

Research and Practice on Teaching Reformation of Engineering Mathematics in Application-oriented Colleges

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Abstract. Engineering mathematics is a branch of applied mathematics which is an important fundamental undergraduate course of science and engineering majors in most colleges and universities, especially the application-oriented colleges. Combining the age backgrounds, the current status for teaching of undergraduate engineering mathematics is analyzed. Thoughts and methods for course reformation are put forward under the new situation. According to the experimental teaching reform revelation, auxiliary course of computer simulation experiment is set up to stimulate the innovation ability of student. The practice proved that simulation experimental reform has great effect on helping student to master the abstract concept and solve the practical problems.

Introduction

Along with the continuous expansion of institutions of higher education in enrollment scale, our country's higher education has entered the popularized education stage from the elite education stage, while the social demands of application-oriented undergraduate students are increasing [1]. At present, applied engineering colleges and universities have always been deepening curriculum reform by optimizing the curriculum system, in order to meet the needs of developing social. There are more than 2,500 colleges and universities in China [2], in which the higher engineering technology education is in the largest scale and involved in most majors, in order to satisfaction the needs of current developing economy for application-oriented personnel training. The importance of engineering mathematics curriculum reform is self-evident. It's not only the footstone for foundation application, but also the source of innovation. All the questions and solutions depend on the understanding and mastering of engineering mathematics.

Engineering is a practical discipline that deals with application of scientific principles and experience to meet social demands within physical economic, manpower, political, legal and cultural limits [3]. Based on engineering science and technology, undergraduate engineering education aims to produce qualified employee who are skilled in transforming theoretical achievements into productivity and capable of solving practical problems. Compared with academic researches specializing in theoretical research, application-oriented personnel should possess not only particular theoretical knowledge, but also the professional qualifications, the ability to link theory, knowledge and practice [4]. Application-oriented universities and colleges account for a major portion of higher education institutions in China.

Engineering mathematics is a branch of applied mathematics concerning mathematical methods and techniques that are typically used in engineering and industry [5]. Along with fields like engineering physics and engineering machinery, engineering mathematics is an interdisciplinary subject motivated by engineers' needs both for practical, theoretical work [6]. It is an important fundamental undergraduate course of science and engineering majors in most colleges and universities, especially the application-oriented colleges. It is therefore important to explore the practical teaching models for application-oriented universities.

Current Status of Engineering Mathematics Teaching

Big Difference in the Source of Students. Due to historical reasons, at present, the teacher–student ratio of application-oriented undergraduate college is generally low [3]. So that the engineering mathematics are usually implemented in large class with same teaching standards and requirements for all the students, even up to 100 ones, with different background and cognition degree. Undergraduate students are usually come from different provinces with different mathematical knowledge structure. For example, the students from some provinces master well at the concept of trigonometric functions, limit and derivative. While the other students master badly because these concepts are not in the compulsory outline of the college entrance examination. At the same time, the increasing enrollment of universities also leads to lots of incoming freshmen with mixed inconsistent learning ability. So it's difficult to totally control the difference of Individual scientific literacy, mathematical ability and learning psychology in such a large class with hundreds students.

Lack of professional teachers. Despite of the low teacher–student ratio of application-oriented undergraduate college, most engineering mathematics teachers are graduated from mathematics major, and they do not adapt to the current curriculum reform since lacking of knowledge of special engineering expertise [4]. Most teachers only mainly focus on teaching materials, don't know what and how the knowledge could be used in practical engineering, which leads to a disconnect gap between theoretical teaching and practical learning.

Reduction of Teaching Hours. In the process of higher education and curriculum reformation across the country, in order to meet the need for training of applied talents, some new courses are added into the outline of personnel cultivating program, while some old courses like mathematics must be delete or reduce in teaching hours in varying degrees. For example, the course of *linear algebra* and *complex variables functions* are all reduced to 32 hours in our school. Some teaching contents of certain chapters are omitted or simplified due to the limit of teaching hours in order to keep up with the teaching progress.

The impact of the Internet. With the rapid development of internet technology and the popularization of personal smartphone, student spend more time in surfing internet, and little time in learning, reading or even thinking [7-10]. Students are literally losing the precious ability of questioning and discussing. When do exercising, they just look up the answers at the back of the book or check it out in the internet. What they want is a direct definitive answer but the process of solving problems. But in the real process of innovating, there may no straightforward answer for the encountered problem, not even basic ideas by hand. If a student can't go through the process to think deep about it, analyze it, and research on it, but only blindly pursue the results online, he can get nothing useful eventually.

