

## Research on research-based teaching of higher mathematics

Yi Liu<sup>1</sup>, Xiaobo Liu<sup>2,\*</sup>

<sup>1</sup>Ideological and political theory teaching and research Department, Jiangsu Police Institute, Nanjing, China

<sup>2</sup>School of information engineering, Nanjing Xiaozhuang University, Nanjing, China

\*Corresponding author

**Keywords:** Higher mathematics, research teaching.

**Abstract:** The research-based learning of mathematics should not only focus on the basic knowledge of mathematics, the basic skills and the basic methods of learning, but also reflect the fun and challenge of learning. Problems are the foundation and source of inquiry learning. In teaching, teachers should take cultivating students' problem awareness as the focus of teaching activities, make mathematical problems challenging, and thus constitute the starting point of research-based teaching.

### 1. Introduction

The purpose of higher mathematics education is not only to teach students some mathematical knowledge, but also to cultivate students' innovative consciousness and spirit. The inquiry teaching mode of higher mathematics is actually a simulated scientific research activity, which includes three interrelated aspects. On the one hand, it is a learning-centered learning environment; On the other hand is to provide students with necessary guidance; The third aspect is the mathematics experiment link about the inquiry principle applies to the practice, which is the quality education key. At the moment when the practical ability of students is strongly advocated, it is of great help to develop a good mathematical experiment course and guide students to experience the characteristics and charm of the tool subject of basic mathematics in the experiment, so as to improve students' learning interest and exploration spirit.

### 2. Characteristics of research-based teaching of Higher Mathematics

#### 2.1 Incentive of interest

An important prerequisite for students to take the initiative to carry out research-based learning of mathematics in teaching is to be good at stimulating students' interest in learning. With students' enthusiasm for research-based learning, learning activities are not only not a heavy burden for them, but also a pleasant experience. The more students learn, the more they want to learn.

#### 2.2 Guidance from teachers

As we all know, Abstract mathematics content sets a high threshold for students' learning, not to mention the research-based learning of mathematics, which is beyond the traditional learning method, but also a learning in the meaning of problem analysis and solution based on inquiry. Therefore, when students are confronted with various questions and mistakes in the process of research-based learning, teachers need to give timely guidance and help students. On the other hand, teachers should not stop students from doing their own research for fear that they will make mistakes.

#### 2.3 Process monitoring

Like other kinds of learning, research-based learning of mathematics is also a kind of learning under metacognitive control. It requires students to discover research topics and look for research clues, conduct research on their own, and exchange and evaluate the research conclusions obtained.

Students should consciously reflect on the real problems encountered in the process of research-based learning. To this end, teachers should guide students to constantly summarize experience, and guide students to make regular self-examination, self-evaluation and self-improvement in the formulation of research programmes, and the implementation of research plans, and the improvement of research methods.

### **3. Research teaching practice of higher mathematics**

Creative mathematical thinking forms the basis of inquiry learning. First of all, we should strengthen thinking training, such as analysis, comparison, Abstraction, analogy, imagination, generalization and other specific thinking methods training, so that students can understand the laws and methods of mathematical thinking in learning. Secondly, teachers should pay attention to develop the creative quality of students' thinking. Mathematics, as a mode constructed by thinking on the basis of social practice, has strong creativity itself. Mathematical achievements and their forms are mostly composed of divergent thinking and convergent thinking, image thinking and Abstract thinking, intuition thinking and logical thinking. Therefore, the research-based learning requires students to comprehensively use a variety of thinking methods to understand mathematics, students should cultivate keen insight and rich imagination, in order to improve the flexibility and creativity of mathematical thinking.

#### **3.1 Research teaching process of higher mathematics**

From the perspective of the process of research-based teaching, it can be divided into the following three coherent links.

##### **3.1.1 The stage of problem creation**

In this stage, teachers can reveal contradictions and raise questions by holding lectures, case studies and discussion of problems, so that students can explore. Cause interesting math problems will stimulate students' strong desire to explore.

##### **3.1.2 The stage of independent learning**

Chen Xingshen pointed out that mathematics is the product of people's own thinking, and it sometimes takes a long time to think about mathematical problems. At this stage, teachers should set aside enough time so that students can think independently. Teachers should actively guide students to ponder over problems of methodological significance, such as types, nature and methods of solving problems, and guide students to develop the habit of qualitative analysis in the process of “collecting materials, determining plans, analyzing data, modifying methods, organizing and discussing, and improving conclusions”.

