Discussion On Teaching Reform Of Calculus In Engineering Science Major

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***Abstract*—Calculus is one of the most important and fundamental courses for students of engineering and science. This paper puts forward some suggestions on teaching reform of calculus course from the aspects of adjusting teaching contents, improving teaching methods and adjusting assessment.**

Keywords—Calculus; Engineering Science Major; teaching contents; teaching strategies; assessment

I. Introduction

Calculus (most universities of China is called advanced mathematics), one of the common mathematics courses, is one of the most important and fundamental courses for first year students of engineering and science. The aims of the courses are to give students basic knowledge of the concepts and theories of calculus, understand the idea of analysis, develop skill in corresponding computations and learn to work independently. High-level students are expected to have the ability to analyze problems, apply mathematical tools to establish mathematical models, and use calculus to solve the problems with the help of computers. The course must also prepare students for further study in other courses. In our university, Calculus is a two semester compulsory course for the first year engineering and science students. The course contains 128 hours of lectures. The course topics include functions, sequences, limits, continuity, derivatives and differentials, integrals, differential equations, series, etc.

In my university, the current most of teaching approach is teacher-centered. The teacher plays a leading role and transfers information. Teachers present lectures by introducing definitions, proving properties and theorems and giving some examples for computations and applications. In the ordinary way, the teacher gives the physics or geometric background of a concept before he write down its definition on the blackboard. The primary ways students' learn calculus is by attending lectures, taking notes, reading textbooks, doing homework and asking questions. At the end of each semester, students take a closed-book examination, then students gain their final marks from the examination and their homework throughout the semester. The total mark is 100, and its distribution is 70 for the examination and 30 comes from the assignments. If a student's final mark is less than 60, he fails the course.

In recent years, colleges and universities continue expanding the enrollment. The number of students has constantly increased. Simultaneously, the quality of students generally becomes worse. Most students find it difficult to learn Calculus and each semester more than 20%-40% of students fail this course. Then, many students have no interest in learning Calculus, and someone think it is abstract and useless. In order to change the current situation of students' learning Calculus, taking appropriate measures and improve the quality of teaching has become an urgent need to solve the problem in the teaching process.

II. Improvement Strategies

A. Adjust the teaching contents

From modern perspectives and new mathematical thinking, there are many problems worthy to study, research and practice in teaching contents. The traditional teaching contents have been investigated and some new methods for processing, simplifying, adjusting teaching contents and adding modern practical knowledge are proposed. According to the mathematics foundation of the current students in my university, Calculus course need not too subtle $\varepsilon-\delta$ method, unilateral limit and the infinite limit strictly proved. Kinds of strange series convergence tests, such as integral test method also are not need to talk about. The 'limit' is a basic concept in calculus and it will be used in the later content of calculus and other mathematical courses. But many students are confused by what the limit is, even if the rigorous $\varepsilon-\delta$ definition is given. In fact, the mathematical concept of limit is a particularly difficult notion. One of the great difficulties in the teaching and learning of the limit concept lies not only in its richness and complexity, but also in the extent to which the cognitive aspects cannot be generated purely from the mathematical definition[1].

If we give up some abstract definitions, it is necessary to add mathematical experiments and other content in Calculus. We can teach students how to use mathematical software (such as Mathematica, Matlab, Maple and so on). Processing real life data are fast and easy using software, so students will feel mathematics is useful. The ability to solve seemingly complex problems under the instruction of tutors will make students more confident, and using the pictures and animation will make the course more interesting, so that students will not find the class boring. For example, by plotting graphs or making computations with Mathematica and so on, students can preview lessons more effectively than if they only use pen and paper.

Example 1 Make $x^2+y^2=z^2$ and $(x-1)^2+y^2=1$ intersection graphics.

Input:

```
g1=ParametricPlot3D[{r*Cos[t],r*Sin[t],r},
{r,-3,3},{t,0,2 Pi},DisplayFunction->Identity];
g2=ParametricPlot3D[{2Cos[u]^2,Sin[2u],v},
{u,-Pi/2,Pi/2},{v,-3,3},DisplayFunction->Identity];
Show[g1,g2,DisplayFunction->$DisplayFunction]
```

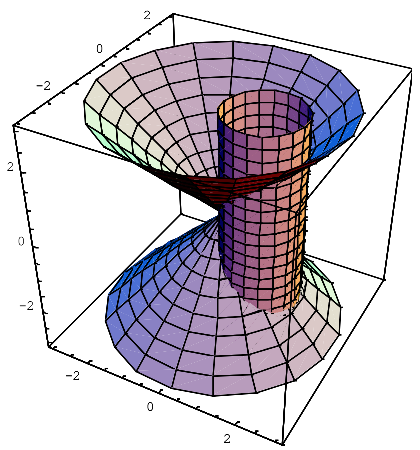

Fig. 1

Obviously, plotting this pictures on a blackboard is time consuming and difficult, whereas using software is accurate, easy and beautiful. By using computers, students will not worry about numeric computation. With the help of computers, students are learning Calculus better and more effectively with deeper understanding .

