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ABSTRACT

The purpose of this study was to find the differences between middle school mathematics programs in China and the United States. More specifically, the objectives of the study were to compare how mathematics is presented in the curricula and textbooks in China and in the United States, and to compare how mathematics is taught in classrooms in these countries. The ultimate goal of this study was to provide data and recommendations which may be used to identify problems in mathematics programs in both U.S. and Chinese middle schools. It is concluded that there are problems in mathematics education in both China and the United States. China needs to find a way to reduce the high pressure from the exam-driven system to develop multiple teaching strategies and apply new technology in mathematics teaching and learning. The United States should look for new approaches to improve on weaknesses in basic conceptual understanding and skills. (Contains 25 references.) (ASK)

A Comparative Study of Middle School Mathematics Programs in China and the U. S.

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A Comparative Study of Middle School Mathematics Programs in China and the U. S.

Introduction

During the past several decades, there has been considerable attention to cross national comparisons of education. There is a remarkable growth in international dimension in mathematics education (Bishop, 1992). According to Robitaille and Travers (1992), the reasons for the growth are varied. First, in every country, mathematics is an important part of the curriculum, usually considered the second most important subject after the native language. Second, there are many similarities in the content of mathematics curricula among countries. Third, the language of mathematics is truly universal.

Different cultures and societies have different philosophies regarding the teaching and learning of mathematics. These variations of beliefs and values concerning mathematics education result in different education systems. The differences include the designing of curricula, the use of textbooks, and teaching methods. There are also similar issues in education that many countries share. For example, the search for how to develop effective and efficient education is a common goal in countries around the world (Spaulding, 1989). Therefore, as Robitaille (1992) notes, comparative study provides opportunities for the sharing, discussion, and debate of the important issues, in an international context. Stigler and Perry (1988) observe:

Cross-cultural comparison also leads researchers and educators to a more explicit understanding of their own implicit theories about how children learn mathematics. Without comparison, teachers tend not to question their own traditional teaching practices and are not aware of the better choices in constructing the teaching process (p.199).

Comparative Study of Mathematics Programs in Middle Schools

In China and the U.S

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Different cultures and societies have different philosophies regarding the teaching and learning of mathematics. These variations of beliefs and values concerning mathematics education result in different education systems. The differences include the designing of curricula, the use of textbooks, and teaching methods. There are also similar issues in education that many countries share. For example, the search for how to develop effective and efficient education is a common goal in countries around the world (Spaulding, 1989). Therefore, as Robitaille (1992) notes, comparative study provides opportunities for the sharing, discussion, and debate of the important issues, in an international context. Stigler and Perry (1988) observe:

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Many comparative studies have provided opportunities for researchers, educators, and policymakers to examine their own educational systems, and to develop the best possible alternatives to curricula and instruction.

In general, the U.S. has viewed Asian countries, including China, as having a superior educational system, especially in mathematics. For example, the third International Mathematics and Science Study (TIMSS) revealed in 1998 that U.S. eighth and twelfth graders score below average in mathematics compared to 41 nations in the TIMSS assessment. According to the Report to the Nation on the Future of Mathematics Education (Everybody Counts, 1989): "The development of more effective strategies for revitalizing mathematics education must be based in part on an understanding of why it is so difficult in the United States to bring about change in education. The truth we shrink from confronting is that most previous reform efforts have failed." Therefore, mathematics education in the U.S. may need to shift its attention internationally to find ways to improve and to compete globally.

The purpose of this study was to find the differences between middle school mathematics programs in China and the United States. More specifically, the objectives of the study were to compare how mathematics is presented in the curricula and textbooks in China and in the United States, and to compare how mathematics is taught in classrooms in China and the United States. The ultimate goal of this study was to provide data and recommendations, which may be used to identify problems in mathematics programs in both U.S. and China middle schools.

