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ABSTRACT

Rapidly changing technology is affecting mathematics instruction in both the People's Republic of China and the United States. This study examines methods used in the two countries, addresses common problems facing both countries, and suggests alternative approaches for meeting these challenges. The study investigated class size and teaching load, class activities, small group methods and problem solving, and daily math lessons for early childhood and primary grades; small group setting activities and homework assignments for fourth-, fifth-, and sixth-grade levels; and entrance examinations vs. open door policy and traditional lecture-demonstration methods for middle and high school level. Problems faced by both countries included: (1) a lack of qualified mathematics and computer science teachers; (2) the increasing number of high-risk students in junior high schools; (3) the students' lack of interest in studying mathematics; and (4) the growing number of ill-prepared students in both countries. Study findings suggested several areas for further research such as upgrading current educational options and training teachers to better meet the needs of rapidly changing technology, developing home-based education using the World Wide Web, and explaining the impact of home-based education on employment of teachers. (Contains 12 references.) (ND)

# Mathematics in the 21st Century

*A Comparative Study of Teaching Mathematics Between China and the United States of America*



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## *Issues*

As technology has rapidly changed during recent years, especially currently, the whole world has begun focusing on wireless technology as the wave of the future -- the on-ramp to the "Information Super Highway." These revolutionary telecommunications are beginning to reach every household in America as world-wide Internet access to its customers increases dramatically. There are several very important issues within our international educational communities which, in light of this technological age, must be addressed:

* How to teach mathematics effectively to students who are having difficulty in learning to face this kind of massive technological revolution.
* How to improve the teaching techniques of today's teachers with this revolution, as well as their knowledge of subject matter.
* How to train our future teachers to utilize the full range of scientific activities and materials available to satisfy tomorrow's new curriculum.

In order to meet the challenge of providing adequate training to our younger generation and to meet the minimum requirements of basic skills needed to satisfy tomorrow's complex society, the NCTM's (National Council of Teachers of Mathematics) Curriculum and Evaluation Standards for School Mathematics advocates enhanced usage of modern computing technologies (Cuoco, Goldenberg, Mark, 1995). They suggested that we need to help students to use this technology to better understand mathematical phenomena, by aiding their growth in stature as real-world problem-solvers. Cuoco, Goldenberg and Mark (1995) further stated "...empowering teachers with the nuances of modern techniques and upgrading the quality of instructional materials are the initial strides toward effective classroom usage of advanced computing technologies."

A study of school curricula, teacher training, in-service education, instructional methods, and school systems of the People's Republic of China and the United States will be beneficial to all concerned. This paper will emphasize the teaching of mathematics -- instruction method. As I mentioned in my book entitled A Comparative Study of Mathematics Education Between the Province of Taiwan, Republic of China and the United States

> "...an appreciation and an understanding of differing cultures through cooperation in educational activities will give a comprehensive view of today's issues -- such as the shortage of qualified, competent teachers, the best possible teaching techniques, the choosing of appropriate materials from the massive amounts available, the decline of the 'Three R's' among high school graduates, the increasing number of underprepared students, and the lack of students interested in studying mathematics..." (Chang, 1985).



* This paper is a portion of a presentation to the Eighth International Congress on Mathematical Education, University of Seville and Sociedad Andaluza de Matematica, Seville, Spain. July 14-21, 1996

These ten year-old issues are still critically facing us today. We expect a renewed urgency to adapt our present traditional classroom setting to meet the rapidly expanding new cradle-to-grave educational needs of the next century. Here are the issues:

1. What are the differences in the teaching of mathematics in public schools between these two countries?
2. How can we improve and change the traditional lecture demonstration methods to more up-to-date techniques?
3. How can we present long-range goals for mathematics education, especially for the rapidly expanding computer-based learning and high speed information dissemination?
4. How can we use this world-wide massive information dissemination as a supplement to help them to teach?

The style and context of the mathematics in the two countries have significant differences due to traditional attitudes, social behaviors, and cultural heritage. There are also specific differences in the training of teachers, the method of teaching techniques, and the application of pure and applied mathematics. Even though there are many differences between these two countries, this study will be able to isolate effective methods and help us to attack the common problems facing both of our countries. Of course, we will not be able to suggest uniform models of solutions for these issues, but at least we will be able to utilize the best available resources from both countries. Hopefully, we can provide alternate approaches for meeting the challenge of math education in these two countries.

