Research on the Teaching Mode of Higher Mathematics in New Era

—Taking Double Limit Calculation as an Example

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Abstract—**In order to solve the problems existing in traditional Higher Mathematics classroom teaching in China, it is necessary to reform the current teaching mode. This paper mainly introduces a new teaching mode, and discusses how to reform traditional classroom teaching mode from the teaching thoughts, teaching content and teaching methods and means. To improve students' classroom learning efficiency, new ideas, new methods and new concepts need to be created on the basis of old experiences and methods. After taking Double Limit Calculation as an example for specific explanation, the teaching result shows that this new teaching mode proposed in this paper is more suitable for the current mathematics curriculum for Chinese college students.**

Keywords—Higher Mathematics; Traditional teaching mode; Double Limit Calculation; New teaching mode

I. INTRODUCTION

Nowadays, with the development and wide application of electronic information technology, more and more new information processing equipment and information technology mean to begin to be applied to daily education and teaching practice. In order to meet the needs of classroom teaching in the new era, the key work of college education and teaching reform began to gradually change into thinking about how to internalize knowledge and pass it on to students. This paper gives an account of new teaching mode in a higher mathematics course, and develops a new teaching mode suitable for practical teaching in the higher mathematics classroom. Through specific cases, this new teaching mode is studied and analyzed.

II. THE SIGNIFICANCE OF THINKING AND RESEARCH ON THE TEACHING MODE OF HIGHER MATHEMATICS COURSE IN THE NEW ERA

As a traditional public basic course in Colleges and Universities, Higher Mathematics is a compulsory course for all freshmen. Since the establishment of calculus in early-stage, teachers of Higher Mathematics have been teaching in classroom in accordance with the traditional teaching ideas and follow the ideas of former teachers[1]. However, with the progress of times and change in students' thinking mode, the traditional old experiences and old methods can no longer adapt to the teaching mode of the new era. In order to cultivate new application-oriented university talents that adapt to the development of the new era, we must reform the current teaching mode of Higher Mathematics course [2].

In the current Higher Mathematics classroom, students will encounter various problems in the learning process [3]. The reasons for these problems are as follows:

A. Reason 1

Learning in universities is different from that in high schools. In high school, mathematics is a major subject, and regular time is arranged every day, while the time of college mathematics learning is relatively loose. Taking 72 + 72 hours of higher mathematics course as an example, three major courses are arranged every week at most, and the rest of the time requires students to take time to preview, review and consolidate.

B. Reason 2

The students who study higher mathematics are mainly non-mathematics majors. They pay less attention to mathematics. Occasionally, there are several students who are particularly interested in mathematics. However, most students regard mathematics as an "audition course".

C. Reason 3

Usually, teachers only pay attention to the imparting of knowledge in the course of preparing lessons, and the teaching content cannot be closely linked with students' majors. Moreover, for freshmen, professional courses will pay more attention to their consciousness. Once they feel the teaching content of higher mathematics is not helpful to their specialty, they will soon lose their learning motivation. Further, their interest in learning will also be weakened.

In order to solve the above problems, we need to think and reform the current teaching mode, and put forward solutions according to the problems. Based on the author's own teaching experience, this paper combines the above-mentioned questions with the course content of "Double Limit Calculation" in higher mathematics courses as an example to carry out the trial and research of the reform of the curriculum teaching mode under the new era.

III. ANALYSIS OF THE COURSE CONTENT OF "DOUBLE LIMIT CALCULATION"

The Double Limit is an extension of the limit content of the unary function. In the process of solving the problem, we need not only the methods and ideas of solving the limit of a unary function, but also the frontier knowledge of the content of two-variable functions, which itself has certain rules and skills in solving the problem [4]. How to take a Double Limit exercise course has always been a difficult problem for most teachers of higher mathematics. In the specific teaching process, less knowledge taught by teachers will result in insufficient examinations for students. If the teacher's lecture content is too much, the class time is not enough. If the teacher's lecture content is simple, students will think that this part is too simple and not important; but if the teacher is too esoteric, students will produce fearful emotions. Therefore, combining years of teaching experience and students' feedback information, this paper analyzes the specific process of teaching the "Double Limit Calculation" course with the traditional teaching mode and the new teaching mode, so as to explore the general method of how to improve the high-level mathematics course [5].

