An Introduction to CUMCM: China/Contemporary Undergraduate Mathematical Contest in Modeling

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ABSTRACT

China Undergraduate Mathematical Contest in Modeling (CUMCM) is a national event held annually in China since 1992. The first character "C" in CUMCM is now redefined as "Contemporary" for participants from outside China Mainland. During the three-day contest, teams of up to three undergraduate students investigate, model, and submit a solution to one of two simulated real-word problems in engineering, management, etc. The aim of the contest is to expose students to the real world challenges inherent to mathematical modeling and applications, and provide educational (creativity, challenge, etc.) experience unique to problem bare learning. The contest has been influenced by and has also significantly influenced the teaching of mathematical modeling and applications in China. In this paper, we briefly introduce the aims and scope, organization and achievement of CUMCM. In particular, we explain why CUMCM is so successful in China. We also talk about some problems and difficulties for the contest we currently face.

1. INTRODUCTION

The tertiary education in China has a very short history compared with the long history of China and the long history of the tertiary education in Europe. In fact, the first university in China was not established until about 100 years ago, and before 1950s there are only about 100 universities in China, each of them with very few students. After 1950s, the number of universities increased dramatically and now there are more than 2000 universities in China. However, before 1980s, the mathematical education system in nearly all China universities follows the (former)

Soviet Union style and focuses on teaching the students "mathematical knowledge and skills" other than the ability of using mathematics to solve real-world problems.

In the last thirty years, as reform-and-open policy was carried out in China, more and more universities recognized this kind of teaching style should be changed and a more close relationship between mathematics and industry should be emphasized. In particular, mathematical modeling courses and related activities are highlighted as the breakthrough of reforming mathematical education in China universities (Xiao, 2000; Jiang et al., 2007). The reason behind is that mathematical modeling is not only the first step to apply mathematics in industry, but also very difficult for the modeler and original innovation is needed. The key to mathematical modeling teaching process is 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 is put on the students' ability of acquiring new knowledge and the processes of problem solving, rather than only knowledge and skills in pure mathematics. Therefore, mathematical modeling is gradually becoming the best bonding point to enhance students' mathematical knowledge and application ability.

In order to promote the teaching of mathematical modeling courses and providing the students with more chances to doing mathematical modeling, a contest named CUMCM (China Undergraduate Mathematical Contest in Modeling) was created in China in 1992. In my own opinion, CUMCM is the most important event 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 CUMCM and its influence in China universities.

2. AIMS, SCOPE AND HISTORY

CUMCM is a national annual contest in China for undergraduates. The first character "C" in CUMCM is now redefined as "Contemporary" for participants from outside China Mainland. The aim of the contest is to give students an opportunity for practicing the whole mathematical modeling process; to improve students' understanding of mathematics, especially mathematical modeling; to enhance students' motivation for learning and applying mathematics; and to cultivate students' overall competency (creativity / innovation, collaboration and practice competencies).

The contest rules are completely different from traditional mathematical contests such as Olympic mathematics competition. The students should participate in teams other than individually, with each team consisting of up to three undergraduate students from the same institution. Each team's task is to investigate and develop models to solve one of two given contest problems, which simulate real-word problems in engineering, management, etc. The contest lasts for three days (72 hours), usually starting at 8:00AM on the second or third Friday in September and ending at 8:00AM on Monday of the following week. During the contest, teams are permitted to reference any materials they wish (including any software, references or data source they can find in library, Internet, etc.), 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 (which is only optional) or anyone else, except other members of the same team. That's to say, inputs of any form from anyone other than the team members are strictly forbidden. Before the ending time of the contest, based on their own research work, each team should submit a solution paper to the contest organizer which is the only evidence used for rank the teams.

This unique feature of the contest is first initiated in Unites States other than in China. In fact, the Consortium for Mathematics and its Applications (COMAP) first organized the Mathematical Contest in Modeling (MCM) in 1985. In 1999, COMAP start to organize a similar contest named ICM (Interdisciplinary Contest in Modeling). Teams from China participated in MCM every year since 1989 and ICM since 1999. In recent years, the majority of the participants (more than 80% of the MCM teams and 90% of the ICM teams) are from China (please refer to Table 1).