## *Questions*

My 1992 lecture tour took place in Liuzhou, Guangxi, a city with a population of two million, in the southern part of China. In my two largest three-hour presentations, 1,500 elementary school teachers attended the first session, and more than 800 teachers from the junior and senior high school level participated in the second session (Chang, 1992). The following were the most asked questions from my presentations and round-table discussions with small groups of interested teachers:

### I. Questions regarding teaching mathematics in early childhood and primary grades:

a. How do you teach a class of more than 60 students effectively? (question asked by kindergarten, first and second-grade teachers)
b. Can we use the problem-solving techniques to teach earlier grades? (asked by second and third-grade teachers)
c. Are there any new teaching methods for dealing with bigger classes in earlier grades?
d. How do we use the computer or audio-visual aids in teaching?
e. How many mathematics classes does the American teacher teach per week?
f. Do American teachers have large first and second-grade classes?
g. How early do American children start preschool or kindergarten?
h. How do American teachers teach preschoolers? What kinds of activities?

### II. Questions regarding teaching mathematics in fourth, fifth and sixth-grade.

a. Do the American teachers give a lot of homework to their students every day?
b. Do the American elementary school students feel any pressure from the teachers or their parents that they have to do well in order to advance to the next grade level?
c. How do the American teachers handle a large class of students with varied abilities?
d. What is the best way to teach problem-solving, with real-life applications, to students?
e. Do the American students do their calculations with pencil and paper or do they use calculators and computers?

### III. Questions regarding teaching mathematics in middle and high school.

a. Do American schools place heavy emphasis on mathematics as a requirement for continuing on to the next grade?
b. Do American students have to take an exam to proceed to the next grade?

c. Are American high school graduates required to take an exam in order to enter a college or university? If so, what kind of test?
d. Do the individual colleges and universities in the U.S. have their own entrance examination or is there a general exam for all of them?

## *Response and Discussion*

### *I. Teaching mathematics in early childhood and primary grades.*

#### Class Size and Teaching Load

In American schools, the enrollment of each class is far less than their counterpart in China. The average normal enrollment in early childhood and primary grades in an American public school is between 15 and 25. In China, it is common practice to have 60 students in one class. American teachers average 5 class periods and one free period per day. Therefore, the teachers have to teach 25 hours per week compared to only a 15-hour teaching assignment in China. How do we teach this large group of students? Following are my suggestions.

#### Class Activities

As a teacher of childhood and primary grade levels, he/she should be well acquainted with his/her lesson plan. Therefore, the teachers need to collect many examples of various group activities, especially the group games involving numbers, directions, relationships as well as the real-life story activities. In order to provide individual attention, this large primary class needs to be divided into several small groups of 3 to 5 students per group. During regular class meeting, each group should be engaged in either solving a problem or playing an activity or even doing a problem designed for group interest. The teacher should serve as a facilitator, a counselor, and a friend instead of a rapid-delivery-lecture teacher (Chang, 1986). In order to effectively utilize the small group activities, the teacher needs to be very skillful in assembling a schedule of six day's activities.

#### Small Group Methods and Problem-Solving

A. **Daily Activity Model (for all levels):**

| | |
|---|---|
| I. Teacher delivers mathematics content | 20 - 30 minutes |
| II. Hand held manipulative materials demonstration (if materials are available, use occasionally) | 20 - 30 minutes |
| III. Group activities | 20 - 30 minutes |
| a. Doing a worksheet of 5 - 10 newly learned skills | |
| b. Group contest: solving problems, playing games | |
| c. Other real-life activities | |
| IV. Review session of old and new materials | 20+ minutes |
| V. Question and answer session (try to schedule more time if necessary) | 20+ minutes |
| VI. Group demonstration session: let group member put problems on the board and explain to the class. | 20 + minutes |

The teacher should be able to adjust the time allocation and use the activities interchangeably and wisely.

B. **Problem-Solving Activity Model (for all levels):**

This model will probably require the whole class period. Teachers should be able to use various techniques to help students understand a problem and formulate procedures to solve problems. The teacher should emphasize finding the correct answer is not the vital aspect of solving a problem. Rather, the teacher must emphasize the importance of teamwork necessary to devise a plan of how to solve a problem. The activities consist of the following steps (Polya, 1971):

Problem-solving pattern for the early childhood and primary grades:

1. Tell: Read the problem
2. Show: Looking for a pattern
3. Solve: Find the answer
4. Check: Search for alternate solutions.

Problem-solving pattern for fourth-grade through high school:

1. Understand the problem
2. Devise a plan
3. Carry out the plan
4. Look back.

## Daily Math Lessons

At the early childhood level, Chinese children in most of the large cities start kindergarten at the young age of 3. American children begin preschool around age 3, and kindergarten at age 5. Kindergarten teachers incorporate mathematics throughout their curriculum. Most teachers have a 20 - 30 minute mathematics period as well as incorporating some special mathematics programs utilizing manipulatives. In China, teachers of early childhood and elementary school spend approximately 80 - 90 minutes on mathematics per day for 6 days per week. Chinese mathematics teachers teach no other subject but mathematics. In America, all the early childhood and primary grade teachers have to teach every subject in his/her own class.