IV. TRADITIONAL "DOUBLE LIMIT CALCULATION" TEACHING MODEL

In the traditional teaching mode, the process of classroom teaching design for "Double Limit Calculation" is introduced as follows.

A. Teaching Objective

Let students master six common types of Double Limit Calculation methods and apply them skillfully.

B. Emphasis and Difficulty in Teaching

1) Emphasis: Enable students to master various methods of Double Limit Calculation.

2) Difficulty: Make students proficiently apply different methods of Double Limit Calculation and solve problems flexibly.

C. Teaching Method

Lecture.

D. Teaching Process

1) Introduction
Review the solution method of the limit of unary functions.

① Continuity and Elementary Transformation of Unary Functions; ② two-sided clamp criterion; ③ Equivalent Infinitesimal Substitution; ④ the product of infinitesimal and bounded functions is still infinitesimal quantity; ⑤ Differential Mean Value Theorem and Integral Mean Value Theorem; ⑥ Lobida's law.

2) New Course Teaching
Explanation of Double Limit Calculation method.

This lesson mainly explains six calculation methods commonly used in Double Limit, as follows: ① Continuity of Binary Function; ② two-sided clamp criterion; ③ two important limits; ④ Equivalent Infinitesimal Substitution; ⑤ change the Double Limit into the Limit of Unary Function by Variable Substitution; ⑥ the product of Infinitesimal and Bounded Function is still infinitesimal.

3) Explanation of Typical Examples
For the above six common methods, the following specific examples are given for explanation.

Case 1 Finding Double Limits (1) $\lim\limits_{\substack{x\to 1 \\ y\to 0}} \dfrac{\ln\left(x+e^y\right)}{\sqrt{x^2+y^2}}$;

(2) $\lim\limits_{\substack{x\to 0 \\ y\to 0}} \dfrac{x^2+y^2}{\sqrt{x^2+y^2+1}-1}$.

Case 2 Finding Double Limits $\lim\limits_{\substack{x\to 0 \\ y\to 0}} \dfrac{\left(x^2+y^2\right)}{|x|+|y|}$.

Case 3 Finding Double Limits (1) $\lim\limits_{\substack{x\to\infty \\ y\to 2}} \left(1+\dfrac{1}{x}\right)^{\frac{x^2}{x+y}}$;

(2) $\lim\limits_{\substack{x\to 0 \\ y\to 2}} \dfrac{\sin(xy)}{x}$.

Case 4 Finding Double Limits $\lim\limits_{\substack{x\to 0 \\ y\to 0}} \dfrac{\sin\left(x^3+y^3\right)}{x+y}$.

Case 5 Finding Double Limits $\lim\limits_{\substack{x\to 0 \\ y\to 0}} \dfrac{\ln\left(1+x^2+y^2\right)}{x^2+y^2}$.

Case 6 Finding Double Limits $\lim\limits_{\substack{x\to 3 \\ y\to 2}} \dfrac{(x-3)^2(y-2)}{(x-3)^2+(y-2)^2}$.

4) Classroom Summary and Reflection

A. Classroom Summary

This lesson mainly introduces the six problem-solving methods in the calculation process of the Double Limit and specific application examples. Through the study of this lesson, students will master the problem-solving methods and techniques for solving Double Limit and use them flexibly.

B. Classroom Reflection

Use the knowledge you have learned today to solve the following Double Limits.

(1) $\lim\limits_{\substack{x\to 0 \\ y\to 0}} \left(x^2+y^2\right)^{x^2 y^2}$; (2) $\lim\limits_{\substack{x\to\infty \\ y\to\infty}} \left(1+\dfrac{1}{xy}\right)^{x\sin y}$.

C. Assignment

Topic 1 on page P45. (1) - (4) of the textbook.

The above-mentioned case is a typical classroom teaching process of traditional exercises. In the classroom teaching process, teachers do impart knowledge to students and the difficulty of the knowledge content is in line with the students' ability to accept, but at the same time this traditional teaching mode ignores the student-centered education principle. In the long run, students will lose the ability to think creatively to solve problems, and then annihilate creative thinking in the process of learning Calculus.