Methods

Research Design and Questions

In May of 1999, we were invited by the Ministry of Education in China to go there to present mathematics teaching methods to a group of Chinese educators and researchers. This request puzzled us. What would Chinese educators hope to learn from U.S. educators, and what are the differences in mathematics education in both countries? With these research questions, the study combines both qualitative and quantitative research designs to examine the differences between middle school mathematics programs in both countries. The primary focus of this study is the comparison of the differences between the two mathematics programs.

Data Source and Procedure

In the Spring of 1999, I visited five schools, interviewed 30 educators and researchers, surveyed 18 teachers, had five group discussions, and observed ten different levels of mathematics classrooms in China. In the Fall of 1999, I observed fifteen classrooms in the U.S. Curricula from both countries were analyzed, and more than five different sets of textbooks from the U. S. and China were evaluated.

Descriptive information and intervention data were gathered through use of qualitative and quantitative research methods. The qualitative methods included observations, interviews and surveys. The quantitative data were collected from analyses of curricula and textbooks.

The Development of Mathematics Education in the United States

Mathematics has developed and has been institutionalized for use in schools for thousands of years around the world. Although mathematics education in different countries has different systems, influenced by their cultures, its main goal is the same, to develop students' ability in reasoning and problem solving. According to Kilpatrick (1994), primary mathematics education has attempted to prepare children for their future by teaching mathematics as a tool for solving practical problems, while secondary and college mathematics teaching has as its aim the appreciation of deductive reasoning and axiomatic structure.

Although the development of mathematics has a long history, mathematics education as an academic field started at the end of the 19th century, with the beginning of teacher education in universities and the reform of secondary curriculum by mathematicians (Kilpatrick, 1994). After the Second World War, influenced by economic and political events, the U.S. began to restructure the educational system (Smith, 1994). A second reform of mathematics education emerged. New concern with teaching of science and mathematics led to two international conferences in the 1950s and the 1960s. Both conferences proposed "a restructuring of mathematics curricula as the panacea for learning problems: Children should be learning organized concepts and not drill in specific and arbitrary material" (Smith, 1994). This revolution in the study of mathematics, with an emphasis on the basic concepts of mathematics, programmed learning, and discovery learning, was called the "New Math" movement. Willoughby (1990) reveals that the major failure of new math was in the direction, in which "the overformalism and the lack of any obvious connections to the real world strengthened opponents of the movement when nostalgic, unenlightened pedants took us squarely back into the 19th century with the back-to-basics movement" (p7.). In 1983, *A Nation at Risk* alarmed the country by pointing out problems in the U.S. educational system. *Everybody Counts*, produced by the National Research Council, called for reformulating mathematics curricula and teacher preparation, focusing on reasoning and problem solving and completely changing the way mathematics was taught and learned.

The Standards produced by NCTM in the past decade - the *Curriculum and Evaluation Standards for School Mathematics* (1989), the *Professional Standards for Teaching Mathematics* (1991), and the *Assessment Standards for School Mathematics* (1995)

– "challenged the assumption that mathematics is only for the select few, with a persuasive argument that everyone needs to understand mathematics and that there should be no conflict between equity and excellence" (NCTM, 1998). These standards have had a deep impact on the development of mathematics education in the past decade.

In order to ensure continued quality, to indicate goals, and to promote positive change in mathematics education in grades pre-K to 12 in the 21st century, NCTM has developed revised *Principles and Standards for School Mathematics,* whose aim is to build a solid foundation with a set of principles and standards that are focused, coherent, responsive, and grounded. Two key issues are addressed in the new standards. The first is: What are the characteristics of mathematics instructional programs that will provide all students with high-quality mathematics education experiences across the grades. The second is: What mathematical content and processes should students know and be able to work with as they progress through school. In order to play an important role in the guidance of mathematics instructional programs, the *Principles and Standards for School Mathematics* need ongoing experimentation, implementation, and updating.

Characteristics of Chinese Mathematics Education

The Examination System

China's civilization had a great impact on education in China. For many centuries, Chinese education was characterized as scholar-nurturing education. Education was equated with moral superiority that justified political power and high social states. One of the distinctive features of this form of scholar-nurturing education was the dominance of the state, which grew steadily with the elaboration of the examination system (Pepper, 1996).

