EIMI 2010

Conference

EDUCATIONAL INTERFACES between MATHEMATICS and INDUSTRY

Proceedings

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Lisbon – April, 19–23
Portugal

Mathematical Modeling Courses and Related Activities in China Universities

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Abstract Mathematical modeling courses and related activities are the most important events in China university mathematical education in the last thirty years, which significantly changed, and will continue to change the contents and forms of mathematical education in China universities. This paper summarizes the history and current status of mathematical modeling courses and related activities (in particular, the mathematical contest in modeling) in China universities.

Introduction

In the last thirty years, due to carrying out Reform-and-Open Policy in the economic field, China's national economy has gained great achievements. However, the reform in China education system lags behind and is not as fruitful as in the economy field. As a result, the education system is oftentimes, especially in recent years, attacked and criticized in China by pointing out that the students graduating from colleges and universities lack innovation consciousness and creative abilities (Dan & Xie, 2009).

For example, in 1999, the Ministry of Education of China and the China Youth League cosponsored a survey for China students' creative thinking abilities among 19,000 students in 31 provinces (Ban, 2001). The survey revealed that only 4.7 percent students considered themselves to have curiosity, confidence, perseverance and imagination. Only 14.9 percent students hoped to cultivate their exploring spirits for new things, and to enhance their abilities of information collection and imagination. Only 33 percent students participated in practicing activities during their study life in schools. The proportions of the students with the initial creativity personality and creativity characteristics are as low as being 4.7 percent and 14.9 percent respectively. In addition to this, if a student raised an objection to his/her teacher in the class, 48.1 percent students thought that most students would keep silent, and 16.5 percent students even thought that most students would criticize the objector.

The findings from the survey clearly reveal that most students in China lack innovation consciousness. The reasons for that are surely complicated. One of the most important reasons might be that the schools and teachers in China put their attention on teaching the students only about the knowledge and skills, but neglect cultivating students' creative thinking ability. As a result of this kind of teaching styles, the knowledge and skills are the only pursue for students. The second reason lies in that the evaluation criteria in China schools neglect the student's individuality and personality development. For a long time, one thinks a good student is the only one who gets very high grades in his/her class courses, and the students with lower grades but more creative ideas are considered to have ridiculous thoughts. The evaluation criteria have suppressed students' personality development (Dan & Xie, 2009).

In more recent years, it is widely recognized in China that in order for the country to be able to obtain sustainable development, it is crucial to construct China into an innovative country. Since the education system shoulders the special mission in cultivating national spirit of innovation and the cultivation of creative talents, reforming the teaching styles and the evaluation criteria for students has attracted more and more attention in China. The prima-

ry objective of the reform is to regard the cultivation of the innovation spirit and practicing ability as the key of the education system (Dan & Xie, 2009).

As one component of the education reform in China tertiary education, mathematical modeling courses and related activities are highlighted as the breakthrough in mathematical education reform (Jiang, 1998; Xiao, 2000 & 2002). The reason behind this is that more and more mathematical teachers in China have recognized the importance and value of mathematical modeling teaching process and related activities. Therefore, mathematical modeling is gradually becoming the best bonding point to enhance students' mathematical knowledge and application ability. It is also an important way to enlighten innovative consciousness and thinking, as well as to train innovative talents (Dan & Xie, 2009).

In my own opinion, mathematical modeling courses and related activities are the most important events in China university mathematical education in the last thirty years, which significantly changed, and will continue to change the contents and forms of mathematical education in China universities. This paper summarizes the history and current status of mathematical modeling courses and related activities (in particular, the mathematical contest in modeling) in China universities.

Mathematical Modeling Courses

Origination and development

Before 1980s, the university mathematical education in China followed the 1950s' system of former Soviet Union in all respects, with the objective of passing on the knowledge of pure mathematics - from definitions and theorems to reductions and proofs. The teachers' teaching processes and the students' learning processes were both "examination-oriented", while the students' ability of using mathematics to solve real-world problems was highly neglected. As a result, most of the students, who usually loved mathematics very much at their primary and middle schools, were weary of the university mathematics as it was tedious and uninteresting (Jiang, 1998; Xiao, 2000 & 2002).

In early 1980s, as China opened to the world again, more and more mathematical educators in China began to pay attention to such phenomena and were eager to change the situation by learning from modern education system of foreign countries. Recognizing that mathematical modeling is a bridge between the real world and mathematics, some top universities in China started to offer mathematical modeling as an optional course. The contents of the course revealed intimate connections between mathematics and real-world

industrial problems. The teaching process of the course was to create an environment to arouse students' desire to learn and develop their ability of self-study, and to enhance their application and innovation ability. In order to improve the students' quality in mathematics, the emphasis was put on the students' ability of acquiring new knowledge and the processes of problem solving, rather than only knowledge and skills in pure mathematics.