V. NEW "DOUBLE LIMIT CALCULATION" TEACHING MODE

Under the traditional teaching mode, students just follow the teacher's train of thought. They do not take the initiative to think, and do not have a dominant position in the classroom learning, so that the classroom is caught in the old mode of "full house irrigation". In the new teaching mode, on the one hand, teachers should make full use of various new teaching methods, such as: cloud classroom, micro-class, SPOC, flip classroom, Curtain, Shadow and other information technology-based teaching modes. On the other hand, they should also boldly reform and innovate, create new ideas and methods based on old experiences, such as: O2O, OBE and OAO concepts [6], etc. By using modern thinking methods, teachers change the traditional introduction of knowledge into a new teaching mode based on the development of mathematical thinking [7].

In the following, this paper introduces the classroom teaching design process of "Double Limit Calculation" under the new teaching mode by comparing it with the traditional teaching model.

A. Analysis of Teaching Objects

Compared with traditional methods, the new teaching method increases the process of analyzing students' grades, majors and related knowledge and abilities, which makes the setting of teaching objectives more targeted.

"Double Limit Calculation" is the content of Chapter 10 in Higher Mathematics. In view of the second semester of Java Major in Software College of our university, students have studied higher mathematics for one semester, and have mastered the contents of Limit and Continuity, Derivative and Differential. The number of teaching classes is 96. From the first semester, classroom atmosphere will polarize according to the difficulty of teaching content: when the content is simple, most students can actively listen to the class; when the content involves any difficult knowledge, some students begin to have resistance to learn.

B. Teaching Objective

Different from the traditional teaching mode, the new teaching mode is based on the students' level and specialty. At the same time, combined with the concept of advancing with the times in the new era teaching model, this paper adopts the three-dimensional target mode for teaching objective setting.

1) Knowledge Objective

Assist students to understand the six types of Double Limit Calculation methods and use them skillfully in practice

2) Ability Objective

Master the calculation methods of six common types of Double Limit. According to the specific situation of the function expression, choose the correct method to calculate the Double Limit. In combination with the students' profession, encourage them to use the program to verify whether the calculation results are correct. Finding the appropriate calculation method by letting students does more exercise and practice.

3) Emotional Attitude and Value Objective

For Java majors, teachers should pay attention to the description of computational skills rather than the complicated proof of the reasoning process. Let students combine software programming in the learning process to carry out practical operations, through the calculation of paper and pen, combined with computer software programming to achieve the purpose of verifying the calculation error. In this way, the students will really apply the learned mathematics to their professional fields.

By combining the professional and advanced mathematics knowledge together, students can not only strengthen their understanding of majors, but also feel that mathematics is not just boring formula theorems, but can also be necessary tools to solve practical problems in real life. This allows them to build confidence in solving problems independently and gain the interest of creative learning.

C. Emphasis and Difficulties in Teaching

The key and difficult points of teaching are consistent with the requirements of traditional methods.

D. Teaching Method

Change the old ways of teachers' lectures and students' learning during the traditional teaching process, and make full use of various new teaching media. The teaching methods used in this lesson are Micro-class, Flip Classroom, Graphite Documents, Curtain and Brainstorming, etc.

E. Teaching Process

1) Introduction

In the process of reviewing the solution method of Limit of Unary Functions, the micro-class method is first adopted: the teacher records the course content in advance and publishes it to students for self-review before class. Then, use the Flip Classroom method: that is, in the classroom, students use the way of writing on the blackboard (Fig. 1) to check the knowledge mastery in the pre-class preparation process.

Fig. 1. Students write on the blackboard in class.

2) New Course Teaching

In the process of new teaching mode, the teacher uses the knowledge points and examples to explain at the same time, that is, while giving a knowledge point, simultaneously publish the corresponding examples on the WeChat applet Graphite Document (the examples still use the classic ones in the traditional class). The specific implementation process is explained as follows.

In the first method, we use the continuity of binary function to solve the problem. Because we continue the thinking of solving the limit of a unary function, this method is very simple for most students to migrate. In order to achieve the purpose of attracting students' interest in learning, the answer to Case 1 is relatively simple. When the topic is published in Graphite Document, most of the students can answer and upload photos to the cloud platform in time.

In the second method, when using the two-sided clamp criterion to solve the Double Limit Calculation problem, first, I use the multimedia courseware to review the basic principle of the two-sided clamp criterion, which is to let students review the previous learning. Then, the Graphite Document is still used to allow students to answer questions.