China has a long history in the Examination System that drives curriculum and instruction. As Ashmore and Cao (1997) observe, "Examinations are a crucial feature of

Chinese education. They determine whether an individual is eligible for more advanced training and what form that training will take."

The civil service examinations, which survived until 1905, date from the Sui dynasty (581-618 A.D.) and were used to enhance the dynasty's power by invoking the Confucian tradition of merit to legitimize imperial hegemony over administrative appointments. During the Song dynasty (960-1279 AD) the examination system expanded quantitatively when increased economic productivity and accumulation of wealth, together with the development of printing and publishing, led to growing pools of candidates and degree holders. In this manner, a ruling class of literati-bureaucrats emerged (Pepper, 1996). As the centuries progressed, the examinations grew increasingly formalistic. The influence of the examinations ultimately pervaded the entire society. They became the chief mechanism for bestowing local and informal elite status as well as for choosing government officials. Confucian learning, imperial power, and bureaucratic authority were bound together in a mutually sustaining relationship that would dominate Chinese intellectual life until examinations were abolished in 1905 and the imperial system was overthrown in the 1911 revolution (Pepper, 1996).

In recent decades, primary school graduates have been required to take an examination to determine which middle school (junior-high school) they will attend. Students are admitted into different schools according to their scores. Those with high scores are admitted to the key middle schools. After finishing three years in middle school, students have to take an examination to determine whether they will enter a key high school or a regular high school. Those who fail the entrance examination are placed in vocational high school. Once graduated from high school, students have to take rigorous entrance exams to be able to qualify for universities.

Some Chinese feel that there are some advantages to this system. For example, students will have a strong basic foundation in all subjects and have a strong capability to enter the competitive world. However, many feel that there are problems with an educational system so driven by examinations. Teachers in this study feel that the examination system does not allow them to do anything but provide direct instruction in their classroom. The examination system also puts tremendous pressure on the teachers as well as the students and their families. Brauchli (as cited in Ashmore & Cao, 1994) also observes, "Parents put intense pressure on their children to study, even sending five-year-olds to boarding school and encouraging youngsters to do homework three hours a day." Besides a five-day per week school, most students have to go to Saturday classes to prepare for the entrance examinations for middle school, high school, and college. Some parents save money for their children to have private tutors for mathematics after school.

Educational researchers and educators in China have noted the problems in the examination system. They have called for a reform of the educational system. In recent years, most school districts have abolished the requirement of taking a middle school entrance examination for elementary school graduates. In the Spring of 2000, the State Education Commission of China issued a document to abolish middle-school entrance examinations in the whole nation. According to the Research Group of National Curriculum Standards of Mathematics (1999), assessment should not only assess the result of students' learning mathematics, but also it should evaluate the changes and development of students in the process of learning mathematics; assessment should not only determine the levels of the students' mathematics learning, but also should examine students' feeling about and attitude toward learning mathematics. The purpose of assessment is to promote the development of students as a whole, and to provide more individual space for students' learning and teachers' instruction. China is now exploring a scientific and reasonable assessment system, which can combine different methods of assessment such as quizzes, tests, projects, essays, and observation.

The Development of Mathematics Education

Traditional mathematics during the early developmental period (200 B.C.) was listed as the sixth of six skills for the scholars in China. It was used as a method to select officers in government, as the tool in management, as the necessary educational course for the noble elite and as a daily tool for farmers, workers, and traders. The famous mathematicians in the history of China came from different levels of society. Some of them were government officers who specialized in mathematics education and the computation of astronomy, such as Zhang Heng and Zhu Chongzi. They were high level officers of the government or scholars, and their objective in the study of mathematics was to know the truth and serve the emperor, such as Zhong Chang did. Some worked in various levels of government management, such as tax collection, creation of budgets, and construction. Some of them were also ordinary intellects, such as Mo Zi, who treated mathematics as a special research area, and Zhou Shuang, who used mathematics as a tool of astronomy.

