

Teaching Reform of Calculus Course for Students of Petroleum Science based on Research Oriented Teaching

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Abstract:

The calculus is an important basic mathematics course for the students of engineering colleges. A research oriented teaching reform of the calculus course of petroleum science specialty had been carried out from the aspects of teaching cases design, classroom teaching, and assessment, in order to get rid of the problems of traditional teaching methods. The teaching reform has been proven successful and effective by the teaching practice of calculus experimental classes of Yangtze University in recent years. It can help the students to improve their abilities of understanding and application the calculus knowledge. It also can help the students to learn the specialization knowledge related with petroleum science easier in the rest years in the University.

Keywords

Teaching reform; Calculus course; Petroleum science; research oriented teaching.

1. Introduction

The research oriented teaching is a relative new teaching method which combine teaching, researching, and studying together. It aims at training the innovative spirit and ability of innovative, comparing with the traditional teaching method [1]. The teachers act as guiders, in the research oriented teaching, guiding students to put forward problems based on learned knowledge and analyzing problems during study. Students become self-developing and creative person by learning how to solve the practice problems [2]. The calculus is an important basic mathematics course for students of engineering college. It is not only an important carrier for cultivating the abilities of logical thinking and learning of students, but also an important foundation for students to follow up on their professional knowledge. It is also an important mathematical tool for further study and research [3]. Currently, most teachers of colleges are still using the traditional teaching mode, which is “teacher presentation, while

students listening”. It is not good for cultivating the abilities of independent thinking and innovation ability of mathematical knowledge [4]. Therefore, it is necessary to employ new teaching mode to change the passive acceptance of students, and to develop students’ thinking and application ability. Petroleum science disciplines are the characteristic disciplines of our university, which include the Geophysics, Geology, Petroleum Engineering, and other petroleum-related specialties. There are about 2,000 students in the Petroleum science disciplines in our university. The calculus is a critical important mathematical tool for the petroleum science.

In this paper, we present the methodology and the teaching case of research oriented teaching of the calculus in petroleum science. The teaching practices show that our research oriented teaching reform is successful and effective.

2. Methodology

2.1 Research oriented teaching framework

The research oriented teaching has three main parts, research on teaching syllabus, teaching including classroom teaching and practice teaching, and assessment method. The teaching part is the most important one of the research oriented teaching. It contains several teaching cases. The teaching method for each case consists of three sub-modules, Design which means teacher put forward the problem need to study and solve, Implement which means students study and solve the problem put forward by teacher, and Reflection which means teacher and students discuss and summary together. The framework of research oriented teaching is illustrated in Figure 1.

2.2 Design teaching cases

We design the research-based teaching cases, which are listed in Table 1, according to the knowledge system of higher mathematics and the characteristics of petroleum science.

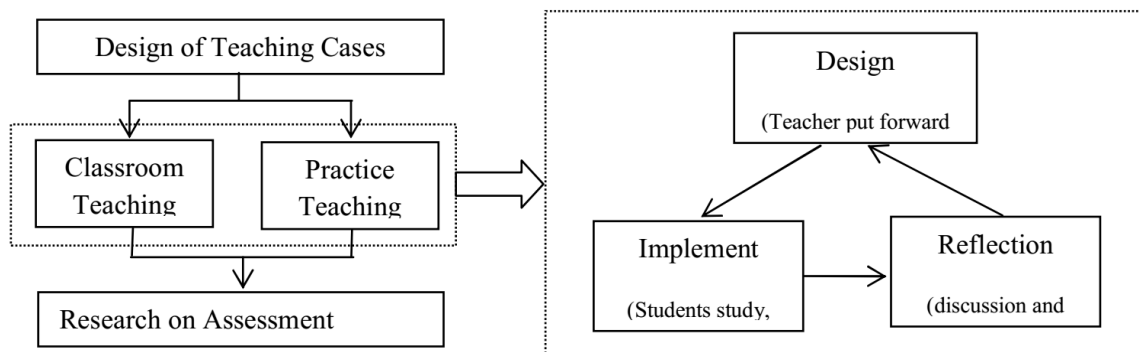


Figure 1. Research oriented teaching framework

Table 1. The teaching cases for the research oriented teaching of calculus

No.	Knowledge	Research Oriented Teaching Case
1	Functions and Limitations	Limitation in petroleum science
2	Derivative	Edge detect for the potential anomaly
3	Integral	Use integral to calculate gravity anomaly
4	Spatial Analytic Geometry	Scientific visualization, how to calculate the interface of two curve space
5	Differential Calculus of Multivariate Functions	Gradient descent method in the optimization in petroleum science
6	Integral Functions of Multivariate Functions	Understand the Maxwell Equations
7	Ordinary Differential Equation	Use ODE to solve the geophysical forward problem
8	Infinite Series	Fourier Series and its application

2.3 Classroom teaching

(1) Design

In the problem design stage, teachers put forward a problem, which is associated to the learned knowledge and new knowledge, based on the teaching plan and classical teaching case. The students could active think about and solve the problem.

(2) Implement

In the implementation stage, the teacher should guide the students to divide into groups forming learning atmosphere and discussion. The students in a same group cooperated each other. At this stage, teachers act as collaborators, coordinators, counselors and inspectors, who identity students learning process to track.

(3) Reflection

In the reflection stage, both students and teachers should reflect deeply. The teachers mainly reflect on the problems in the research based learning and the organization discussion. The students summarize the obtained knowledge and method, abstract them into mathematical theory and methods, and form a comprehensive knowledge system gradually.