Exploration of Teaching Reformation

Teaching staff. As mentioned before, teachers from theoretical mathematics major cannot teach this course well because of lacking the relevant engineering experience. Limited by the knowledge structure of teaching staff and the shortage of teaching hours, it is very hard to explore a mathematical knowledge point deep enough into a professional level. We suggested that the course of engineering mathematics should be taught by professional teacher, as they know what is important relevant to engineering practice. For instance, the teaching staff of engineering mathematics in our school are all professional teachers from their respective majors. We have been teaching the course of *linear algebra* and *complex variables functions* in school of opto-electronic engineering since 2010. We introduced professional applications into curriculum content to stimulate the interesting of learning and obtained good teaching evaluation feedback every year.

Teaching Content. At present, the content of most popular text book is mainly basic theoretical knowledge, little contains professional applications. So we filled up and rearranged the instructional programme with professional applications and connections in between follow-up courses. The connections of *complex variables functions* and some other follow-up course are shown in Table 1. All of the knowledge points in our courses contains three parts of different levels: basic theory, augmented

knowledge and application examples. The last two parts is the extending content, which is usually connected to other courses or related to engineering practice.

Table 1 Integration scheme of *complex variables functions*

teaching content	correlated curriculum	semester
residue theorem	theoretical physics	5th
laplace transformation	electric circuit	3rd
z transformation	automatic control	4th
conformal mapping,	electromagnetism	4th
fourier transformation	Signals and Systems	5th

Teaching Method. In our country, the traditional exam-oriented education mode still prevails in university mathematics teaching, which is characterized by duck-stuffing cramming method. The teaching process include concept definition, theorem inference and example calculation. It's a teacher-centered cramming method where teaching is emphasized but learning is neglected. According to the experimental teaching reform revelation, we set up the auxiliary course of computer simulation experiment to stimulate the innovation ability of student. Some scientific research projects that related to this course are introduced in course and simulated with computer. For example, how can sine functions sum up into a square wave function is always a question puzzles student. So we wrote a Matlab program to simulate the situation. With more and more items are included, the sum is approaching the square wave function. Fig. 1 shows the result of 5 items are included. And how does water flow across a baffle plate is calculated with conformal mapping method. As shown in Fig. 2, the curves in the graph stand for filament line. The practice proved that simulation experimental reform has great effect on mastering the abstract concept and solving the practical problems encountered in campus study and daily life.

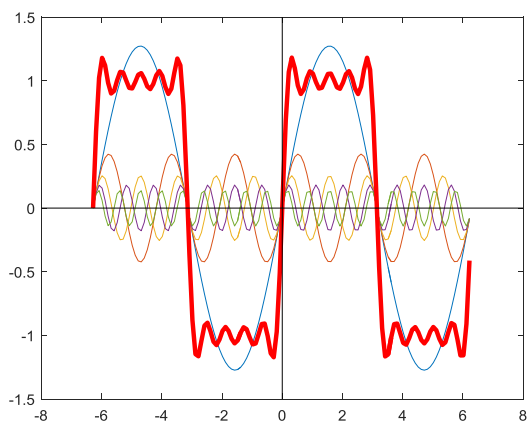


Figure 1. Simulation of fourier series

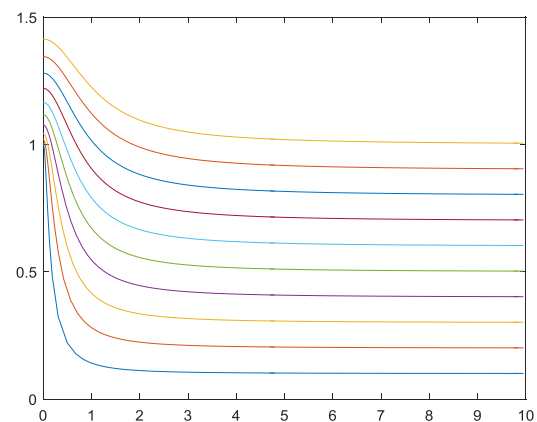


Figure 2. Simulation of conformal mapping

Teaching Medium. Massive open online courses (MOOCs) has been sweeping the world's higher education in recent years for the teaching and learning of different subjects [11-14]. However, MOOCs typically have low completion rates, at least when compared with traditional courses. Completion rates can be as much as 40%, but less than 10% is typical [15]. Small private online courses (SPOCs) is a viable option, which support blended learning and flipped classroom learning.

Summary

Over the years, the curriculum group has been paying attention to teaching content optimization and knowledge system reform. Students are interested in this course and changed from passive studying to initiative exploration. their problem solving ability and innovative ability are enhanced. The score and the assessment results of this course are promoted year by year.

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