

# Innovation and Reform of Calculus Teaching

Yi Huang

Wuhan Technology and Business University  
Hubei, China

**Abstract**—Aiming at some disadvantages in calculus teaching, this paper summarizes the important significance of the reform of calculus teaching, and mainly discusses some measures of reform from the aspects of teaching content, teaching method, and teaching evaluation method. It is pointed out that the teaching of calculus should be based on modern educational technology, combine with the teaching of digital information, and the idea of mathematical modeling should be introduced into the classroom, which are effective ways to reform the teaching of calculus in colleges and universities.

**Keywords**—Calculus; Reform of teaching; Mathematical modeling; Computer software

## I. INTRODUCTION

At present, there are many problems in the teaching of calculus in colleges and universities in our country, such as "single means, low efficiency and disjointed learning". In the traditional calculus teaching class, the mode of teacher lectures, student listening to classes and examination scores has long solidified. Teachers explain the theorems and examples according to the invariable teaching materials, students are limited to listening, reading and practicing in the whole teaching process, and they lack the practical process of applying calculus to the practice and their own specialty. It curbs the development of learning ability and creative thinking.

In addition, there are more and more differences in the teaching contents and hours of basic courses in various specialized courses, and the demands of professional teachers for reform are also very strong. Calculus courses themselves are highly sequential, intrinsically linked, and systematic, which is in conflict with teaching what is required of the major, changing the content of the course, and the order of the class. So it's inevitable to adapt to the reform and to improve the level of teacher.

Therefore, it is imperative to innovate and reform the calculus teaching in colleges and universities in order to achieve the goal of "cultivating applied talents of higher technology with comprehensive professional ability and comprehensive quality". This article mainly carries on the reform from the teaching content, the teaching method and the teaching evaluation way, proposes that the calculus teaching should take the modern education technology as the platform, unifies the digital information teaching, at the same time, introduces the mathematics modeling thought into the classroom, so that the teaching of calculus can be advanced to a new level.

## II. SIGNIFICANCE OF REFORM

Calculus is an important basic course for college students. Francis Bacon, a famous British philosopher and scientist in the 17th century, stressed: "Mathematics is the key to science." The role of calculus teaching in the cultivation of innovative talents can be clearly seen from the positioning of calculus by Richard Crantt, a famous American mathematician. He believes that calculus is one of the great achievements of human thinking. This subject comes from the crystallization of human intellectual struggle for more than 2500 years. It is deeply rooted in many fields between human natural science and humanities, and promotes human beings to innovate in the process of understanding themselves and nature.

At present, the college entrance examination system is being reformed, which is very beneficial to calculus, and at the same time, the teaching of calculus is constantly reformed. It is believed that in the near future, the teaching quality of calculus will rise to a higher level in our country. Calculus not only occupies an important position in higher mathematics, but also is an important part of many interdisciplinary disciplines [1,2,3]. Therefore, it is of great practical significance to reform the teaching of calculus. On the one hand, the reform of university calculus course can improve the teaching quality of calculus and give teachers more time and energy for scientific research. On the other hand, the curriculum of calculus after reform can make students feel the great role of calculus in mathematics and natural science, thus arousing their initiative and enthusiasm, and promoting the teaching activities of calculus.

### A. *Tamp the foundation of many subjects in the other fields*

Mathematics is rigorous and precise, the Russian mathematician Alexander Rove, in his book "Math-its content, method, and significance", mentions that the mathematical conclusion itself is characterized by a very strict logicity. And mathematical reasoning has indisputable and certain precision [4]. Calculus, as an important milestone in the development of mathematics, inherits the precision of reasoning and the logic of conclusion. This characteristic is the tool and foundation for the construction of many other professional disciplines. Through the systematic study of calculus, freshmen can lay the foundation for other basic courses.

### B. *Help students to think innovatively*

Calculus, which has been summarized and refined for hundreds of years, can be used as a common scientific

language and tool in many other disciplines, and is very important to the formation of students' scientific methods and innovative thinking. In the reform of calculus teaching, it can always be run through the cultivation of innovative thinking of students. And enlighten their creative thinking at the same time of preaching, teaching and solving their doubts. The content of university calculus emphasize the development and movement, this is complementary to the phenomena and laws of many disciplines in the other fields. The mathematical ideas and methods contained in calculus are conducive to promoting students to form innovative thinking based on dialectical logic. Innovative thinking is the foundation of all scientific research and practical application of innovative activities, these potential initiative and innovative will lay foundation of making students become innovative talents.