##### **3.1.3 The stage of communication and summary**

The teacher requires students to summarize and sort out the results of each study regularly, and finally form oral or written report materials, and discuss in different forms. Through discussion, teachers and students can pool their wisdom and finally achieve the goal of common improvement.

#### **3.2 Research-based teaching methods of Higher Mathematics**

Freshmen who have just entered the university tend to be superstitious about books and authority and tend to be satisfied with the traditional learning model of “teachers speaking and students listening”. However, according to the results of questionnaires and interviews, students agree with and welcome the “research-based” learning model. Then how to make the students experience the research-oriented learning experience and develop their research consciousness and research ability is a very meaningful subject.

##### **3.2.1 Establish a modular course teaching system**

Establish a modular course teaching system. For example, Algebra: Complex Numbers and

Vectors, Matrices and Determinants, Systems of Linear and Nonlinear Equations. Differential: including Derivative and Partial Derivative, Extreme Value and Curvature, Mean Value Theorem and Taylor Series Algorithm and its application. Integration: including the Numerical Calculation and Application of Various Line Integrals, Multiple Integrals and Surface Integrals. In addition, it is necessary to integrate classical contents, such as ordinary differential equations, linear programming, probability statistics, Laplace transform and the basic parts of fuzzy mathematics into a highly integrated module.

Students are not good at thinking and can not find problems in learning mathematics. Therefore, at the very beginning of teaching, a research environment is created by asking questions, and students' desire for knowledge is aroused by the high starting point of paying attention to phenomena and exploring the essence. Teachers should change the way they teach from "lecture" to "discussion". Before organizing students for discussion, teachers should collect, select, compile and classify typical questions in a targeted way, and carefully design the degree of difficulty. They should adopt the method of "easy first, difficult later" and hierarchical progression to arouse students' desire to explore. Almost every concept, theorem and formula in mathematics has some applicable conditions. If the corresponding conditions are confused, it will lead to conceptual errors and confusion. For example, in Calculus, how to use the parity of integrand and symmetry of integral region to simplify the integral calculation. In order to make students have a thorough understanding, teachers can design some discrimination questions or design a leading question with multiple solutions where students are easy to be confused, so that students can have a deep understanding of the internal relations between the theorem formulas.

### **3.2.2 Design the teaching process**

For a long time, due to the lack of "research consciousness and experience", students in the intellectual lack of development and creativity, but more performance for the reproducibility. We try to combine the "teaching process" with the "self-exploration process". In the class, we focus on the ideas and methods of analyzing and discussing research problems, while the micro learning content is put outside the class for students to learn by themselves. After class, combined with the teaching content, teachers and students discuss and determine specific research-based learning topics through lectures, co-learning supplementary materials, intensive reading of relevant literature and other ways. Teachers urge students to make full use of their spare time to explore independently, so as to cultivate students' research-oriented learning ability and optimize the quality of talents as a whole.

### **3.2.3 Use campus network to construct the second classroom**

Research-based learning should not be limited to extra-curricular subject research, but should be extended to the various space and time of learning. Research-based learning should become a normal learning method. At present, many colleges and universities have basically set up campus LAN, and mathematical research-based learning can make full use of this resource.

(1) Design concept: allows students to Calculus, Differential Equations, Linear Algebra, Probability theory and Mathematical Statistics, the Integral transform ideas and methods have a preliminary understanding, so that students can preliminarily master the basic knowledge of related disciplines, the basic theory and basic skills, students of Abstract thinking, logic reasoning, the reasonable operation and basic "study" ability can get better training, students integrate mathematical knowledge, to solve practical problems in engineering practice ability will be improved.

(2) Development goal: the campus LAN provides students with a virtual online classroom to listen to the lectures of famous teachers at home and abroad, so as to create a good environment for individual learning and research-based learning, and finally create a coherent learning platform with convenient search, clear navigation and rich resources.

(3) Course setting: By setting "learning objectives, learning content, review and summary, self-examination, innovation training" and other fields in the network home page, students can obtain personal notes, E-mail, learning information and resources, comprehensive exercises, large assignments of research topics and stage tests. In order to guide students to carry out research-based

learning, we have designed guidance content such as “one problem has multiple solutions, error discrimination, thought exploration, theorem application”. After the study, students can click “review summary” and “self-test” to make a comprehensive summary.

(4) Technical guarantee: the learning effect can be enhanced by properly adopting multimedia methods, such as video, audio, pictures, animation or virtual experiments, etc. The research-oriented learning question bank can be downloaded through the network to realize paperless answer, while teachers and students can exchange learning information through E-mail.