2.4 Practice teaching

Although mathematics does not like the physics, chemistry and specialized courses which has many experiments, We could add practice teaching in the higher mathematics course, such as digital experiments and mathematical modeling, which not only could help students to understand the learned knowledge, but could cultivate the students' mathematical practice ability. Digital experiment is a new experimental method, which is used to help students to master knowledge and solve the mathematical problems using mathematical software. The purpose of digital experiment is to improve the enthusiasm of students to learn mathematics and the students' abilities to understand and solve practical problems with the knowledge of mathematics and computer technology. It is the effective way for the students to understand the laws and skills of mathematics [5].

Matlab [6] is a useful and open source free mathematical software, which has the advantages of easy learning, powerful graphic functions. Students try to use Matlab to solve the mathematical problems after they understand the basic mathematical concept. It is an effective way for the students to practice the their mathematical

knowledge using Matlab to do the digital experiment [7].

2.4 Assessment method

The focus of research oriented teaching is the teaching process rather than teaching results. Therefore, the evaluation method should be changed from summative evaluation to procedural evaluation [8]. The evaluation of students should also be transformed from a final closed-book examination to a diversified assessment mode. It should be a comprehensive evaluation from aspects of basic knowledge, basic ability, basic methods, and basic ideas, and be carried out during the whole implementation of research oriented teaching.

We designed a assessment method for the research oriented teaching of higher mathematics, which consisted in 3 parts, Attendance, Assessment for the study process, and Final Exam, listed in Table 2.

Table 2. The assessment method of the research oriented teaching

Item	Description	Scores
Attendance	A ≥ 90%; B ≥ 75%; C ≥ 60%; D < 60%	10
Assessment for the Study Process	Homework	10
	Quiz	20
	Group Research orient study	40
Final Exam	Traditional Final Exam	20
Total Score		100

3. Examples of Research Oriented Teaching Cases

In mathematics, a partial derivative of a function of several variables is its derivative with respect to one of those variables, with the others held constant (as opposed to the total derivative, in which all variables are allowed to vary). Partial derivatives are used in vector calculus and differential geometry [9].

In general, it is difficult to understand the concept of partial derivative of a function for the freshman, letting alone how to use it. However, in the field of geophysics, the partial derivative is often used to detect the edge of potential anomaly. The total horizontal derivative (THDR) of potential field data is defined using partial derivative as follow [10],

$$THDR(x, y) = \sqrt{\left(\frac{\partial f(x, y)}{\partial x}\right)^2 + \left(\frac{\partial f(x, y)}{\partial y}\right)^2} \quad (1)$$

Model 1 is a single density model of a vertical hexahedron with the aim to test the peak sharpening effect of the method. Model parameters are: 80 m width in the east-west direction, 160m length in the north-south direction, and a burial depth of 10 to 50m. Figure 2 [10] shows the gravity data and its edge recognition result using THDR.

In the Figure 2, the actual boundary the geology body is marked as black rectangle. We can not locate the edge of geology body from gravity data directly, shown in Figure 1(a). However, we can locate edge of geology body from the THDR of the gravity data easily, as shown in Figure 1(b). From this example, students can understand the concept and usage of the partial derivative much more easily.

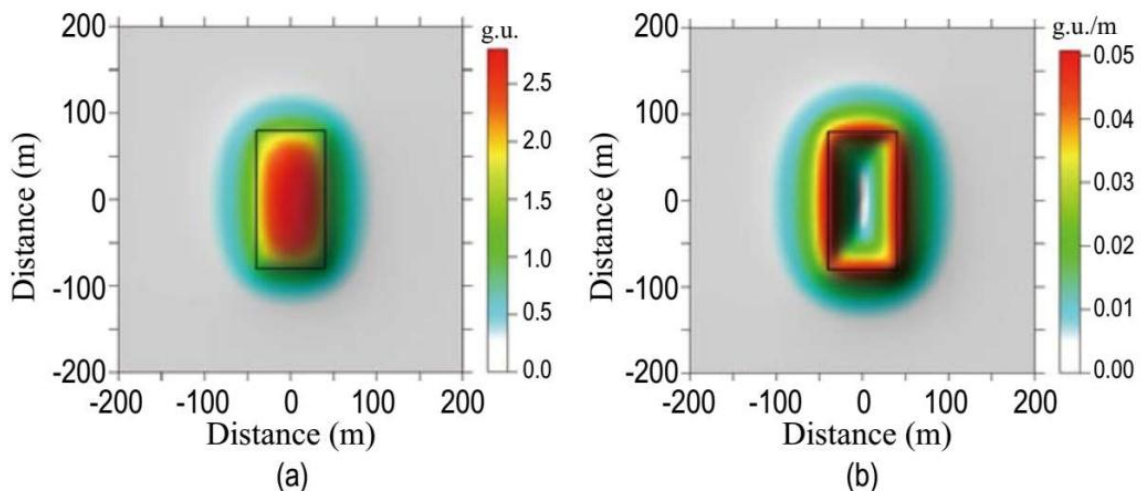


Figure 2. Gravity data and its edge recognition result using THDR (a) Gravity data; (b) edge recognition result using THDR [10]



5. Conclusion

A research oriented teaching reform of higher mathematics course for the petroleum science was carried out from the aspects of teaching cases design, classroom teaching, practice teaching, and assessment methods. After the methodology was proposed systemically, several teaching cases of the higher mathematics in the petroleum science are described in detail as examples. The teaching reform was proven effective and successful by the teaching practice of freshman mathematical experimental classes of Yangtze University in recent years. It improve the students' abilities of understanding and application the mathematical knowledge. It helps students to learn the specialized knowledge in the field of petroleum science easier in the future.

Acknowledgments

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