### *C. Improve the comprehensive quality of students*

Having good mathematical quality is an important standard to measure the comprehensive quality of college students. We emphasize the training of innovative talents and the active development of innovative entrepreneurship education, if we do not have a solid foundation of "mathematical knowledge", it will be groundless and groundless water [5]. Students learn through systematic calculus, their learning and ability of various subjects grow like branches and leaves. At the same time, calculus comes from a summary of the laws of nature. Almost all fields of modern life are closely related to the development and application of calculus. Many concepts and theorems in calculus are introduced through practical application. On the one hand, we can let students understand the thought and connotation of calculus, and improve their ability and experience to solve practical problems through calculus knowledge. On the other hand, we can stimulate students to explore the essence of thinking through phenomena. Through induction and summary, the thinking mode of concrete-abstract-concrete is formed, so as to strengthen and improve the comprehensive quality of students.

## III. MEASURES OF REFORM

### *A. Reform the teaching material and select the teaching content*

First of all, on the basis of the existing teaching materials, combining with the specific conditions of the school, the practical content related to the current economy is added. The scope, depth and weight of teaching materials must as far as possible to meet the professional needs, can meet the needs of the application. Abstract concepts are expressed in simple mathematical and economic languages, and some examples are given which are closely related to the times. Mathematical software and economic modeling knowledge are interspersed in the teaching materials to enable students to master economic application tools.

Secondly, the textbook can use graphics and tables in moderation, and do not require strict requirements for relevant proofs. It's more valuable to help students understand what abstract theorems explain than proving theorems.

Finally, the textbook follows the idea of "concise and vivid", while fully considering the requirements of the students with high learning requirements, the contents that are considered to be "unimportant" are deleted from the calculus textbooks. For example, the concept of function, the nature of basic elementary function and so on, have been learned in middle school, only a brief review is needed to ensure the learning demand of the following content. The concept of limit can be defined as descriptive. The differential mean value theorem is explained by geometric method. Space surface and its equations are proposed as the geometric meaning of multivariate functions and the content is chosen in order to satisfy the need of calculus of multivariate functions.

### *B. Integrating theory with practice and incorporating the idea of mathematical modeling*

If students focus on theory rather than application, it will not fully reflect the importance of calculus. We can take advantage of the popularity of National Mathematical Modeling Competition for College students, integrate mathematical models into calculus teaching, increase challenging problems, stimulating students' interest in learning mathematics and applying mathematics. Let students learn how to find the essence of mathematics from practical problems, build models, and finally solve practical problems with mathematical knowledge. On the premise of not giving up the traditional advantage of paying attention to theory, the application of mathematics should be emphasized. This is a new teaching concept. It is not only the solution and expansion of several application problems, but also the fact that teachers must change their ideas, improve themselves, and allow this concept to run through the whole teaching process. combine with the cognitive level and the characteristics of professional knowledge of the students, fully mobilize the thinking of students, so that the mathematical model promote the curriculum, the curriculum integrate into life. This will greatly improve the enthusiasm and participation in learning of students, and enhance their practical ability, mathematical thinking ability and application ability.

For example, the slope of the tangent line and the velocity of the variable speed linear motion are introduced into the interpretation of the derivative, and the practical problems such as marginal analysis, elastic analysis and taxation are put forward as the application of the derivative. When teaching the extreme value and the maximum value of the function, we can start from the practical problem, enumerate some related optimization problems with the most economical material, the biggest profit and the lowest cost, and present the situation of mathematical modeling to the students. Then students discuss it in groups, and seek the solution, they will not only learn knowledge, but also experience the process of exploring, discovering, creating and solving problems, by building mathematical models to explain and solve practical problems in life. This will be an effective way to cultivate students' consciousness of innovation and mathematics application.

