

# Practice and Research of Blended Teaching of Mathematical Analysis Course Based on Mobile Internet

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**Abstract:** Facing the new era of knowledge economy and mobile internet, higher education needs to keep pace with the times and carry out the reform of blended teaching models. Mathematical analysis is the basic core curriculum of all majors in mathematics, and plays an extremely important role in the professional development of students. In the course of mathematical analysis, the mobile Internet-based blended teaching reform is carried out, and the combination of micro-learning, MOOC, network platform and traditional teaching is used to make students as the center and stimulate students' interest in learning. The teaching practice shows that blended teaching can effectively cultivate the students' autonomous learning ability, improve their ability to analyze and solve problems, and has statistical significance in improving the students' learning performance.

## 1. Introduction

Mathematics is known as the queen of science, and it is the foundation of all science. Behind every major progress of mankind, mathematics has been providing strong supports. In all mathematics courses of the mathematics major students, Mathematical analysis is the basic core course, which mainly includes the limits of series and functions, the continuity of functions, the calculus of single-variable functions, series theory and multivariate calculus. It plays an extremely important role in the follow-up professional studies and professional development of the students.

In the traditional teaching mode, the teacher is the subject in the teaching process, which is the imparter and inculcator of knowledge. However, the student is the passive receiver and inculcator of knowledge. This teaching mode ignores the students' subjective status of learning and damages the students' initiative to learn. After entering the new era of knowledge economy and mobile internet, the educators at home and abroad strive to find a college teaching model that meets the requirements of the new times, and therefore the blended teaching has emerged as the times require.

The concept of blended teaching was first proposed by foreign training institutions. It refers to the blending of online and offline networks, which making up for the lack of internet teaching through face-to-face teaching. In 2003, the professor Kekang He in Beijing Normal University introduced the concept of the blended teaching into China. His point is that the blended teaching mode combines the advantages of traditional teaching methods and networked teaching, which not only exerts the leading role of teachers' guidance, inspiration and monitoring of the teaching process, but also fully reflects the initiative, enthusiasm and creativity of the students as the subject of the learning process. Since then, some professors and scholars working on the front line of teaching conducted in-depth research and application of blended teaching mode, and achieved excellent teaching results.

Mobile Internet technology has powerful functions. On the basis of making full use of mobile Internet technology, many scholars have conducted blended teaching on various subjects. However, it is more difficult to carry out the blended teaching on the curriculum of Mathematical Analysis which has a higher level of abstraction, and therefore less research on this course. To study how to use the mobile Internet technology in the mathematical analysis class is the core of the reform for the blended teaching mode. It is suitable for the cultivation of applied talents and innovative talents

with the "mobile Internet +" element, which can make up for the deficiency of traditional teaching and enrich teaching Means to increase the students' interest in studying mathematical analysis course and improve the quality of training the innovative and applied talents in local undergraduate universities and colleges.

## **2. The Importance and Necessity of Carrying Out the Blended Teaching Mode**

In this section, we explain the importance and necessity of carrying out the blended teaching from four aspects.

### **2.1 The importance of the mathematical analysis course.**

The course of mathematical analysis allows students to systematically master the univariate and multivariate calculus, which is a set of highly abstract, complete and widely used mathematical tools. The course also lays a solid mathematical theoretical foundation for the students in their other professional courses and future work, and improves the students' rigorous logical thinking ability and cultivate the students to analyze problems and solve problems encountered in real life. At the same time, it is extremely important for the students to obtain entrance quality of master's degree examination in the future, and to engage in mathematical education and scientific and technological work after graduation. For the students who wish to be teachers in elementary and middle schools, learning mathematics analysis courses will have a direct and decisive effect on the normal students' successful passing of the teacher qualification examination and their subsequent engagement in mathematics education and teaching. To teach well the functions, inequalities, permutations, and analytic geometry of planes and so on in middle school mathematics, the teachers in middle school must have a good background in mathematical analysis, and have a solid theoretical foundation for mathematical analysis.