Not surprising, the mathematical modeling course was very welcomed by students, and the students' interests in mathematics were recalled lively. Therefore the course obtained forceful support from the universities' administrations. However, due to lack of a strong motivation to change the conventional education style in most of the other universities, as well as lack of qualified mathematical modeling teachers and suitable textbooks, only about thirty top universities offered such courses before 1990, with only eight Chinese textbooks being published during this period (Jiang, 1998).

Popularization

In order to train teachers qualified for mathematical modeling courses and exchange the teaching experience among these teachers, China Conference on the Teaching of Mathematical Modeling and Application (CCTMMA) was organized every two or three years since 1986. In 1990, CSIAM (China Society for Industrial and Applied Mathematics) was founded, and within it a sub-society of mathematical modeling was established. CCTMMA was co-sponsored by this sub-society and the educational committee of CSIAM since 1991. They became powerful players in motivating and organizing the teaching of mathematical modeling. In 2009, more than six hundred teachers participated in the 11th CCTMMA, which was thirty times than the twenty participants in the first CCTMMA of 1986. CSIAM also has been organizing a national annual mathematical contest in modeling for undergraduates since 1992 (more details about the contest will be provided in next Section).

Currently, mathematical modeling courses are offered in about one thousand universities in different forms, which are more than half of all the universities in China. In the last decade, more than 110 Chinese textbooks on mathematical modeling were published, which are suitable to be used in courses for universities of different levels and students from different majors. In these textbooks, various industry problems are modeled as mathematical problems which can be solved with the students' knowledge learnt from their fundamental mathematics courses. Most of the university students, no matter which majors they enrolls in, can get some training in mathematical modeling. Furthermore, more than 200 universities have their own students' societies on mathematical modeling, and the societies are very active in the campuses for organizing extra-curriculum mathematical modeling activities by the students themselves.

Prospects

The teaching of mathematical modeling in China universities has been developing quickly. Below are some new trends we can see in the near future.

Mathematical experiments course

This course is related to mathematical modeling courses, but redesigned to make use of the mathematical experimentation on computers (Jiang, 2001). While the mathematical modeling courses usually consist of various cases from real-world industry, the focus of the mathematical experiments course is put on training the students to learn and use modern mathematical technologies. For example, in my university, this new course tries to integrate mathematical modeling and mathematical software with fundamental mathematical techniques in numerical analysis, optimization, and statistics. Popularization of mathematics software on personnel computers enhances students' numerical computing functions and image processing functions, which provides technical feasibility of the course and ensures the students' learning efficiency for such a course. More and more universities in China begin to offer this kind of courses recently, although up to now there are in different forms and with different contents in different universities (Jiang & Xie, 2007). In order to facilitate the course developments, more than 200 universities set up mathematical experiments laboratories dedicated to the courses.

Merging the idea and the method of mathematical modeling into the main mathematical courses in universities and colleges

This was a project supported by the Ministry of Education of China since 2002. There are usually three main (traditional) mathematical courses in China universities: Calculus, Algebra and Geometry, and Random Mathematics. They prefer to present everything rigorously and systematically, but usually with neither motivations nor applications. Reforming the main mathematical courses to merge the idea and the method of mathematical modeling is a much harder and more important task. The project's emphases are put on designing and writing feasible mathematical modeling modules, which include the explanation of the whole mathematical modeling process from real world problems so that they can be embedded or effectively used for the teaching of the main courses. Most importantly, the use of the modules will not disturb instructors' regular teaching but will stimulate and raise students' interest in studying the main mathematical courses (Jiang et al., 2007b). The project has already lasted for several years, but it is still just at the beginning, and there should be many efforts to be done in this direction.

Mathematical Contest in Modeling

Origination and development

Mathematical Contest in Modeling (MCM) first appeared in USA, which was organized by Consortium for Mathematics and its Applications (COMAP) in 1985. COMAP also initiated Interdisciplinary Contest in Modeling (ICM) in 1999. Teams from China universities have participated in the contest every year since 1989, and recently more than half of the teams of MCM and ICM are from China (Figure 1).

Recognizing the contest is beneficial to the students and helpful to the mathematics education reform in universities, CSIAM organized the first China Undergraduate Mathematical Contest in Modeling (CUMCM) in 1992. CUMCM is co-organized by CSIAM and the Ministry of Education of China since 1994, and from 1999, the contest has been divided into two categories — Group A for four-year university students, and Group B for two or three-year college students. The aim of the contest is to give students exposure to modeling process and to improve students' understanding of mathematics, mathematical modeling and experimentation, thereby providing an opportunity for the students to cultivate their creativity and problem solving ability (Jiang et al., 2007a).