*C. Making full use of computer and mathematical software to realize the diversification of teaching methods and learning models*

Teachers should make full use of multimedia teaching courseware, which integrates graphic, text, sound, image and animation. On the one hand, it can increase the amount of information in the classroom and save the teaching time. On the other hand, it can enhance the intuition, vividness and inspiration of classroom teaching, so as to improve the efficiency of classroom teaching. For example, for the review of the function in Chapter 1, the teacher can show the pictures of the six basic elementary functions on the multimedia, remember the images, observe the images, explain the application of the images properly, and teach around drawing the images of the elementary functions. If we can draw the images of elementary functions, we can grasp the properties of elementary functions thoroughly, so the application of derivative and differential is not difficult to realize. The practice shows that the combination of modern teaching means and traditional teaching means not only improves the teaching efficiency and teaching quality, but also alleviates to a great extent the contradiction between the curtailment of classroom teaching hours and the variety of teaching contents.

Students are encouraged to study the concepts and theorems of calculus by computer, calculators and mathematical software, and to study the properties of functions. It is hoped that students will learn to solve practical problems with the help of computers and mathematical software. Appropriate amount of laboratory study can be set up. Students can do "mathematical experiment" by using their brains in the computer room, and observe what the textbook tells.

For example, limit is one of the most important and difficult problems in higher mathematics teaching. If we can make full use of computer teaching software, such as Mathematica, Matlab, C++ and other scientific calculation and simulation platform, the dynamic process of sequence changing with the number of items  $n$  can be displayed vividly and vividly by means of mathematical experiment. Students can participate, practice and experience what is "infinite proximity" in person, which enhances their understanding of mathematical concepts, and make them feel the fun of mathematics.

For another example, when we explain Taylor formula, we can let the students do the following experiments on the computer. Drawing images of  $y = \sin x$  and some

approximate polynomials  $y = x - \frac{x^3}{6}$ ,  $y = x - \frac{x^3}{6} + \frac{x^5}{120}$ ,

$y = x - \frac{x^3}{6} + \frac{x^5}{120} - \frac{x^7}{5040} + \frac{x^9}{362880}$  in a coordinate

system. Under the guidance of the teacher, the students can find the function approximating to polynomial with higher degree better. It fully embodies their subjective initiative, enhances the comprehensibility and visual display of complex problems, and cultivates their interest in learning.

*D. Diversified the teaching mode*

The single teaching method is easy to cause the classroom low efficiency. The students are in a passive learning state, they accustomed to the teacher teaching and lack of research-oriented attitude, there is a serious division between the two grades of the students. Therefore, a variety of teaching models can be introduced, such as discovery teaching model, self-learning guidance teaching model, cooperative learning teaching model, mastering learning teaching model and so on. Teachers can teach in large classes, discuss in small classes, and promote small class teaching. In teaching the problem of "reducible differential equations", try to send a pre-made video of the fish lightning strike ship to the students in advance, and add animation, background, model and other content to improve the viewing and vividness of the video. Through preparing before class, and then discussing in class, the students will have a deeper understanding of this kind of problem.

Promote the use of micro class, MOOC, SPOC and other forms of teaching. The role of teachers should be changed from the traditional teaching to the tutoring position which combines teaching and solution, and the role of students will emphasize more on the subjectivity and initiative of learning [6]. The key point is to improve the learning atmosphere, improve the teaching quality of calculus, and establish multi-path communication channels and solutions between teachers and students. So that the vast majority of students can choose the most suitable model from the multi-mode teaching form, and their learning efficiency are improved.

*E. Make the operation mode diversified and reform the examination system*

Homework is the test and review of the effect of classroom learning, and also an important indicator of performance evaluation in peacetime. The content of homework should be changed from "dead questions" in books to "living questions" that cannot be found in books and which cannot be copied by students [7]. For example, we can increase the inquiring homework such as case analysis or mathematical modeling, arouse students' enthusiasm and initiative in learning, change their study habits, and change passive learning into active learning.

A variety of assessment methods should be introduced, such as ordinary tests, small papers, mathematical experiments, conversations with students, students' performance in group learning, and so on. Although there is also examination, but it accounts for a reduced proportion in the examination system. The combination of various examination methods, can examine students from many aspects, which can reflect their mastery of knowledge more objectively than a single examination. And it also changes students from the traditional mode of pursuing calculation skills and memory formulas to the pursuit of understanding of concepts and the application of mathematical knowledge.

