenomenon of “two skins” of online and offline teaching, or the form is greater than the content, which does not play an obvious role in promoting the quality of education and teaching of the course, and some even appear to be counterproductive. The literature actively explores the teaching methods of English in the era of “Internet+”, and by exploring the teaching effects of online and offline hybrid teaching English courses, they found that the online and offline hybrid teaching
methods are popular among students. Self-directed learning allows students to acquire knowledge more flexibly and efficiently and makes teacher instruction more relevant and interactive in the offline classroom, thus improving teaching effectiveness. In the new era, the rapid development and advancement of Internet technology, information technology, and multimedia provide good opportunities for China to continue to promote education and teaching reform [25-26]. However, there are still shortcomings in the online and offline hybrid intelligent teaching assistant model, and the overall design strategy for elaborating the online and offline hybrid teaching model still needs to be strengthened.

To effectively apply the advanced concepts and excellent results of mathematics teaching based on the BOPPPS model to classroom teaching, and effectively promote the education and teaching reform and improve the quality of teaching. In this paper, we take “Solution of first-order non-simultaneous linear differential equations” in Advanced Mathematics as an example and discuss the hybrid teaching model based on BOPPPS model and innovate the design of hybrid teaching activities on and offline, inside and outside the classroom, with the author’s practice of BOPPPS teaching.

In order to achieve effective teaching and improve teaching effect, our micro-course design concept is: to integrate mathematical ideas and methods in classroom teaching; to emphasize student-centered and problem-oriented inquiry-based teaching; to focus on the cognitive process of knowledge, to emphasize the natural transition from known to unknown and to emphasize the interactive teaching of clever connection, and to use multimedia to assist teaching, to break the key points and make difficult points.

The micro-teaching design based on the BOPPPS model further introduces the concept of inscribed double integrals through comparative learning with definite integrals, and then leads students to analyze the definition and derive the geometric meaning of double integrals. A problem-driven, contrastive teaching approach is used to promote active thinking and active learning.

2 Application of BOPPPS teaching model in teaching

2.1 Structure of the teaching model

In both online and offline classrooms, the model divides the teaching content into small independent units (no more than 15 minutes) according to the duration of students’ concentration (about 15 minutes), and each teaching unit is focused on achieving the teaching objectives. The six elements that ensure classroom success are Bridge-in, Objective/Outcome, Participatory Learning, Pre-assessment, Post-assessment, and Summary.
2.2 **BOPPPS teaching practice**

According to the BOPPPS model, a 45-minute section can be divided into three complete units, with each individual unit forming a complete “sequence” from the introduction to the summary. The model provides an operable and concrete practical procedure for effective classroom teaching, which makes the arrangement of classroom teaching more organized and rational and is also an effective way to conduct micro-course teaching.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td>Set up questions for heuristic teaching to stimulate interest in learning. Intriguing Teaching Themes</td>
</tr>
<tr>
<td>Learning target</td>
<td>Student-center. The goal is to internalize students’ knowledge, stimulate students’ thinking, and form a self-evaluation system</td>
</tr>
<tr>
<td>Pre-assessment</td>
<td>Use the test method to form feedback on students’ knowledge and understanding, and adjust some teaching goals in time</td>
</tr>
<tr>
<td>Participatory learning</td>
<td>Group discussions by asking questions at different levels according to the learning objectives. Submit a discussion report. Encourage students to think and collaborate in interaction. ability to express. Forming knowledge and understanding solidification</td>
</tr>
<tr>
<td>Post test</td>
<td>Targeted assessment. Strengthen important and difficult knowledge, and make progress and adjust teaching goals</td>
</tr>
<tr>
<td>Summarize</td>
<td>Student feedback on luck. The teacher summarizes the math content and elicit the content of the next lesson</td>
</tr>
</tbody>
</table>

Participatory and interactive learning in the BOPPPS model is the main part of knowledge transfer, and all six teaching stages serve to achieve the teaching objectives. In terms of the nature and laws of teaching and learning, the BOPPPS model has good operability for different disciplines.
3 Examples of teaching methods based on the BOPPPS model

3.1 Pre-test ----- Problem introduction

Using the two points of knowledge that students have already mastered as a grasp, the problem is first elicited from the first point of knowledge: the general form of a first-order non-simultaneous linear differential equation.

\[
\frac{dy}{dx} + P(x)y = Q(x)
\]  

(1)

The solution of the known chi-square equation leads to the core problem: the solution of the non-chi-square equation (1).