### *II. Teaching mathematics in fourth, fifth and sixth grades*

## Small Group Setting Activities

How do we teach mathematics to a group of students with diverse abilities? As previously mentioned, one method of teaching is dividing a large class into several small groups. The success of this method would depend on: 1) Teacher commitment and enthusiasm for small-group instructional method, and 2) teacher's ability to foster small-group instructional processes. The most important characterization of small-group instruction is that the locus of control shifts from a teacher-centered to a student-centered mode where the primary role of the teacher becomes that of a facilitator of learning through question and answer, thus promoting small-group activities (Chang, 1986). If the teacher follows the daily activities model and incorporates teaching activities, he/she should be able to handle any grade level without a problem.

## Homework Assignments

In China, the teachers provide abundant daily homework assignments for their students. In fact, parents complain if no assignment is given. But in America, some of the teachers require students to finish their homework at the school instead of doing it at home. Because of no entrance examination, there is no pressure at all from teachers or parents regarding their studying. In fourth, fifth, sixth and eighth grade, there may be state-wide tests to see what the students have learned.

In China, the parents believe that their children are the best in class. They want their children to receive good grades; therefore, they ask the teacher to provide various help including extra tutoring in school. The students feel a lot of pressure either from their teachers or from their parents.

## *III. Teaching Mathematics in Middle and High Schools*

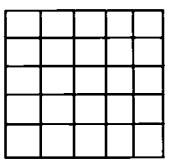
### Entrance Examination vs. Open Door Policy

In China, the teachers have a mathematics session of over 100 minutes each day for six days of the week. They must do extremely well in order to advance to the next grade level. Upon completion of the seventh grade, Chinese students must take an entrance examination to enter the eighth grade.

In America, due to the open door policy of most of the state universities, high school students can apply for admission to any college they choose. The most competitive colleges require high Scholastic Aptitude Test scores in order to obtain admission. In China, because of the severe competitiveness of the entrance examinations of the senior high schools and colleges, the teachers have no choice but to rapidly deliver lectures, show students how to take the tests, and give examinations. The teachers emphasize the test-taking techniques instead of understanding of the content of the materials. Usually, they don't have time to experiment with various instructional methods. However, some teachers are currently using computer-assisted learning in order to offer the students more of a chance to practice review tests before taking the actual entrance examinations for high schools or colleges.

*Teaching Activities Suggested for Problem-Solving*

1. Recognize the geometric shapes in the classroom, such as squares, rectangles, circles, triangles, etc. How may squares in the window, ceiling, or floor of your classroom? (For primary grade levels) (Chang, 1992).
2. A child has a set of 10 cubical blocks. The lengths of the edges are 1 cm, 2 cm, 3 cm, ... , 10 cm. Using all the cubes, can the child build two towers of the same height by stacking one cube upon another? Why or why not? (For early grade levels) (Musser & Burger, 1991).
3. How many whole numbers from 1 to 300 are not multiples of 3 or 5? (For early grade levels) (Bennett & Nelson, 1992).
4. How many diagonals can be drawn in a 12-sided polygon? (For fifth or sixth-grade) (Krause, 1991).
5. How many different squares are in this 5 x 5 square? Can you devise a pattern to find how many different squares from a n x n square? (For middle or high school level).



6. Of one-hundred fifty students who go on a field trip, eighty-two students wear hats. How many students are without hats? (For primary grade levels) (Chang, 1989).
7. Cross-curriculum problem-solving activities: Using the example of the honeycomb, the teacher can teach geometric shapes, explain why and how bees create honey, why bees' honeycombs are made of hexagonal shapes, how they create the honeycombs, how they transport honey, etc. This gives the teacher the opportunity to teach mathematics, social sciences, biological sciences, economics, nutrition, and transportation/shipping of a product all using one problem. (For fifth, sixth and middle school grade levels) (Chang, 1992).
8. Once upon a time in the happy hollow of tiny people, there lived a very fair and good King who had three sons named A, B, and C. In order to train his sons, the King decided to let them be his cabinet. Each son had one vote on any issue concerning the welfare of the kingdom. The King, being old and wise, allowed his sons to make all the major decisions based on majority rule. Clearly, since each son had one vote, no one son was more powerful than the other. One day, the King died. The mean old witch of the kingdom put the elder son under her power. The three sons fought. The wise and good witch of the kingdom intervened and solved the controversy. She allowed (1) the eldest son, A, to have 2 votes, (2) the middle son, B, to have 1 vote and to serve as Chairman with the power to break ties (i.e., if a tie occurred, then B was given an extra vote), and (3) the youngest son, C, was given only one vote. Determine which son then had the most power. How wise was the good old witch? (Chang, 1985). The solution is at the end of the Conclusion section.