In the third method, two important limits are used to solve the Double Limit Calculation, since these two important limits are the limits of the unary function:

$$\lim_{x \to \infty}\left(1+\frac{1}{x}\right)^x = \lim_{x \to 0}(1+x)^{\frac{1}{x}} = e \ \& \ \lim_{x \to 0}\frac{\sin x}{x} = 1.$$

After seeing the examples, there are divergences and puzzles on how to use the formulas. Some students think that the two important limits of unary function cannot be used in the process of Double Limit Calculation. Some students advocate that the Double Limit formula should be transformed into the limit case of unary function as far as possible with the idea of a unified whole. In this process, I first summarize the views of the group members through brainstorming and then use the method of generating cloud images in the Curtain to present everyone's views on the large screen. Through these discussions, students will have a deeper understanding of Method 3.

Method 4, 5 and 6 are mainly continuing to use the method of solving the limit of a unary function. Here we still use Graphite Document to solve the problem online, and at the same time find some students to practice by writing on the blackboard.

Through the specific presentation and analysis of the case teaching process of the above new teaching mode, we can find that this mode can be designed according to the knowledge base of students and the rules of understanding things. In the process of student learning, the teacher enhances the initiative of students through Graphite Document and the Cloud generated by Brainstorming. This can also change the traditional lifeless classroom atmosphere and activate the new classroom atmosphere.

3) Classroom Summary and Reflection

In classroom summary, in addition to the knowledge content emphasized by traditional methods, attention should also be paid to improving students' cognitive ability and increasing the connection between the content they learn and the professional knowledge of students. In terms of cognitive ability, first of all, through learning the Double Limit Calculation, students can understand that the double limit is developed on the basis of the limit of a unary function, and it is related and different from the limit of the unary function. Students can learn to look at problems from a developmental perspective. Secondly, through the analogy of the unary and the binary function to solve the limit calculation, students learn to solve the problems flexibly. In calculus learning and professional contact, it is necessary to further extend the content learned in the advanced mathematics classroom to the students' majors. In the setting of thinking questions in this lesson, students are required not only to use the pen to calculate the Double Limit, but also to use the knowledge of Java programming to test whether the answer is correct.

VI. CONCLUSION

General Secretary Xi Jinping clearly pointed out in the report of the 19th National Congress of the Communist Party of China: "The new era of socialism with Chinese characteristics leads the development of education and gives priority to People-Oriented." In order to accelerate the modernization of education in the new era, it is necessary to reform the current teaching mode. This paper starts with the reform of the teaching mode of higher mathematics courses. Through the comparison of the old and new teaching modes in classroom teaching process of "Double Limit Calculation", this paper explores the teaching mode adapted to the new era. Bring more innovative opportunities to the traditional mathematics teaching mode, and cultivate more excellent applied undergraduate talents for China.

REFERENCES

[1] Zhao Yu, Liu Jun. Analysis on the Training of New Engineering Talents in Local Undergraduate Colleges[J].Education Exploration,2019(02):65-68. (In Chinese)

[2] Peng Yuming. Innovation and Practice of Teaching Models of College Mathematics Courses in the New Period[J]. Comparative Research on Cultural Innovation,2019,3(11):84-85. (In Chinese)

[3] Zhu Lisa, Heng Shuzhen. Study on the Teaching Problems of the Connection of Advanced Mathematics Courses in Applied Undergraduate Colleges[J].Journal of Jilin Engineering and Technology Teachers College,2018,34(08):10-12. (In Chinese)

[4] Mcloughlin M P M. Crossing the Bridge to Higher Mathematics: Using a Modified Moore Approach to Assist Students Transitioning to Higher Mathematics[J]. Online Submission, 2008:31.

[5] Wachira L, Anyieni A. Effect of Change Management Practices on Performance of Teachers Service Commission[J]. Journal of Hubei Radio & Television University, 2018.

[6] Zhang Aiqing, Wang Min, Wang Wei, Ma Shi'an. Application and Effect Analysis of Mixed Teaching Mode in the Teaching of Advanced Mathematics[J]. Education and Teaching Forum, 2019(25): 189-190. (In Chinese)

[7] Liu Xin. Analysis and Research on Teaching Methods of Higher Mathematics Courses[J].Heilongjiang Education(Theory & Practice), 2019(05):69-70.(In Chinese)