3.2 Teaching objectives ----- PPT show

1) Knowledge and ability objectives to understand the origin of the “constant variation method”, master the steps of the constant variation method for solving the non-flush formula (1); understand the structure of the general solution of formula (1); more proficient in using the constant variation method and the general solution formula to solve non-flush linear differential equations.

2) Ideological and methodological objectives Cultivate students’ ideas of categorical discussion and chemistry and transformation by solving first-order linear differential equations categorically; guide students’ exploratory learning by exploring the possible forms of general solutions of non-simultaneous equations.

3.3 Front side ----- Questions and board

Q: Equation (1) corresponds to the general solution of the chi-square differential equation Plate.

\[
y = C(x) \cdot e^{- \int P(x)dx}
\]  

(2)

Introduce the content of this lesson by analogy.

3.4 Participatory and interactive teaching ----- Features design

1) In order to reproduce the cognitive process of knowledge and make a natural transition from the known to the unknown and an effective connection, this paragraph starts from the method of separated variables and the general solution of the equation (1) corresponding to the chi-square equation, which is familiar to students, and adopts a problem-oriented interactive and participatory teaching mode of inquiry. First, we try to use the known “separation of variables method” to explore the solution of equation (1). From:

\[
\frac{dy}{dx} + P(x)y = Q(x)
\]  

(3)

Got:
Clearly, the equation is not an equation in separable variables. What to do (students participate in the discussion)? Considering that the solution of the original equation is a function of, just make the equation at the right end of the above equation hold, then we get:

\[ \frac{dy}{y} = \left[ \frac{Q(x)}{y(x)} - p(x) \right] dx \]  
\[ (4) \]

The familiar equation for the separation of variables is transformed into a familiar equation, where the idea of normalization of the unknown into the known is reflected.

Solving (5) yields:

\[ \ln|y| = \int \frac{Q(x)}{y(x)} dx - \int P(x) dx \rightarrow y = \pm e^{\int \frac{Q(x)}{y(x)} dx} \int P(x) dx C(x) \cdot e^{-\int P(x)} dx \]
\[ (6) \]

Namely:

\[ y = C(x) \cdot e^{-\int P(x)} dx \]  
\[ (7) \]

In this way, we explore together the form of the general solution of equation (1), which is the key to explain the constant variational method. Analogous to the form of the general solution of the corresponding chi-square differential equation (2), it is natural to obtain the constant variation method, the essence of which is the substitution of variables for the unknown function.

2) General solution formula using the constant variational method, substituted into the formula (1), can get its general solution:

\[ y = e^{-\int P(x)} dx \left( \int Q(x) e^{\int P(x)} dx + C \right) \]
\[ (8) \]

3) General solution structure by asking questions, students are asked to summarize the general solution structure of equation (1) based on the general solution formula (5): the general solution of a non-flush linear differential equation is equal to the general solution of the corresponding flush differential equation plus a special solution of the non-flush equation.

4) Can be “double integral” for example, let \( z = f(x, y) \) is a bounded function on the bounded closed region \( D \), the closed region \( D \) arbitrarily divided into \( n \) small closed region \( \Delta \sigma_1, \Delta \sigma_2, \ldots, \Delta \sigma_n \), where \( \Delta \sigma_i \) represents the \( i \) small closed region, also said that its area. Take any point \( \Delta \sigma_i \) on each \( (\xi, \eta) \) and make the product:

\[ f(\xi, \eta) \Delta \sigma_i, i = 1, 2, \ldots, n \]  
\[ (9) \]