*F. Speeding up the construction of the comprehensive double division team "Mathematic-Economic Management" integrated*

For the teaching of economic calculus, besides having solid knowledge of mathematics theory, teachers also need to be familiar with economic and management and other related fields, and have certain practical experience. Only in teaching can the economic application examples in real life be introduced to illustrate the instrumental nature of mathematical knowledge. Therefore, the school should make mathematic teachers study or train, accept economic management knowledge, so as to exchange and promote each other, so that their knowledge and ability become more and more perfect. Of course, in the course of reform, we should also pay attention to the fact that calculus is after all a mathematic course with the characteristics of mathematic curriculum. In the course of reform, it is necessary to combine teaching with the major of economics, not to give up the study of mathematic knowledge, but to make students master the ability of using mathematic knowledge to solve economic problems in the course of dealing with mathematic knowledge well. Only by making students learn and use mathematics well, teaching goals can be achieved.

#### IV. CONCLUSION

Cultivating innovative talents in colleges and universities is an effective means to improve the level of national development. Calculus is a core basic course, and its teaching reform is beneficial to the improvement of students in many perspectives like innovative thinking, innovative personality, innovative ability and comprehensive quality. In the teaching of calculus, reform the teaching material and select the teaching content; integrating theory with practice and incorporating the idea of mathematical modeling; making full use of computer and mathematical software to realize the diversification of teaching methods and learning models; make the operation mode diversified and reform the examination system; speeding up the construction of the comprehensive double division team "Mathematic-Economic Management" integrated. These measures will benefit the cultivation of innovative talents in various fields.

In the course of the reform of calculus, in addition to the points listed above, there are still a lot of things to be done. For example, we should reform the way of learning [8,9,10], change from teacher-centered to student-oriented, then

teachers and students learn together. It is also worth studying the contradiction between mass education and student personality development. Some colleges and universities are trying hierarchical teaching, offering different calculus courses for students. In a word, the teaching reform of Calculus is endless. As the teacher of this course, we should always combine the teaching reform of Calculus with the daily teaching and research, constantly renew the teaching concept and make due contribution to cultivating scientific and technological talents with higher mathematic quality.

### Acknowledgment

This article does not contain any other published or written works or results, individually or collectively. I am personally responsible for the contents and fully aware that the legal consequences of this statement are my responsibility.

#### REFERENCES

- [1] Ellie Darlington, Jessica Bowyer. Decision Mathematics as Preparation for Undergraduate Computer Science[J]. *International Journal of Modern Education and Computer Science*, 2017, 9(4):1-11, 2017
- [2] Baldwin, D., Walker, H.M., and Henderson, P.B. 2013. "The roles of mathematics in computer science", *ACM Inroads*, 4(4), 74-80.
- [3] Nuffield Foundation. 2012. *Mathematics in A-level assessments: A report on the mathematical content of A-level assessments in business studies, computing, economics, geography, psychology and sociology*. London.
- [4] Alexander R. *Mathematics-its content, methods and meaning*[M]. Beijing: Science publishing house, 2008:69-82.
- [5] Zheng L.C. & Y.Zhang. Research and practice of cultivating scientific thinking and innovation ability of students[J]. *College mathematics*, 2014, 30(2):43-47. (in Chinese)
- [6] Yixun Shi, "Problem Solving, Computer Technology, and Students' Motivation in Learning Mathematics", *IJEME*, vol.1, no.1, pp.1-5, 2011.
- [7] Wu H. & Z.W.Bi. Exploration and practice of diversification of calculus operation mode under innovation system[J]. *College mathematics*, 2013, 29(3):5-8. (in Chinese)
- [8] Jamal Raiyn. Developing a Mathematics Lesson Plan based on Visual Learning Technology[J]. *International Journal of Education and Management Engineering*, 2016, 6(4):1-9.
- [9] Mohamed Salim Trigui, Daniyal M. Alghazzawi. Learning the related mathematics to Cryptography by interactive way[J]. *International Journal of Modern Education and Computer Science*, 2012, 4(2):8-14.
- [10] Li Chang-xing. Research and Reflections on College Mathematics Teaching Based on Information Educational Technology[J]. *International Journal of Education and Management Engineering*, 2011, 1(2):43