Because of the various roles of mathematicians in society in China, mathematicians were more interested in developing mathematical computations to solve real world problems. For example, in the Tang dynasty the official school created a computation course. The main purpose of this course was to apply mathematics to solve real world problems. The *Arithmetic of Nine Chapters* was used as the textbook. According to Li and Chen (1995), "It is the classic work *Arithmetic in Nine Chapters* that has exerted the greatest influence upon the science of mathematics and its education in China. It has settled the traditional mathematics style that is very useful in application and calculation." In that book, there are

246 application problems about measuring and dividing fields, growth and depreciation, division, balance, equation, and Pythagorean calculations related to people's daily life. The feature of this book is a sequencing of questions, answers, and principles. Specifically, the procedure of this model of education is to pose a question, to find the solution for the question, to use the principle to explain the problem, and to apply it in the real world. The centers of this instructional model are the questions, and the emphasis is on the computations. Since mathematicians focused on the application of mathematics, they tried to generalize real world situations in patterns and find unified ways to solve various kinds of problems. The key to the generalization is to find an accurate and efficient way of computation. That is why the Chinese called mathematics "Suan Xue". "Suan Xue" means "the study of computation." So, the main characteristic of Chinese mathematics is to build a model of a real world situation and to develop methods to solve the problems contained therein.

At the beginning of the 19^{th} century, Western mathematics, including algebra, analytic geometry and calculus, was introduced in China. However, under the influence of the examination culture, mathematical problem solving become the equivalent of problem answering on examinations, and mathematics teaching and learning mainly focused on preparation for the exam.

Spring (1998) observes that under traditional Confucianism, the school system becomes authoritarian, rigid, and antidemocratic. In the past few decades, China has had one national curriculum and one unified set of textbooks. In the 1950s, the Chinese mathematical curriculum and textbooks were influenced by the Soviet Union. A national curriculum of mathematics was issued in 1963. This mathematics curriculum formed a rigorous, logical and purely deductive system. In it, mathematics teaching and learning emphasized mastery of skills and accuracy in computation and the rigor of deduction to meet the high competitiveness of the examination. This exam-driven system isolated mathematics learning from applications and modeling and problem solving in the real world.

However, under the influence of global education in recent years, China has begun the process of reforming curriculum. China has been allowing various textbooks to be published by different states or cities, guided by the national curriculum. A commission to evaluate textbooks from K to 12 was founded to examine and approve the textbooks. In order to reform the national curriculum for mathematics to meet the needs of global education, the Department of Education in China formed various research groups to study mathematics curricula of different countries.

Significance of Findings

This study finds that Chinese educators are actively looking for opportunities to exchange ideas with educators from other countries. Importantly, results of the study indicate differences in middle school mathematics education in China and the U.S.

The Goal of Mathematics Education

Historically, according to the NCTM Standards (1989), societies have established schools to-

1. Transmit aspects of the culture to the young;
2. Direct students toward, and provide them with, an opportunity for self-fulfillment (p.2).

However, in order to meet the economic need today, new goals for education include 1) mathematically literate workers, (2) lifelong goals, (3) opportunity for all, and (4) an informed electorate (NCTM, 1989). Specifically, new goals for students are: (1) learning to value mathematics, (2) becoming confident in one's own ability, (3) becoming a mathematical problem solver, (4) learning to communicate mathematically, and (5) learning to reason mathematically (NCTM, 1989). The aim of *Principles and Standards for School Mathematics* is to build a solid foundation with a set of principles and standards that are focused, coherent, responsive, and grounded. The five process standards describe the mathematical processes through which students should acquire and use their mathematics knowledge: problem solving, reasoning and proof, communication, connections, and representation. Under the influence of these standards, the goal of mathematics teaching is not only to teach mathematics knowledge, but most importantly, is to help students become "capable of thinking and reasoning mathematically" (NCTM, 2000) and be able to solve real world problems to face new challenges in their life.