And as a sum \( \sum_{i=1}^{n} f(\xi_i, \eta_i) \Delta \sigma_i \) if the limit of this sum always exists when the maximum value of the diameter of each small region \( \lambda \rightarrow 0 \) and is independent of the partition of the
closed region and the way the point \((\xi_i, \eta_i)\) is taken, then this limit is called the double integral of the function \(f(x, y)\) over the region \(D\), denoted as \(\iiint_D f(x, y) d\sigma\), i.e.:

\[
\iiint_D f(x, y) d\sigma = \lim_{n \to \infty} \sum_{i=1}^{n} f(\xi_i, \eta_i) \Delta \sigma_i
\]  

(10)

Where \(f(x, y)\) is the product function; \(D\) integral region; \(x, y\) integral variable; \(\iiint_D f(x, y) d\sigma\) integral expression. \(\sum_{i=1}^{n} f(\xi_i, \eta_i) \Delta \sigma_i\) integral and about the above definition, a few notes should be given to the students to help them understand the definition better. In a right-angle coordinate system, dividing \(D\) by a line parallel to the coordinate axis, we have:

\[
d\sigma = dx dy
\]  

(11)

So, there was:

\[
\iiint_D f(x, y) d\sigma = \iint_D f(x, y) dx dy
\]  

(12)

Volume of the above curved-topped column:

\[
V = \iint_D f(x, y) dx dy
\]  

(13)

Emphasize that the volume of a curved-topped column can be expressed as a double integral, but the double integral is more than just the volume of the curved-topped column to reinforce students’ thinking. In analogy to the geometric meaning of definite integrals, what is the geometric meaning of a double integral? (Students share, teacher summarizes)

The geometric meaning of the double integral: when \(f(x, y) \geq 0\), \(\iiint_D f(x, y) d\sigma\) represents the volume of the curved top column; when \(f(x, y) \leq 0\), \(\iiint_D f(x, y) d\sigma\) represents the opposite of the volume; when \(f(x, y)\) is both positive and negative, \(\iiint_D f(x, y) d\sigma\) represents the upper volume minus the lower volume. If:

\[
f(x, y) \equiv 1
\]  

(14)

Rule:

\[
\iiint_D f(x, y) d\sigma = S_D (Area \ of \ D \ region \ D)
\]  

(15)

3.5 Post-test ------ Classroom exercises

Use the constant variation method to find the equation:

\[
y' - \frac{2y}{x + I} = (x + I)^{\frac{3}{2}}
\]  

(16)
3.6 Summary ---- Emphasize ideas and expand methods

The PPT presentation is dynamic and emphasizes the idea of generalization to expand the solution method. The above example combines the problem-based and inquiry-based learning approach from the introduction of the problem, the investigation of the general solution form of the equation, to the summary of the general solution structure and the expansion of the solution method, so that the constant variation method can be introduced naturally, and the difficulties can be overcome smoothly. The extensions are combined with the results of the thesis, and two additional solutions are added to facilitate the development of students’ horizons. The students are the center, the problems are the guide, and the effective achievement of teaching objectives is the core, to integrate mathematical thinking and methods in classroom teaching, build a bridge of transition before teaching new knowledge, effectively overcome the difficulties and highlight the key points, and realize effective classroom teaching.

4 Teaching effectiveness and evaluation

In the pre-study task released before class, several discussion topics are designed for the group to choose, and the group reports the results of the group discussion in class, and all students participate in the grading, to enhance the students’ awareness of teaching participation and participation and focus on cultivating students’ thinking methods and thinking ability.