B. Adjust the teaching strategies

Lester [2] identifies three types of frameworks used to support and guide research into mathematics education: theoretical, practical, and conceptual. And he shows 'a conceptual framework is an argument that the concepts chosen for investigation, and any anticipated relationships among them, will be appropriate and useful given the research problem in investigation'. Conceptual understanding which refers to an integrated and functional grasp of mathematical ideas. We think that there are different ways to develop mathematical proficiency, but each way involves the construction of a web of connections of relationships and meanings associated with concepts and operations. As you know, the 'derivative' is a basic concept in calculus and it will be used in the later content of calculus and other mathematical courses. Thurston [3] identifies several different related ways of developing proficiency in comprehending and using the concept of derivative:

(1) Infinitesimal: the ratio of the infinitesimal change in the value of a function to the infinitesimal change in a function.

(2) Symbolic: the derivative of $\sin x$ is $\cos x$, etc.

(3) Logical: $f'(x)=\lim_{h\to 0}\frac{f(x+h)-f(x)}{h}$

(4) Geometric: the derivative is the slope of a line tangent to the graph of the function, if the graph has a tangent.

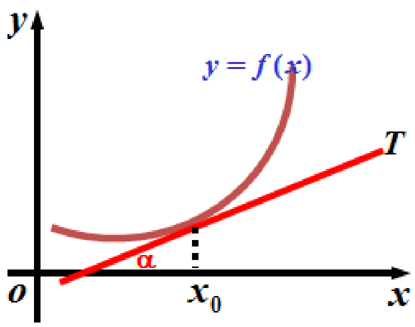

Fig. 2

(5) Rate: the instantaneous speed of $f(t)$, when t is time.

(6) Approximation: The derivative of a function is the best linear approximation to the function near a point.

(7) Microscopic: The derivative of a function is the limit of what you get by looking at it under a microscope of higher and higher power.

If students relate and cognitively integrate the different interpretations and meaning of this concept into a whole, a robust comprehension of the derivative concept takes place.

Albert Einstein said: 'ask a question more often than to solve a problem is more important.' Learning mathematics is not only learning rules, statements and definitions, or demonstrating theorems using them in the solution of problems. Learning mathematics is also solving a challenging problem, trying different strategies and finding a shorter and simpler way to come to an exact conclusion. Mathematical modelling plays a very important role. The mathematical modelling approach to problem as follow:

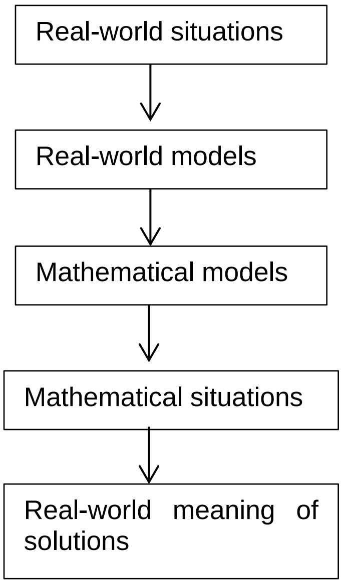

Fig. 3

Mathematical modeling activity, which can enlighten innovation consciousness and creative thinking, is one of the best way to improve students' mathematics application ability.

C. *Adjust the assessment*

As you know, assessment is a significant component of teaching and learning. Our aims of assessment will mainly be to stimulate students to work hard and produce deep level learning. The traditional assessment is mainly determined by the final closed-book examination at the end of each semester. In the end few weeks for the examination, some students study very hard and they often successfully pass the examination, but forget most of the knowledge as soon as they have finished the test. There are exist so-called 'high mark but low ability' phenomena. This assessment does not evaluate students properly. We should base more assessments on students' learning processes and assess their understanding at frequent intervals throughout the learning processes, meaning the final examination scores should be reduced in importance.

Table 1 Original and new assessment of numerical compare

Original assessment	**New assessment**
Homework 20%	Homework 10%
	Mathematical experiments 15%
	Student's ordinary performance15%
Final examination 80%	Final examination 60%

ACKNOWLEDGMENT

This work was supported in part by the Educational Reform Research Fund of Hunan University of Humanities, Science, and Technology(no. RKJGY1526).

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