According to the State Education Commission of P.R of China (1989), the goals of primary education are to enable young children to develop morally, intellectually, physically, and aesthetically; to lay a foundation for the improvement of the national quality; and to cultivate the socialist citizens with ideals, morality, and discipline. The *Mathematics Curriculum for Nine-Year Compulsory Education* (1995) states the following goals of mathematics education for middle school students: In order to be a successful citizen in modern society and to meet the needs of daily life and further education, students should master the necessary basic knowledge and skills in algebra and geometry, develop computational abilities and logical thinking abilities, enhance the concept of space, and apply knowledge learned from the classroom in solving simple real world problem. Furthermore, mathematics education needs to foster students' good character and develop in students the basic concepts of dialectical materialism. Looking toward the twenty-first century, China is updating new goals for mathematics education (Research Group of National Curriculum Standards of Mathematics (1999): Elementary and secondary mathematics education should build a solid foundation in the development of a student's whole life, leading to an understanding of the close relationship between mathematics, nature, and human society, having the student understand the value of mathematics, increasing confidence through understanding the applications of mathematics, using mathematical thinking to observe and analyze the real world and to solve the problems of daily life, enhancing the ability of exploration and creativity, and obtaining the important mathematics knowledge and thinking methods and application skills to fill the needs of development in the future of society.

The majority of Chinese teachers in this study believe that the goal of education in China is to cultivate people and increase the quality of the whole nation. Specifically, the goal of education should foster students' development in five areas: moral, academic, physical, aesthetic, and work, while at the same time focusing on the expansion of students' creative ability. The goals of mathematics education are to develop the student's thinking ability and creative ability, and to help the student use these abilities in solving real world problems. Under this goal, teachers strongly emphasize basic concepts and skills in Chinese mathematics education. While the American classes focus on students' interests and individuality, they place less emphasis on basic concepts and basic skills. The TIMSS (1998) report had similar findings - that eighth-grade U.S. mathematics teachers' typical goal is to teach students how to do something; in contrast, the Chinese teachers' goal in this study was to teach students how to do something and also to understand mathematical concepts so that they can solve future problems. The American psychologist Howard Gardner made similar observations - that American education encourages individuality but ignores basic concepts and skills; China emphasizes basic concepts and skills but fails to encourage individuality (Gardner, 1989).

Mathematics Curriculum

Curriculum plays an important role in education. In the past few decades, China has had one national curriculum and one unified set of textbooks. The mathematics curriculum, based on the mathematics curriculum of 1963 and limited by social and technological development, has focused on a rigorous, logical and purely deductive system. By pursuing the rigorous study of subjects, mathematics teaching and learning emphasizes strong skills and accuracy in computation, and the rigor of deduction. Middle school in China is from 6^{th} to 9^{th} grades or 7^{th} to 9^{th} grades. Students learn Algebra from the first year of middle school until the last year. At the same time, students learn geometry from the second semester of the first year of middle school. The organization of the mathematics curriculum is by level of difficulty, which gradually increases in each topic. For example, the Algebra I course in the first semester has only four topics: Basic Knowledge of Algebra, Integers, Addition and Subtraction of Algebraic Expression, and One Variable Equations. The second semester of Algebra has the following topics: Two Variable Equations, Inequalities and Compound Inequalities, and Multiplication and Division of Algebraic Expression. In the second year, students will learn Factoring, Rational Expressions, Square Roots, and Quadratic Equations. Students will continue to learn Algebra I until they finish the third year. Each grade has different topics and each year there are no more than eight topics in Algebra courses. In contrast, in the U. S., most students take Algebra I in 9th grade (a few honor students take it in the eighth grade). There are more then 12 topics in Algebra I in the U.S. In one year students are expected to master all the algebra concepts and skills which Chinese students take three years (7^{th} to 9^{th}) to learn. As a result, every year most students fail Algebra I in the U.S. For example, the End-of Course Algebra I Examination in Texas fails about 70% of students every year. This is one of the main reasons why we are struggling to have Algebra taught to all students in the U. S.