### **2.2 The current situation of teaching mathematical analysis courses in our college.**

For local undergraduate university and college such as Jiaying University, a large part of the students have passed the sea test training in high school, and the mathematical foundation is relatively weak. Many knowledge points such as inverse trigonometric functions, trigonometric functions are not tested in the college entrance examinations and therefore in the middle school stage, most students have no intention to study, and the knowledge structure of elementary mathematics is not systematically complete. The accumulation of students' basic mathematical knowledge and mechanical thinking habits since middle school are difficult to adapt to the study of highly abstract mathematical analysis courses. Students don't like to use their brains and pens, they have obvious feelings of distress, and they lack the initiative to study well. Therefore, combining with the actual situation of local college students, we need to change the teaching method of mathematical analysis courses which to make mathematical analysis courses more attractive to the students, and to promote the students' enthusiasm and subjective initiative in learning the course of Mathematical Analysis.

### **2.3 Carrying out the blended teaching will help the math normal students to pass the teacher qualification examination.**

The Normal University students in Guangdong Province who entered colleges after June 2016 are required to take the teacher qualification examination. Among them, the subject for the Math Teacher Qualification Examination "Discipline Knowledge and Teaching Ability" has a large amount of professional knowledge in "Mathematical Analysis" course. After researching on the test questions in the subject of "Discipline Knowledge and Teaching Ability" in recent years, it is not difficult to find that among the test questions on "Mathematical Analysis", the number of test questions are the following three parts: function continuity, derivative and differentiation, and limits are the most. "Mathematical Analysis" is the focus of attention for the teacher qualification examination. Series and integrals also appeared in the examination questions. These contents are more difficult to accept and are more abstract for the students wish to become mathematics teachers.

In order to improve the learning interest and improvement of students, traditional teaching methods are difficult to achieve. Through practice and research, it has been found that blended teaching is more appropriate in the teaching of these professional knowledge contents. Online and offline blended teaching using the mobile Apps such as Superstar Learning Platform, Rain Class, and the "UMU" can achieve better teaching results.

## **2.4 Carrying out blended teaching meets for trend of 'classroom revolution'.**

On September 8, 2017, Comrade Baosheng Chen, secretary of the party leadership group and minister of the Ministry of Education, wrote an article in the People's Daily, explaining that "striving for a satisfactory education for the people", demanding that "deepen the reform of the training mode for talents, and set off the 'class revolution' ". An important direction of classroom teaching reform is to return from knowledge-based to ability-based, that is, teaching should not only stay at the level of knowledge transmission, but also pay attention to the construction and internalization of knowledge. This requires local undergraduate universities and colleges to reform the classroom teaching mode basing on knowledge transmission and create a new teaching mode that is conducive to the knowledge construction and ability formation of today's college students. In this era of knowledge economy, Internet, 5G, 6G and other communication technology development, it is an inevitable trend to carry out the reform of classroom teaching modes suitable for training the creativity ability of the students in local undergraduate universities and colleges.

## **3. Teaching Practice of Blended Teaching Mode with Superstar Learning Platform as Media**

### **3.1 Online self-study before class**

In traditional teaching, teachers first introduce new lessons by reviewing in the classroom. Because of the emphasis on the systematicness and logical rigor of curriculum knowledge, it is inevitable to explain the theorem and theoretical proving. Then, the teachers give the examples, student exercises and homework assignments, which makes the teaching process more abstract and boring. With the expansion of colleges and universities and college entrance examination reforms, and so on, some students have a poor foundation in elementary-level mathematics and therefore these students lack interest in learning. Teachers need to complete the teaching content of the teaching plan and hence cannot take care of all the students and result in their poor class performance.[3,4]

In the blended teaching, the teachers first prepare teaching resources. Upload the overall instructional design, unit instructional design, instructional videos, lesson plans, courseware PPT, micro-lesson videos, exercise library, after-school answers and reference database on the superstar learning platform, laying a foundation for mixed teaching Resource base. In addition to Superstar's micro-learning video resources, classroom teachers also have to develop their own micro-lecture videos. For example, in the beginning of "mathematical analysis", for many students who did not learn the inverse trigonometric functions seriously in middle school, the teacher did not have much time to talk about all of these in limited class time. We therefore recorded Four micro-lecture videos: the inverse sine function, inverse cosine function, inverse tangent function, and inverse cotangent function, each of which includes the domain, range, function image, and monotonicity of the function, the relationship with the corresponding trigonometric function, and the derivation of the angle of the known trigonometric function value. We provided these teaching materials in the Superstar Learning Platform for the students to self-learn and discuss in the class.