CUMCM can be seen as a Chinese copy of MCM/ICM. Recognizing the mathematical contest in modeling is beneficial to the students and helpful to the mathematics education reform in universities, the China Society for Industrial and Applied Mathematics (CSIAM) began to organize 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 levels (categories) ---- University Level for four-year university students, and College Level for two-or-three-year college students. 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 curricular scientific activity for undergraduates in China. In 2011, there was participation by 19490 teams from 1251

institutions in the contest, representing almost all of the most prominent institutions and more than 50% of all institutions in China. It is also interesting that more than 80% of the participants are engineering, economics, management, and even humanities majors, other than mathematics majors one might expect. Table 1 gives the statistics on Chinese students participating in the contests MCM, ICM, and CUMCM. More details about CUMCM can be found in Li (2011), or from the web site http://en.mcm.edu.cn (in English) or http://cn.mcm.edu.cn (in Chinese).

Table 1. The statistics on Chinese students participating in MCM / ICM and CUMCM

Year	MCM in USA		ICM in USA		CUMCM in China	
	No. of all teams [a]	No. of Chinese teams [a]	No. of all teams [a]	No. of Chinese teams [a]	No. of institutions	No. of teams
1989	211	4(1.9%) [b]				
1990	235	6(2.6%)				
1991	260	21(8.1%)				
1992	292	26(8.9%)			74	314
1993	259	40(15.4%)			101	420
1994	315	84(26.7%)			196	867
1995	320	84(26.3%)			259	1234
1996	393	115(29.3%)			337	1683
1997	409	107(26.2%)			373	1874
1998	472	138(29.2%)			400	2103
1999	479	155(32.4%)	[c]	[c]	460	2657
2000	495	169(34.1%)	[c]	[c]	517	3210
2001	496	198(39.9%)	83	38(45.8%)	529	3887
2002	525	216(41.1%)	106	54(50.9%)	572	4448
2003	492	218(44.3%)	146	83(56.8%)	637	5406
2004	600	297(49.5%)	143	102(71.3%)	724	6881
2005	644	389(60.4%)	164	126(76.8%)	795	8492
2006	748	466(62.3%)	224	194(86.6%)	857	9898
2007	949	627(66.1%)	273	234(85.7%)	969	11742
2008	1162	847(72.9%)	380	357(93.9%)	1023	12846
2009	1675	1282(76.5%)	374	340(90.9%)	1135	15042
2010	2254	1854(82.3%)	356	331(93.0%)	1196	17317
2011	2775	2357(84.9%)	735	683(92.9%)	1251	19490

Note: a) The data are collected from http://www.comap.com. b) The bracketed numbers represent the proportion of Chinese teams in all teams participated. c) For the MCM and ICM contests of 1999 and 2000, ICM teams are included in the MCM teams in this table.

In order to celebrate its 10^{th}, 15^{th} and 20th anniversaries, CUMCM organized university students' summer camps on mathematical modeling in 2001, 2006 and 2011 respectively. Besides, motivated by CUMCM, many similar contests, with possibly smaller sizes and dedicated scopes, are also organized by various organizers in China.

3. ORGANIZING AND JUDGING SYSTEM

There is a CUMCM National Organizing Committee (NOC), which is setup by the Ministry of Education of China and CSIAM. In most of the provinces or regions in China, there is a CUMCM Local Organizing Committee (LOC). Currently, 28 of the total 34 provinces (or regions) in China have established their own LOC. Currently, the registration fee for each team is 200 Yuan (RMB), but no registration fee is needed for teams from outside China Mainland. Some industrial companies (e.g. China Higher Education Press, MathWorks China Ltd, etc.) provide financial support to the contest.

The contest problems are usually simplified versions of real world problems. Each year, the contest organizer (i.e., NOC) sends "call for problems" to professionals (professors, engineer, manager, etc.) to ask them to submit their problem suggestions as candidates. Currently NOC can usually collect more than 40 suggested problems each year. NOC will choose from them the most suitable ones and then finalize them. When choosing a problem for the modeling contest, it is important to make balance between two aspects: 1) the problem should be challenging and attractive to the students, usually with no solutions can be easily found from anywhere (that's not easy in current Internet age); 2) to solve the problem, the students do not need to use very complicated knowledge and skills in mathematics, since most of the participants do not major in mathematics and they only learn standard mathematical courses in universities. A list of all the contest problems for CUMCM 1992-2011 is provided in Appendix for your reference. The details of the problems (in English) can be freely downloaded from http://en.mcm.edu.cn. As you can notice, these problems are from very different industrial backgrounds, but all of them are interesting and attractive to students.