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Figure 2. Structure of blended instructional design based on BOPPPS model

Figure 2 contains three sessions: Participatory Teaching P, Post-test P and Summary S. Participatory teaching P emphasizes knowledge interaction and reflection, guiding students to take the initiative to think and actively participate, and its modes can be various, such as problem-based, case-based, comparative, seminar, heuristic, flipped classroom, and mind mapping, etc. By setting up problems to guide students to participate in discussions, using actual engineering cases to analyze professional problems, and using functions such as pop-ups or voting in the rain classroom for multiple people to simultaneously express their opinions. Post-testing can be done immediately after the completion of a knowledge point or teaching objective, or the test can be completed within 5-10 minutes before the end of the classroom lecture, such as using Rain Classroom to set various objective questions to complete the real-time assessment, and seminar-style questions can be completed by releasing
subjective questions in Rain Classroom. By recording students’ performance data in detail throughout the teaching process, teachers can effectively grasp students’ classroom participation and learning effectiveness and use it as a reliable source of material for the final summary S session. The summary S session usually summarizes the knowledge points, reviews the results of in-class discussions, and analyzes the questions in the post-test session.

To make the results more convincing, the following will choose the same science and technology majors, and the teaching plan and the amount of class time are exactly the same for the comparison of majors and students.

As shown in Figure 3, in the fall semester of 2018, the teaching practice of the teaching method proposed in this paper was carried out in a total of 6 classes of 183 students in the Sino-foreign cooperative school of the School of Information and Mechanical Engineering of the University of Foreign Languages on the course of Advanced Mathematics. Comparison. The design of the decomposition BOPPPS model and its application in the teaching of basic university public mathematics courses can be seen from the above graph, the proportion of students with scores above 90 and 80-90 has increased significantly, while the proportion of students who failed has decreased significantly. This shows that the proposed teaching method in teaching can significantly increase the percentage of students with high scores, improve the teaching effect, and effectively reduce the failure rate, enhance students’ learning motivation and ability to master knowledge. The average grade of students in Advanced Mathematics was 73 in the semester when the dissertation teaching method was implemented, while the average grade of students in normal teaching was 68. From the perspective of the average grade, the proposed teaching method has obvious practical significance in improving the teaching effect. In addition, in terms of students’ evaluation of teaching, the students’ evaluation score at the end of the semester was 99.5 (out of 100). Many students in the comments pointed out that “the knowledge points were clearly organized”, “good at stimulating our interest in learning”, “able to give us timely feedback on our problems”, and “inspiring and able to fully deepen students’ interest in learning” and “focused and well-layered”. These comments well reflect that the purpose
and advantages of the teaching method proposed in the thesis are fully recognized by students in the teaching process. In summary, it is evident that the BOPPPS model can significantly improve the teaching effectiveness and gain wide support from students in teaching the most important course in the university public mathematics course of “Advanced Mathematics”. It is a reasonable, effective and practical teaching model.

![Diagram](cloud_class_diagram.png)

**Figure 4.** Online cloud classroom structure

The information technology integrated in Figure 4 includes live tools such as cloud classroom, WeChat group, and learning platform, covering a total of three sessions: post-test P, objective O, and summary S. Post-lesson tasks are assigned through the above information tools, including course assignments, reading extended literature, topic design, questionnaires, and discussion questions. Reviewing and echoing the teaching objective O of the course, the post-test P session is conducted again, and the teacher makes a comprehensive assessment of the learning effectiveness based on the completion of the students’ learning tasks, completing a diversified and comprehensive evaluation. The summary S session of this stage includes both students and teachers: students’ self-reflection, sorting and summarizing of teaching contents, communication and discussion among students; teachers understand the learning situation through questionnaires, compile and analyze students’ performance in various teaching interaction activities, conduct online centralized Q&A for the problems that appear in the pre-class and in-class stages, and conduct one-to-one discussions with the “problem students” prompted by the rain classroom teaching data. One-on-one communication with the “problem students” suggested by the teaching data of Rain Classroom, etc. Finally, the results of the summary S session and the post-test P session are used as feedback information to correct, supplement, and improve the teaching activities in the pre-class and in-class phases of the next lecture, forming a closed loop of teaching.