In the reform of blended teaching, teachers should play the role of teaching designer and teaching method researcher. The big difference from traditional teaching is that the process of blended teaching is no longer teacher-centered. Teachers need to fully mobilize the enthusiasm of students, reflect the team spirit of group cooperation, and realize student-oriented and teacher-led teaching process. Students are divided into study groups before class, and the group members are controlled by 6~9 people. The group is used as a unit for learning and online teacher-student communication. After the students form groups, they look up learning materials online, watch

videos provided by the teacher in the Superstar, and search on the Internet to find answers. After the group students' discussion, they should submit group work online. Hence the learning is not limited by the time and place, the students just complete the video study before the next class, submit online quizzes, ask questions, and complete teacher-student network interaction. The flip is to prepare for the group discussion in the classroom.

### **3.2 Task-driven and offline discussion classroom**

At present, the mathematics analysis courses are basically combined classes, and there are more students in the classes. The "low heads" in the classroom have always been a headache for teachers. Superstar Learning Platform uses mobile phones as teaching and learning media which can reduce blockages, and solve blended teaching difficulties. Superstar Learning Platform's screen sign-in function saves the time of traditional roll call, prevents students from cheating, and significantly improves the students' attendance.[5]

In the blended teaching of mathematical analysis, we organize students to discuss in the classroom on the basis of students' watching videos of micro-learning lessons online, and organize classroom teaching in a task-driven form. For example, the task for the class of the one-point continuity of a function. The students are required to watch the micro lesson videos, and then they are asked to complete the following three tasks: 1. what is the difference between continuity definition of a function at one point and the definition of the existence of function's limit at that point? 2. If the function is continuous at one point, is there a limit at that point? 3. How to judge whether the function is continuous at one point? If the function is a piece-wise defining function, how to judge the continuity at the piece-wise point? And the group students discuss and solve these problems under the guidance of the teachers. Another example is when teaching the Cauchy mean value theorem, we complete the following tasks by asking the students watching the micro-videos: 1. Under what conditions the Cauchy Mean value theorem will reduce to Lagrange mean value theorem and Rolle theorem as special cases? 2. What is the geometric phenomenon revealed by Cauchy mean value theorem? 3. What problem does the mean value theorem solve? 4. What is the connection and difference between the proof of Cauchy mean value theorem and Cauchy mean value theorem? 5. Ask the students to realize the application of Cauchy mean value theorem. In this way, the students can learn the content of the Mathematical Analysis course online with questions and discuss the tasks in the offline classroom. This allows the students to bring important and difficult points to the classroom, discuss and learn with tasks, so that the students can better grasp the knowledge and the teacher can vigorously improve the students' practical ability, greatly improve their learning efficiency and the learning results.

In the class activities, we use the Superstar Learning Platform to enhance the students' mathematical activities and mathematical experiment teaching. Through mathematical activities, students can experience the process of discovering mathematical theorems, the formation of mathematical concepts and skills, mathematical modeling and mathematical operations. For example, the usage of blended teaching allows the students to explore the decay of radium, the modeling and solving of the first and second cosmic velocities, and the problem of the biggest benefit of newspaper boy selling newspapers, all of which help improve the core literacy of students in mathematical modeling. In the class, we illustrate the students how to operate the Matlab and SPSS software by self-made micro-videos, and taught the students to use Matlab to perform differential and integral calculations, how to draw various types of quadratic surfaces, and solve the corresponding problems such as surface integrals. Through the intuition of video animation and the autonomous exploration, the students' intuitive imagination ability and mathematical operation ability are greatly improved. For example, we often have to imagine the condition of the surface when we are looking for multiple integrals, curve integrals, and surface integrals. It is difficult to explain clearly in language, and hence it is difficult for the students to imagine that the integration area and geometric images are not easy to draw on the blackboard. The content of the surface is learned in the spatial analytic geometry, so the teachers use the mobile phone APP software to give the micro-class video. The students are required to review the knowledge of geometry such as