Registered teams download the contest problems at the prescribed time through the CUMCM Website. In this three-day long (72 hours) contest, teams of up to three undergraduates students will investigate, model, and submit a solution to one of two modeling problems, which simulate real-word problems in engineering, management, etc. During the contest, teams are permitted to refer to any data source they wish, but they must cite all sources. Failure to credit a source will result in a team being disqualified from the competition. Team members may not seek help from or discuss the problem with their advisor or anyone else, except other members of the same team. When the contest ends, each team should submit a solution paper to the contest organizer for judging. Currently, only top 2% of the total solution papers will be awarded as the first prizes, with about next 6% as the 2nd prizes.

Popularization

Because of the very challenging nature of the contest, it attracts the most competitive students in China in an ever-increasing manner. Currently, CUMCM has become the most widespread extra-curriculum scientific activity for undergraduates in China. In 2009, there was participation by 15042 teams from 1135 institutions in the contest, representing almost all of the most prominent institutions and more than 50% of all institutions in China. It is

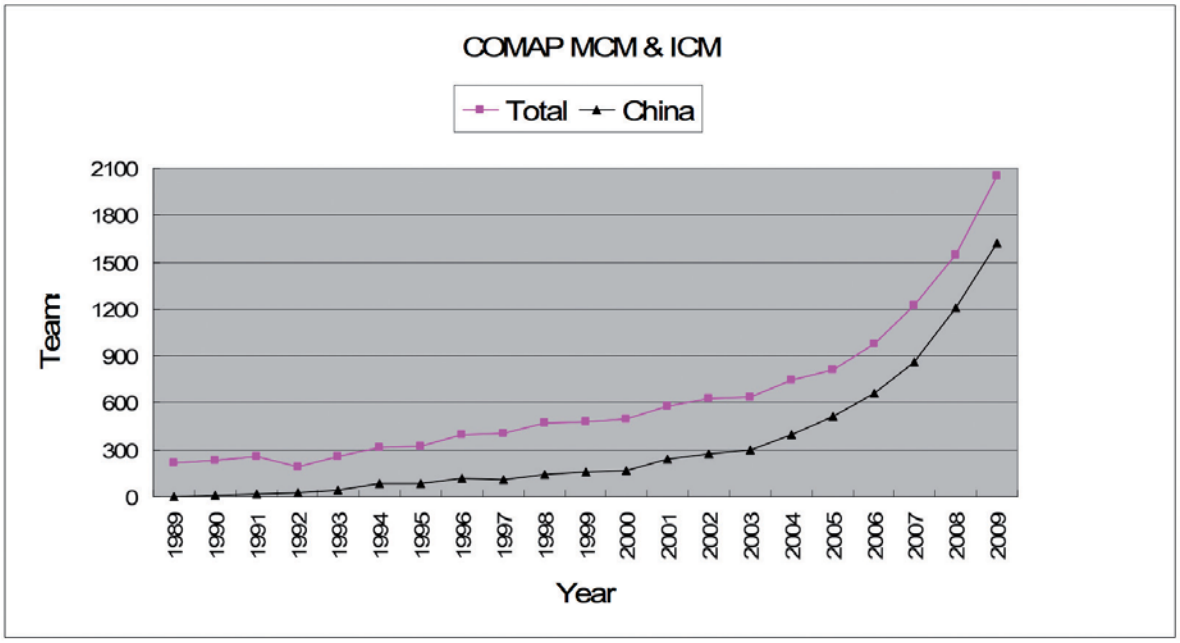

Figure 1—Number of teams participating in COMAP contests.

also interesting that more than 80% of the participants are engineering, economics, management, and even humanities majors, other than mathematics majors one might expect. Figure 2 plots the statistics on the numbers of institutions and teams participating in CUMCM. More details about CUMCM can be found in Li (2008), or from the Web site http://www.mcm.edu.cn (including all the contest problems used in previous years in English). We also welcome teams from other countries to join the contest.

In order to celebrate its 10th and 15th anniversaries, CUMCM organized university students' summer camps on mathematical modeling in 2001 and 2006 respectively. Many similar contests, with smaller sizes and dedicated scopes, are also organized by various organizers in China.