Teams register, obtain contest materials, and download the problems and data at the prescribed time through the CUMCM website. During the three-day contest, teams of University (College) Level can choose any one from the two contest

problems of A and B (C and D). It's no need for all the participants to get together during the contest, since the students finish their tasks on their own campus. Each team should submit a solution paper to the corresponding LOC before the contest deadline. After the contest, LOCs will starts judging to rank the submissions by the contestants. About top 10% of all entries will be submitted to NOC for second round evaluation, and the others will also be ranked and perhaps, awarded prizes at the regional level. After the second round evaluation by NOC, only about top 1% of the total solution papers will be awarded with the national-level first prize, and the figure for the 2nd prize are about 6%. Finally, each year about 15 outstanding papers will be selected and published in the journal *Engineering Mathematics*, which is one of the official journals of CSIAM.

The solution papers (including appendices such as computer programs) are the only materials used for rank the teams. Although there are no absolutely correct or incorrect answers for the contest problems, there are basically four criteria which can be followed to evaluate and rank the solution papers: the reasonability of the model assumptions, the creativity/innovation of the model, the correctness of the solutions, and the readability of the presentation.

4. THE TRAINNING AND ITS INFLUENCE

Most students who register to the contest can get some guidance from their advisors before the contest. They usually have some kind of training on how to participating in CUMCM from their mathematical modeling courses, related mini-courses, or seminars. Some students prepare for the contest independently through studying materials related to mathematical modeling.

The most important achievement of CUMCM is that the contest has successfully promoted mathematical modeling courses and related activities in China. As CUMCM getting more and more popular, the mathematical modeling courses are also getting more and more popular. Before 1990s, only about 30 top universities offered the mathematical modeling course to students in mathematics majors; while currently, almost all students in all majors can get some training in mathematical modeling. Conversely, the popularization of mathematical modeling courses has enhanced the quality of the contest.

Teachers of mathematical modeling courses are the key to the success of CUMCM since they not only teach the students mathematical modeling skills but also usually serve as the contest teams' advisors. In order to properly prepare the

university professors as contest advisors and good teachers in mathematical modeling courses, in last twenty years NOC have cooperated with CSIAM and several universities to organize short-term training seminars. NOC also organizes a national conference titled CCTMMA (China Conference on the Teaching of Mathematical Modeling and Applications) every two years to as an educational forum of exchange where teachers share information and discuss how to mentor the students effectively and how to prepare and teach a high quality mathematical modeling course. These activities have had great impact on the mathematics education reform, and have enhanced the teaching quality of courses related to the mathematics in most universities and colleges. 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. The contest also boosts the publication of many innovative textbooks on mathematical modeling and mathematical experiments. 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.

Why the contest CUMCM is so successful in China? I think there are at least two reasons. The first reason is that the contest is a real challenge to its participants and thus is very welcomed by the students. The special and unique experience students have got during the contest, e.g., solving problems from real industry, cooperative teamwork and 72-hour hardworking, improved students' competency in a lot of aspects, enriched extracurricular lives, etc., 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 of CUMCM have done very well in their successive courses and projects before their graduation. This naturally leads to the second reason why the contest is so attractive to students – 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. Therefore, the participants, especially the winners of the contest, have a much brighter future in their life (good job, good salary, more chance, etc.). An example is that one advertisement of the IBM China Research Lab in 2009 announced that in order to get some of its research positions, "award in highly regarded mathematical modeling contest is a plus".

5. DIFFICULTIES AND PROSPECTS

CUMCM does encounter some difficulties as the participation continuous to grow. The most important task facing NOC is about how to improve the whole quality of the contest. 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. As a matter of fact, some teams do violate the contest rules, for instance, looking for help from teachers or other persons outside the team even on the Internet. The organizer emphasizes the very importance of self-discipline. A firm policy is observed by NOC, namely, once we have the evidence of violating the contest rules by some teams, these teams will be disqualified from the competition.

6. CONCLUSION

It now becomes an important part of contemporary industrial and applied mathematics and an absolutely necessary step for connecting mathematics and applications. 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. For university students, it should emphasize and organize their formation and training on mathematical modeling. Based on this thought, a contest in mathematical modeling named

CUMCM is organized in China to promote mathematical modeling activities. According to our practice, the contest provides a good educational interface between mathematics and industry. CUMCM and the related teaching activities in mathematical modeling and applications are very successful in China universities, which play an important role in reforming the contents and forms of mathematical education. It will be helpful to investigate whether this experience can be extended to other countries.