## Traditional Lecture - Demonstration Method

The traditional lecture-demonstration method is still the most common mathematics teaching method in both countries. In the United States, teaching techniques such as self-paced learning, audio-visual instruction, computer-assisted learning, and small-group setting discussion methods are increasingly being used. In China, due to the entrance examination's severe competitiveness, most of the mathematics teachers have no choice but to use speedy lecture-demonstration to show students the problems most likely to appear on the test. The only method they might like to use is the method which will benefit their students' chances to get the highest scores on the test. Unless policy on examinations changes, it will be very difficult to try any new method, as quoted by one of the math professors from Guangxi University of Technology during my 1992 lecture tour.

A comparison of mathematics programs in the United States and China reveals that Chinese schools provide a very intense mathematics course at the middle school level (Jiang and Eggleton, 1995). Due to the expectations of the parents and the pressure from the principal, the mathematics teachers at Chinese schools, at all levels, require the students to attend long tutorial sessions, to do plenty of exercises, to take a lot of simulation tests, and, of course, to work harder and harder (such as doing more exercises, repetitions of old tests, etc.). Their ability to solve problems is no doubt far better than that of the American students. According to Jiang and Eggleton (1995), "the Chinese students generally hold mathematical ability in high esteem, unlike most of American students. As a result, Chinese students are expected to work harder in their classes whereas American students will simply move to a less demanding class so that they don't have to work hard."

## Conclusion

The world-wide information super highway has dramatically increased in its accessibility to the general population. How do we as teachers utilize this vast information bulletin board to help us to teach, to assist us to benefit our students? The computer can quickly provide answers, therefore drastically reducing the amount of time spent problem-solving, providing more time for teachers to introduce other new areas to our students. It is clear that the computer has changed our society, just as the Industrial Revolution changed history centuries ago. In 1983, ICIUT (Ninth International Conference on Improving University Teaching) predicted that computer-assisted learning will expand rapidly during this decade to set the stage for computer-based learning. Just as books and printed materials were central to a modern educational system a century ago, so the education early in the next century will probably be based on computer and other electronic information technology (ICIUT, 1983). The world-wide internet substantiates the forecasts of 13 years ago.

How can mathematics instructors use the computer to assist in teaching mathematics? This is still a big issue facing our two countries today. Cooperation between countries toward the solving of this educational problem should be long range, such as economic, political, social issues, etc. These other issues will become less important as they become linked to our huge educational enterprise. We need the cooperation of teachers, parents, and others concerned in our society, otherwise our younger generations from both countries might have trouble coping with the technological advancements and the complexity of the twenty-first century.

At the present time both countries are facing similar problems; the lack of qualified teachers of mathematics and computer science, the increasing number of high-risk students in the junior high schools, and the students' lack of interest in studying mathematics. The most critical issue is the growing amounts

of ill-prepared students in both countries' school systems. We need to continue to investigate the following issues:

1. We need to upgrade the current educational system to meet the needs of rapidly changing technology.
2. We need to train our teachers in the field of mathematics and computer science to meet society's changing needs.
3. We need to prepare our students to meet the challenge of this complex technological age.
4. We need to introduce some kind of a home-based education via use of the World Wide Web to reduce the overcrowding and expense of public education in both countries.
5. We need to move to a home-based educational system to create more educational opportunities for our students.
6. We need to explore the impact of this home-based educational system on the employment of teachers.
7. We need to find a way to "project" our teachers over the internet (via audio-visual technology) so that students from all over the world may observe their instruction through their own computers.
8. We need to re-direct our displaced classroom teachers to the home-based system.

In conclusion, cooperation and joint participation between the U S A and China toward solving these complex educational problems should be an important venture. We need to examine the role of cultural and societal factors and their interaction with professional factors in determining the success of this new educational, technological enterprise. It will be an exciting and challenging task for both of our countries to accomplish in the beginning of the 21st Century.

* Here is the solution for the Teaching Activities Suggested for Problem-Solving, #8.
Before King died:
Winning Collation: {A, B, C}, {A, B}, {A, C}, {B, C}
After King died:
Winning Collation: {A, B, C}, {A, B}, {A, C}, {B, C}

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