Apparently, the organization of middle school mathematics curriculum in the U.S. follows a spiral order, repeating topics in different ways. Jiang and Eggleton (1995) had similar findings: The majority of middle schools in U.S. have a spiral curriculum in mathematics. Mathematics topics are briefly introduced one year and then reviewed in successive years to build on the former learning. This spiral curriculum requires students to learn each topic in an insufficient and short time. Therefore, succeeding years allow even less time to cover the material supposedly mastered in the previous year. That is why some middle school students spend three years to learn fractions, decimals, percentage, ratio, and proportion, and are still very weak in these topics in high school. Repetition is one of strategies in learning, but simply repeating the same topics for three years will make students lose interest and confidence, and pay less attention to mathematics learning. "The U.S. mathematics curriculum is characterized by a great deal of repetition and review, with the result that topics are covered with little intensity" (McKnight et al., 1987, p. ix). NCTM's Standards (1989) state, "A comparison of the tables of contents shows little change over grades 5-8. It is even more disconcerting to realize that the very chapters that contain the most new material, such as probability, statistics, geometry, and pre-algebra, are covered in the last half of the books - the sections most often skipped by teachers for lack of time" (p.66). McKnight et al. (1987) considers this a low intensity curriculum. He says, "the U.S. has no one emphasis, but rather shares time among a variety of topics" (p.87). However, according to Jiang and Eggleton (1995), China's mathematics curriculum is much more sequentially organized, with almost no repetition. Different topics are taught in different grades. Similar findings are revealed by Su and Goldstein (1995) that the Chinese science curriculum is uniform, narrow, and deep, while the American curriculum is varied, broad, and flat.

However, although the Chinese mathematics curriculum has its strengths, it has many disadvantages compared to the U.S. mathematics curriculum. Some of the contents are old, narrow, and disconnected from the real world. It ignores the cultivation of the students' characters, including students' attitudes, feelings, and individuality in mathematics teaching; ignores the progress of society and mathematics itself, and ignores the process of exploring, discovering, and sharing of students' learning of mathematics. Consequently, Chinese mathematics education "uses yesterday's knowledge to teach today's students and to cultivate tomorrow's talented people" (Research Group of National Mathematics Curriculum Standard, 1999).

In 1999, the Research Group of National Curriculum Standard held several meetings at various cities in China to discuss how to reform the mathematics curriculum. The group which studied the United States not only examined the NCTM Standards, but also conducted research to discover the reasons for the revision of the NCTM standards, and explored the trends in development of the NCTM standards in the 21st century. By learning from other countries, China created a new mathematics curriculum with Chinese characteristics in the year 2000.

There are some debates and discussion on the following issues in Chinese mathematics education:

1. When should teachers introduce calculators in mathematics classrooms?
2. Should mathematics teaching reduce the requirement of speed in computation and reduce the difficulty level of computation?
3. Should mathematics education simplify arithmetic application problems?

4. Should elementary mathematics include equations?
5. Should elementary mathematics include integers?
6. Should middle schools reduce the requirement on the logic proof level in geometry courses?
7. How far should middle school algebra go? Until quadratic equations, or rational and irrational equations?