quadratic surface offline by the micro-lessons, and the teacher use the precious time in the classroom to organize the group discussion. For example, when teaching the geometric application of surface integrals, in order to help students imagine and calculate the area of the space surface and the perimeter of the space curve, Matlab software are used to assist the teaching and help the students to form the intuition of space graphics. For example, we ask the students to solve the area and perimeter of an ellipse  $z = x^2 + y^2$  which is cut by a plane  $x + y + z = 1$ . The teachers demonstrate how to draw the intersection line (shown in the following Figure 1) in class, so that the students can form an intuitive imagination of the ellipse of the intersection line, and then they start to calculate the area and perimeter by a much easy way. It is easier for students to accept and the level of understanding and problem solving ability of the students has improved accordingly. The core literacy of the students' intuitive imagination has also been greatly improved, and better teaching effect has been achieved.

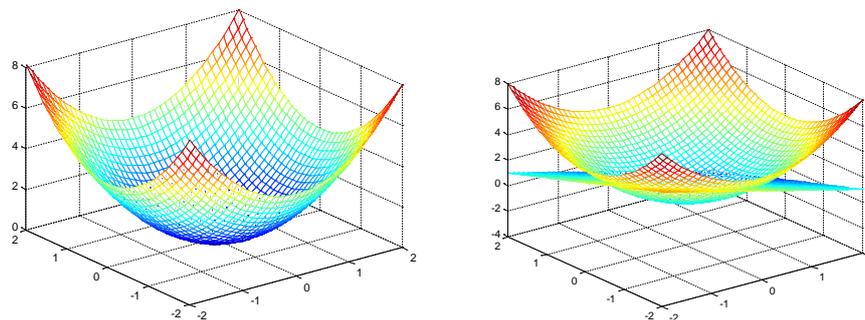


Figure 1 Intersection of an elliptic paraboloid cut by a plane

Superstar Learning Link provides a platform for communication and interaction between teachers and students. In traditional teaching, it is difficult to answer the questions for each student. First, teaching time in the class is limited, and it is inconvenient for students to find the teachers after class. Some students are introverted because they are shy and embarrassed to ask questions. Now, we have realized the zero-distance communication between teachers and students by using the Superstar Learning Link. Compared with traditional teaching, it improves the learning interest of the students. Using Superstar's quiz function, teachers can impromptu ask questions for the students to answer in the classroom. Through topic discussions, scoring, timers and other functions of the Superstar Learning Link increase teacher-student interactions. By viewing and exporting test statistical results, the teachers can learn about the situation of the students at any time and evaluate the teaching effects in a timely manner.

### 3.3 Consolidation and improvement after class by blending teaching method

In traditional teaching, teachers' knowledge of students' mastery of knowledge is usually through homework, and they need to be reviewed in the next class. Teaching feedback is not very timely, and students have difficulties in getting targeted counseling. After-class assignments for blending teaching can be published on the Superstar platform or on the mobile phone, which is convenient and quick. Homework assignments can be selected from the test library or written manually at any time. Students submit their assignments online, and their scores can be quickly calculated. Unit tests and final exams can also be used to answer questions online, saving time for teachers to mark papers.

Watching the micro-lecture video is not only a task of flipping the classroom, it is also part of the homework. Combining the key points and difficult points of each lesson, the teachers can make the content of each lesson into 4 to 6 micro-lessons, and the time of each micro-lesson is controlled between 5 and 10 minutes, which is convenient for the students to concentrate themselves on the watching and self-study .[6]

Micro lessons meet the fragmented requirements of the learning content for different learners and have a high degree of flexibility. If the students do not understand the contents taught by the

teacher during the lesson, they can watch the micro-lecture video after class and pause or replay these videos according to their own needs to realize autonomous learning. Learning micro-lecture videos help the students to check for gaps and reflections after class. The number and time of the students watching micro-lecture videos, teachers can get the data on the teacher's side, as part of the means of assessing students' ordinary performance.