The following example takes the above course teaching model as the basis of research and uses the blended BOPPPS teaching model as the research content to explore and practice the reform of teaching role change. The blended BOPPPS teaching model for the corresponding course considers each part of the teaching process, dismantles, and analyzes the teaching process, identifies blind spots based on feedback results, improves and enhances teaching effectiveness, and realizes effective teaching (i.e., effective, efficient and efficient teaching). The following questionnaire is also designed for teaching effectiveness, including clarity of teaching content, clarity of teaching objectives, effectiveness of teaching, optimization of teaching methods, liveliness of classroom atmosphere and
effectiveness of listening to lectures. Through the teaching practice, the overall evaluation of students was good. Students have a clearer understanding of the concepts in the course and are more organized in answering questions and doing experiments.

During the implementation of the project, two questionnaire surveys were conducted, including whether they were more able to stimulate effective thinking, more likely to be interested in the content of the lectures, more willing to express their own views, more willing to take the initiative to think, find it easier to learn, more likely to follow the teacher’s pace, more likely to complete the learning tasks, more likely to grasp the key points and difficulties of learning, clear learning objectives, more willing to communicate with classmates items such as discussion.

The data of the statistical results are shown in Figure 5(a): the survey in the middle of the project implementation showed that 92.56% of the students were very satisfied and satisfied with each index on average. The results of the same survey at the end of the project showed that 93.21% of students were very satisfied and satisfied, with most students being very satisfied and a significant decrease in the number of students who considered it average. Only the classroom activity had students who expressed disagreement with this one, and it is important to further improve student participation and optimize the overall teaching effectiveness in the future. Teachers were able to sense from the classroom observations that the teaching content was more likely to attract students’ interest. The interactive sessions designed during the teaching process not only achieved communication between teaching and learning, but also enabled the teacher to identify and correct students’ deficiencies and errors in the learning process. The teaching process verifies the effectiveness of the blended BOPPPS model teaching method, which not only improves teaching efficiency, but also greatly increases students’ participation and interaction between teachers and students.

The data of the statistical results are shown in Figure 5(b): the mid-term survey of the program implementation showed that 86% of the students were very satisfied and satisfied with each index on average; the survey results of the same content at the end of the program implementation showed that 92% of the students were very satisfied and satisfied, among which the majority of the students were very satisfied and the number of students who thought it was average was significantly lower at the end than the mid-term survey results. Only individual projects have students who expressed disagreement, indicating that students are dissatisfied with their classroom performance and can achieve better classroom learning in the future by previewing classroom content.
(a) Statistical chart of classroom performance evaluation

Classroom performance survey

- Totally agree
- Agree
- General
- Not agree

(b) Student satisfaction index

Figure 5. Student survey results
In conclusion, the blended BOPPPS teaching model combines pre-testing with students’ pre-testing and uses micro-video to stimulate students’ interest in learning, so that students can realize their potential for independent learning and further improve their learning efficiency. At the same time, teachers can keep abreast of students’ pre-testing and can better adjust teaching priorities and design participatory learning in a targeted manner. It ensures that students can complete the teaching objectives of each lesson step by step, form knowledge accumulation, firmly grasp the knowledge points, and further improve the quality of teaching.

5 Conclusion

The BOPPPS model emphasizes the student-centered teaching concept and participatory learning through teacher-student interaction. The BOPPPS model emphasizes the concept of student-centered teaching and learning and focuses on interactive and participatory learning between teachers and students. The teaching practice of this study also shows that teachers need to invest more time and effort in lesson preparation because they need to thoroughly understand the course objectives, content, and innovative and challenging course materials, as well as fully understand students’ knowledge base, personality characteristics, and dynamic learning situations when designing hybrid teaching. Students also need to change their learning concepts and learning styles from the traditional lecture mode to independent learning and self-inquiry mode to improve their own self-learning and creative abilities. But in the final analysis, students are the main bearers of teaching. From the viewpoint of teaching methods and teaching quality, the design effect of teaching mode should be reflected in students’ acceptance and course learning effect, and targeted solutions should be given according to different demand objects to finally achieve the most optimal teaching effect. Adopting the BOPPPS model, establishing a perfect teaching system, emphasizing the participation of teachers and students, can not only improve teachers’ skills, but also exercise students’ independence and autonomy in learning, cultivate solidarity and collaboration, stimulate innovative thinking, and optimize the effect of teaching to a certain extent.

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