Textbooks

The differences in scope and depth in the education curricula in the U.S. and China are also reflected in the textbooks. For the past few decades, China has used a unified set of textbooks for grades 1 to 12 because of the highly centralized educational system. Since state and local experts make decisions on curriculum in the U.S., there has never been a unified set of textbooks. However, since 1989 NCTM has provided guidelines to U.S. textbook publishers for developing unified goals for mathematics instruction (Jian & Eggleton, 1995). While the U.S. is currently developing unified standards for mathematics instruction, China has begun to publish several different sets of new textbooks to test (Wang, 1991). Until 2000, there were more than 60 sets of textbooks that could be used for grades 1 to 12 in China. Both countries are trying to reform textbooks, but taking different directions. In mathematics education, there is a systematic emphasis on the basic concepts and skills in the Chinese textbooks, which allows teachers and students to progress on a continuous ladder towards a comprehensive, solid and deeper understanding of basic concepts. For example, the 6^{th} grade textbook (unified textbook, 1991) consisted of 9 chapters in a total 214 pages. There are five chapters in the first semester book: 1) Multiplication of Fractions, 2) Division of Fractions, 3) Order of Operation in Fractions, Decimals, and Applications 4) Percents, and 5) Rectangles and Square Prisms. The content of fractions is ordered from simple concepts and skills to the level of comprehensive and application skills. In the first semester textbook, 69 pages out of 113 pages are about fractions. After mastering basic concepts and skills of multiplication and division, students learn the order of operation of fractions and decimals to reinforce and develop the concepts and skills of fractions, and from the application of fractions, students are able to extend the concepts and skills of fractions. At last, students are taught a percent concept using fraction ideas. Students spend more than half of a semester's time in learning and developing fraction concepts and skills, in strictly sequential order. This not only provides students sufficient time to learn fractions, but also provides students opportunities to clarify, justify, emphasize, and develop their understanding of fractions in the connected sequence of contents. However, this connected sequence content is also narrow and rigid, with insufficient hands-on experiences, lack of application problems, and limited exposure to knowledge regarding new technology. American textbooks are diversified, loosely structured, broad in coverage and attractive to students (Su and Goldstein, 1995). They have a discontinuity between topics with more than three times the pages of the Chinese textbooks in the 6^{th} grade textbook. For example, in the sixth grade textbook (Scott Foresman - Addison Wesley, 1999), there are 12 chapters in a total of 708 pages for two semesters. They are Statistics; Connecting Arithmetic to Algebra; Decimals; Measurement; Patterns and Number Theory; Adding and Subtracting Fractions; Multiplying and Dividing Fractions; The Geometry of Polygons; Integers and The Coordinate Plane; Ratio, Proportion and Percent; Solids and Measurement; and Probability. There are 79 pages on fractions and 65 pages on Ratios, Proportions, and Percents, which relate to the fractions. A total of 144 pages out of 708 pages are fractions or connected with fractions, compared to 92 pages out 214 pages related to fractions in the Chinese 6^{th} grade textbook. This shows that the U.S. textbooks spend .203 time of the total year on the learning of fractions in 6^{th} grade, while

Chinese textbook spends .429 time of the total year on the development of fraction concepts and skills. Chinese textbooks use double the amount of time than the U.S. to build the students' mathematics concepts. The order of content in the U. S. textbook indicates the disconnected structure. On the above contents, fraction chapters follow "The Geometry of Polygons" instead of the chapter on "Ratio, Proportion, and Percent." It does not provide students continuity in learning, which usually helps students gain more understanding about previous concepts and skills.

In mathematics education, Howe (2000) observes that teachers in China have materials, texts and teaching guides that support their self-study and help them to prepare instructions, but "American texts tend to be lavishly produced but disjointed in presentation, and the teacher' guides do not help much either." Howe stresses the importance of creating new materials and texts for teachers, which will help them "learn and transmit a coherent view of mathematics."

Classroom Teaching

Most Chinese teachers in this study use a traditional way to teach mathematics. According to these teachers, this traditional way is the elicitation method, in which a teacher inspires students to think deeply and to learn actively. Chinese teachers feel that the elicitation method can build a strong foundation in basic knowledge, computation, and analysis systemically. However, the disadvantage of this teaching method is that it is teacher-centered, which often ignores the functions of students, neglects the development of character of the individual, lacks a creative ability, disconnects learning with students' real life, and overlooks the interchange relationship between teacher and students. Especially under the driving pressure of exam taking, the objectives of teaching do not consider students' interests. In order to finish large amounts of content, teachers often give lots of exercises to students, which results in teacher instilling knowledge into students. According to the Research Group of National Mathematics Curriculum (1999), the order of objectives in mathematics teaching in Compulsory Education should be knowledge, skills, and attitude, but there is almost no "attitude" objective involved in some mathematics teaching. In the mathematics classroom, there is only logical thinking and no exploration. "We can observe more on teachers' wisdom and talent in the classroom, and rarely see the talent from students" (The Research Group of National Mathematics Curriculum, 1999).