#### 4. Empirical Analysis of Teaching Effect of Blended Teaching Mode

We use the statistical analysis methods to compare and analyze the final exam scores for the students of 2018 class majoring in “Mathematics and Applied Mathematics” and “Applied Statistics” by using the blended teaching mode and traditional teaching mode.[1] We test the differences in the learning performance of the students by using different teaching modes.

Table 2: Descriptive statistics of the test results in Mathematical Analysis course

Teaching mode	Average	Std Deviation	Sample size	Passing rate
Blended	$\bar{x} = 77.04$	$S_x = 15.64$	$m = 73$	89.04%
Traditional	$\bar{y} = 71.81$	$S_y = 13.78$	$n = 59$	84.76%

From the data in Table 1, the pass rate and average score of the students in the blended teaching mode are much higher than the pass rate and average score of the students in the traditional teaching mode, but the standard deviation is slightly larger than the latter.

In order to further explain whether there are significant differences in the students' performance in different teaching modes, it may be useful to assume that the students' score which adopt the blended teaching mode  $X \sim N(\mu_1, \sigma_1^2)$  and the students' score which adopt the traditional teaching mode  $Y \sim N(\mu_2, \sigma_2^2)$ . Basing on the results described above, we consider the hypothesis test  $H_0: \mu_1 \leq \mu_2$  and  $H_1: \mu_1 > \mu_2$ . If we take the following  $u$ -test statistic (since  $m+n$  is large, it can also be regarded as a t-test statistic):

$$u = \frac{\bar{x} - \bar{y}}{\sqrt{\frac{S_x^2}{m} + \frac{S_y^2}{n}}} \approx \frac{\bar{x} - \bar{y}}{\sqrt{\frac{(m-1)S_x^2 + (n-1)S_y^2}{m+n-2} \sqrt{\frac{1}{m} + \frac{1}{n}}}}. \quad (1)$$

We obtain the rejection domain of this hypothesis test is  $W = \{u > u_{1-\alpha}\}$ . By taking the significance level  $1-\alpha = 0.95$ , then we get  $u_{0.95} = 1.645$ . We substitute the sample mean, sample standard deviation and sample size of the results in the two teaching modes into the test statistics, then we get  $u = 2.0384 > 1.645$  and therefore we reject the original hypothesis  $H_0$ , which can be considered that the blended teaching mode has significantly improved the students' learning performance.

It can also be seen from Table 2 that the standard deviation of the students' learning performance in blended teaching mode is slightly larger than that of traditional teaching mode. A natural question arises: can we explain that the blended teaching has a more unstable impact on performance than the traditional teaching mode? To answer this question, we consider the hypothesis test  $H_0: \sigma_1 \leq \sigma_2$  and  $H_1: \sigma_1 > \sigma_2$ . Taking the F-test statistic  $F = \frac{S_x^2}{S_y^2}$ , we deduce that

the rejection domain of this hypothesis test is  $W = \{F > F_{1-\alpha}(m-1, n-1)\}$ . Taking the same significance level of  $1-\alpha = 0.95$ , then  $F_{0.95}(72, 58) = 1.52$ . We substitute the sample mean, sample standard deviation and sample size of the results in the two teaching modes into the test statistics, then we get the value  $F = \frac{15.64^2}{13.78^2} = 1.2882 < 1.52$  and therefore, the null hypothesis cannot be rejected, that is, it can be considered that the blended teaching has not caused more unstable learning performance.

## 5. Conclusion

In short, with the help of the mobile technology and Internet teaching platform, the blended teaching mode of Mathematical Analysis course provides the students with independent learning space to a large extent, which greatly increase the opportunities for communication between teachers and students. The learning interest in the mathematics course in the process of the blended teaching has been continuously enhanced. At the same time, unexpected gains will continue to generate new motivations and positive energies among the students, thus forming their inexhaustible motivation to learn well in progress. Of course, there are some imperfections in the blended teaching of Mathematical Analysis course, such as single teaching activities and students' insufficient ability to actively learn. [2] Therefore, the blended teaching mode places higher requirements on the teachers. How to effectively solve the above problems requires us to continuously explore and improve gradually in the future teaching.

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