### 3.3 Research-based teaching cases

The research-based learning of mathematics should not only focus on the basic knowledge and skills of mathematics, but also reflect the fun and challenge of learning. In teaching activities, teachers should always insist on cultivating students' problem consciousness as a focus of teaching, so that mathematical problems constitute the starting point of research-based teaching. The teaching material of university mathematics contains a large number of research questions. Take calculus as an example, does the Derivative at the Discontinuous point of a function exist? What is the detailed relationship between the Limit, Continuity, Derivability and differentiability of Functions of Several Variables? Does Infinity and Infinitesimal exist objectively? How do people perceive it? Why are there so few ways to sum a series, but so many ways to collect it? How do you think of Constant Variation in differential equations? Why is Integral harder to learn than Differentiation? What's the idea of proving a function inequality with a formula? What are the common participation principles for determining the integral region of a double integral? What is the four-step method of drawing a plane curve in polar coordinates? How to distinguish the convergence and divergence of infinite products? and so on. Under the guidance of these questions, students will be consciously engaged in the research-based learning activities of learning, thinking and finding answers.

Case study of research-based teaching: exploring various problems and methods of seeking limits

Design idea: research-based learning refers to question-centered learning. However, the core of this learning method is whether it can raise questions that are challenging and attractive to students and make them aware of problems, which is the basis of structured research teaching.

Due to the limitation of the length of teaching materials, most teaching materials often scatter different methods to find the limit in the related knowledge points. Due to the lack of overall comparison and connection, students are likely to have a feeling that there are many methods to solve problems but they are very messy. In fact, the discovery and proof of limits is an interesting and challenging process. This question is not only helpful to enlighten students from familiar knowledge points to explore new problem methods, and help them find a variety of methods to solve problems, but also helpful to develop students to do a good habit of organizing and summarizing the knowledge.

Teaching objectives:

- a. Explore various problems and methods to find the limit of variables
- b. How to apply various methods to find the limit
- c. What are the characteristics of the application conditions and scope of use of each method

Process design:

- a. problem discussion

The teacher had better let the student collect the limit solution question and the method as much as possible before class, and writes the research study report separately with the group form. In class, teachers can take the form of a salon to discuss the research conclusions of each study group.

- b. problem solving

Common methods to find the limit:

- Use the definition of a limit
- Use the limit rule or function continuity
- Use the Cauchy's rule
- Use the two important limit formulas

Use the Squeeze rule  
 Use the monotone bounded criterion  
 Use the L 'hopital's rule  
 Use the Infinitesimal order to estimate  
 Use the Studs theorem  
 Use the Definite integral definition  
 Use the derivative definition  
 Use the mean value theorem of integrals  
 Use the Convergence of infinite series  
 Use the Taylor formula  
 Use the Substitution of variables or other methods  
 Combine the above methods to solve the selected example exercises (omitted)  
 c. problem extension

For each of the limits given above, can you explain the mathematical idea behind them?  
 (Questions are the result of positive thinking, as well as the motivation for in-depth exploration.  
 They are also the best stimulus to mobilize students' learning motivation and thinking initiative).

#### **4. Conclusion**

The introduction of research-oriented teaching concept of higher mathematics has become the consensus of many educational peers, which makes the teaching of higher mathematics meet the requirements of the times development and the requirements of lifelong learning. Research-oriented learning in teaching promotes the development and improvement of students' mathematical intelligence and literacy.

Traditional teaching method pays attention to the process of teaching and acceptance, while research-oriented teaching method is more conducive to students' deeper understanding of concepts and theories, to students' bold research and exploration of open questions, and to their cultivation and application of this spirit in future work practice.

#### **Acknowledgement**

This paper was supported by Qing Miao Project of Jiangsu Police Institute (JSPI2018QM), Priority Academic Program Development of Jiangsu Higher Education Institutions (PAPD) of Public Security, Key Construction Disciplines at the Provincial Level of Jiangsu during 13th Five-Year Plan of Public Administration, and Top-notch Academic Programs Project of Jiangsu Higher Education Institutions (TAPP).

#### **References**

- [1] Zhao Haitao, On the American model of learning ashamed of problems, *Global Education*, vol.12, 2004.
- [2] Lv Linhai, Wang Zhiming, Three implementation modes of research-based learning in mathematics, *Journal of Mathematics Education*, vol.2, 2004.