In the American mathematics classroom, teachers used object teaching method. By applying this method, teachers often provide a variety of objects, applications, and audio-visual aids to help students directly perceive through the senses. For example, in one of my observations of a 6th grade class (90 minutes), students spent 15 minutes in comparing their homework to correct answers provided by the teacher, 18 minutes in the computer lab to practice mathematics skills, and more than 30 minutes on activities from the lesson. The teacher spent only about 20 minutes to explain the new lesson. The teacher tried to use manipulation to provide the connections for students and to make students' learning fun. These connections broaden students' knowledge in art, science, and other subjects.

However, the object teaching method does not foster the ability to think effectively, which is the main goal of mathematics teaching. For less experienced teachers, it is difficult to use time efficiently. It is easy to go an extreme: to underestimate the students' abilities by over-emphasis of hands-on activities, and less focus on the conceptual understanding and creative thinking. The lack of the ability to think in learning mathematics limits the level of understanding, which will result in the grasping of concepts and skills of mathematics at a superficial level.

Changes in Teaching

According to the teachers in the study, there are many things that Chinese educators can learn from American educators. These include how to have students learn using manipulative, learning through the use of games and activities, and focusing on the development of creative ability. They feel that by learning these instructional techniques and implementing them in the classroom, students will be better able to connect the knowledge learned in books with the real world. The goal of Chinese educators is to enable students to apply the knowledge learned in the classroom in solving real world problems. They feel that this could be accomplished also by teaching to the students' individual needs rather than strictly following the textbook.

The educators in the study believe that if American educators pay more attention to teaching basic knowledge and basic skills, and are able to combine the manipulative activities and skill practice, this will enable students to be more successful. Particularly, they remind American educators to not ignore the teachers' function in the student-centered approach.

Overall, teachers in this study are interested in exploring new ways to teach mathematics in both countries. Chinese teachers want to learn mathematics applications and manipulative activities from Americans, while American teachers want to know more about how to build a strong foundation of basic knowledge, and how to develop high-order thinking in mathematics teaching.

Educational Significance

In summary, comparative study can increase our understanding of how to produce educational effectiveness (Schaub & Baker, 1991). Specifically, according to Romberg (1999), comparative studies can illuminate procedures used by different systems to solve the same problems, and comparative studies can also reinforce the understanding of common contemporary problems in education. There are problems in mathematics education in both China and in the United States: China needs to find a way to reduce the high pressure from the exam-driven system, to develop multiple teaching strategies such as hands-on activities to help different levels of students, and to apply new technology in teaching and learning mathematics, while at the same time keeping the strong foundation of basic concepts and skills; the United States looks for new approaches to improve on its weakness regarding the lack of strong basic conceptual understanding and skills.

Jiang & Eggleton (1995) state, "Now is the time for mathematics educators to learn from cultural differences and gain insight into cross-cultural practices." Comparative studies will help "America dramatically accelerate and fundamentally change its efforts to improve math and science achievement in order for its students to achieve top ranks internationally" (Riley, 1998). Comparative studies will also help China learn the western educational system, to reconstruct the exam-driven system into a multiple-assessment and teaching system, and to make the best use of its advantages, which will strengthen its basic foundation for students. This study investigated the differences between the middle school mathematics programs in the U.S. and China and discovered how these differences are revealed in the goals of education, curriculum, textbooks and teaching methods. In addition, this study revealed the fact that a balance is needed between unity and diversity in curriculum design and textbooks. Furthermore, a balance is needed between the elicitation teaching method and object teaching method for both American and Chinese schools.

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