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APPENDIX. PROBLEM TITLES FOR CUMCM 1992-2011

(For details, please visit http://en.mcm.edu.cn)

CUMCM-92A. Analysis on Fertilization Effect

CUMCM-92B. Decomposition of Some Experimental Data

CUMCM-93A. Frequency Design of Intermodulation Signal

CUMCM-93B. Sorting Football Teams

CUMCM-94A. Designing a Road in a Mountain Area

CUMCM-94B. Packing Locks into Boxes

CUMCM-95A. Air Traffic Control

CUMCM-95B. Operations Management of Cranes and Furnaces

CUMCM-96A. Optimal Strategy for Fishing

CUMCM-96B. Water Saving Procedure for Washing Machine

CUMCM-97A. Designing Parameters of the Component Parts

CUMCM-97B. Sectional Cuttings
CUMCM-98A. Returns and Risks of Investment
CUMCM-98B. Inspection Tours in a Disaster Area
CUMCM-99A. Management of an Automated Lathe
CUMCM-99B. Layout of Exploratory Wells
CUMCM-99C. Heaping up the Gangue
CUMCM-99D. Layout of Exploratory Wells (similar to CUMCM-99B)
CUMCM-00A. Classification of DNA sequences
CUMCM-00B. Ordering and Transportation of Steel Pipe
CUMCM-00C. Flying over the North Pole Area
CUMCM-00D. Hole Exploration
CUMCM-01A. 3-D Rebuilding for Blood Vessel
CUMCM-01B. Buses Scheduling
CUMCM-01C. Fund Plan
CUMCM-01D. Buses Scheduling (similar to CUMCM-01B)
CUMCM-02A. Optimal Design for Light Source of Headlights
CUMCM-02B. Mathematics in Lottery Ticket
CUMCM-02C. Optimal Design for Light Source of Headlights (similar to CUMCM-02A)
CUMCM-02D. Match Schedule Arrangement
CUMCM-03A. Transmission of SARS
CUMCM-03B. Truck Planning for an Opencast Iron Mine
CUMCM-03C. Transmission of SARS (similar to CUMCM-03A)
CUMCM-03D. Speedily Crossing the Yangtze River
CUMCM-04A. Planning Temporary Mini Supermarkets for the Olympic Games
CUMCM-04B. Transmission Congestion Management of Electricity Market
CUMCM-04C. Drinking and Driving
CUMCM-04D. Recruiting Government Officers
CUMCM-05A. Water Quality Evaluation and Prediction of the Yangtze River
CUMCM-05B. Online DVD Rental Business
CUMCM-05C. Evaluation of Rain Forecasting Methods
CUMCM-05D. Online DVD Rental Business (similar to CUMCM-05B)
CUMCM-06A. Resource Allocation of a Publishing House
CUMCM-06B. The Assessment and Prediction of the AIDS Treatments
CUMCM-06C. Optimal design of the shape and dimension of beverage cans

CUMCM-06D. Inspecting and Controlling of Gas and Coal Dust
CUMCM-07A. Prediction of China Population Growth
CUMCM-07B. Public Transportation Routes Selection Problem
CUMCM-07C. How Many Benefits Does A Package Deal Offer?
CUMCM-07D. Scheduling for physical performance tests
CUMCM-08A. Digital Camera Positioning
CUMCM-08B. On the Tuition in Higher Education
CUMCM-08C. Search in an area
CUMCM-08D. Analysis and Evaluation of the NBA Schedule
CUMCM-09A. Analysis on control method of brake test bench
CUMCM-09B. Assignment of Hospital Beds
CUMCM-09C. Tracking satellites or spaceships
CUMCM-09D. Conference Preparations
CUMCM-10A. Position Identification and Capacity Table Calibration of Oil Tanks
CUMCM-10B. A quantitative evaluation on the influence of Expo 2010 Shanghai
CUMCM-10C. Planning the oil pipeline
CUMCM-10D. Evaluation for four designs of student dormitory
CUMCM-11A. Heavy Metals Contamination in Urban Topsoil
CUMCM-11B. Setting and Scheduling of Traffic and Patrol Police Service Platforms
CUMCM-11C. System Reform of Retired Enterprises Employees
CUMCM-11D. Natural Casing Bundling Problem