Influence

The contest is a real challenge to its participants and is very welcomed by the students. The special experience students have got during the contest is greatly helpful to tap their innovative potential and strengthen their cooperative spirit. The contestants conclude their experience with one sentence "Once participated, benefit for life long". The whole contest process consists of three stages, namely, the training and preparation before the contest, the hard work during the three-day contest, and the summing up of students' own experience and doing further work on the contest problems after the contest. Through these stages students' creativity and overall ability are greatly improved. In deed, most of the winners

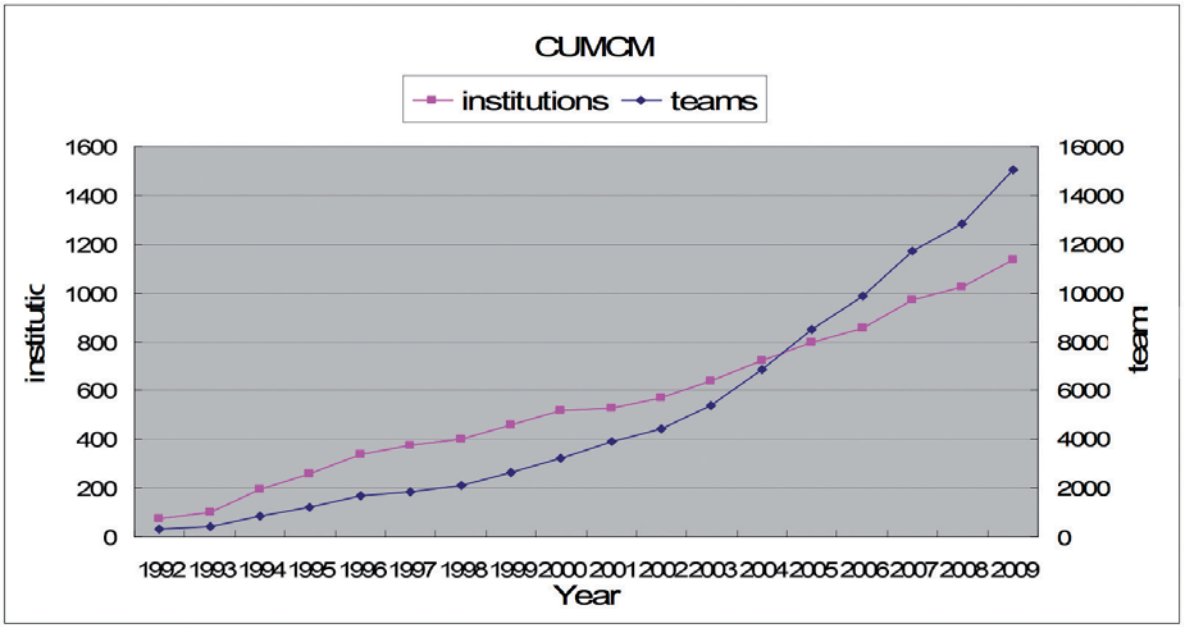

Figure 2—Numbers of institutions and teams participating in CUMCM.

of CUMCM have done very well in their successive courses and final-year projects before their graduation. The scientific and industry communities are getting to know more and more about CUMCM, and they are glad to accept the students who have the experience of the contest when they go to graduate schools or find jobs after their graduation. Some industry corporations, such as World-Sky Group, Netease Corporation, Higher Education Press, Wolfram Research Inc. and The MathWorks Inc. also sponsor the contest or related activities.

Difficulties and prospects

CUMCM does encounter some difficulties as the participation continuous to grow. First of all, the good contest problems are vital to the success of the contest. Contributing a good modeling problem, which is both a meaningful real-world problem and also a solvable problem by most teams within three days, is a real challenging task to the organizers.

Another difficulty the organizer faced is how to ensure the equity and fairness of the contest. Since the contest lasts for three days and it is essentially a completely open contest, it is not easy to supervise if some teams violate the contest rules. The organizer emphasizes the very importance of self-discipline.

Due to the success of CUMCM, a similar contest for the graduated students also appeared in China just several years ago. We are also considering the feasibility to organize similar contests for the primary and secondary students. Actually, in USA, COMAP has organized the contest for high school students for many years. But in China, most of the primary and

secondary students only care about getting high marks in the entrance examination so that the primary students can enter into high-quality secondary schools, and the secondary students can enter into top universities. This situation should be changed before mathematical modeling courses and related activities get into their campuses.

Summary

In order to promote a close relation between mathematics and the world outside mathematics (other sciences, industry and high tech, social and human life etc.), mathematical modeling plays a crucial role. It now becomes an important part of contemporary industrial and applied mathematics and an absolutely necessary step for connecting mathematics and applications. For university students, it should emphasize and organize their formation and training on mathematical modeling. Mathematical modeling courses and related activities are very successful in China universities, which play an important role in reforming the contents and forms of mathematical education in China universities.

Acknowledgement

This paper is compiled and re-organized based on the references list in below (In particular, Dan & Xie, 2009; Jiang, 1998; Jiang and Xie, 2007; Jiang et al. 2007a & 2007b). In fact, it can be regarded as a compound and compressed version of these references.

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