# Comparative Study of the Development of the Mathematics Curriculum in the United States and China

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Abstract:
The present study examined differences in the development of the mathematics curriculum between the U.S. and China from philosophical and historical perspectives. Furthermore, this study addressed the characteristics of Chinese mathematics education and the reform of a national curriculum from a globalization perspective. This study suggests that the practices of each country may be partially adapted to help overcome deficiencies in the other, but wholesale transplantation of curriculum & instruction without regard to the cultural environment and cultural tradition is not applicable and even harmful to each other mathematics education development.

## Introduction

In the beginning of 21st century, there is remarkable growth in the comparative studies in mathematics education. 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 educational systems. The differences include the knowledge of teachers, the design of curriculum, the use of textbooks, and teaching methods. However, there are also similar issues in education that many countries share. Therefore, comparative study provides opportunities for sharing, discussion, and debate of the important issues in an international context. Cross-cultural comparison also leads researchers and educators to develop a deep understanding of various aspects of mathematics teaching and learning. It promotes teachers to question their own traditional teaching practices and find the better choices in constructing the teaching process (Stigler & Perry, 1988).

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 their curricula and instruction.

In general, when cross-national studies in mathematics have included samples of Chinese and U.S. students, the findings have been that Chinese students mathematical tasks at much higher levels of proficiency than U.S. students (Lapointe, Mead, & Askew, 1992; Stevenson et al., 1990). Compared with other countries, the Third International Mathematics and Science Study (TIMSS) revealed that U.S. eighth and twelfth graders score below average in mathematics compared to 41 nations in the TIMSS assessment (Silver, 1998). To compete globally, mathematics education in the U.S. needs to shift its attention internationally to find ways to improve mathematics education.

The present study examined differences in the development of the mathematics curriculum between the U.S. and China from philosophical and historical perspectives. Furthermore, this study addressed the characteristics of Chinese mathematics Education and the reform of a national curriculum from a globalization perspective.

## A Philosophical and Historical Overview of Mathematics Education

Noddings (1995) states, "Philosophers of education are interested in analyzing and clarifying concepts and questions central to education" (p. 4). In order to define the philosophy of mathematics education, we should be interested in answering the following questions: What is the nature of mathematics?

The answer to this question reflects our belief system of teaching and learning. According to Dossey (1992), "Perceptions of the nature and role of mathematics held by different societies have a major impact on the development of school mathematics curricula, instruction, and research" (p.39). Many studies of the reform movement in mathematics and science education consider mathematics as a living, dynamic, growing field of study (American Association for the Advancement of Science, 1989; Mathematical Sciences Education Board, 1989, 1990; National Council of Teachers of Mathematics, 1989; Romberg & Kaput, 1999), while other conceptions of the subject describe mathematics as a static discipline with a set of concepts, procedures, formulas, principles, and skills (Fisher, 1990).

As we examine the history of the development of mathematics, many different philosophies emerge. In the fourth century, Plato claimed that the objects of mathematics had an existence of their own, beyond the mind, in the external world, while Aristotle, the student, viewed mathematics as based on experienced reality, where knowledge is obtained from experimentation, observation, and abstraction. In the early 1500s Francis Bacon separated mathematics into pure and applied mathematics. Descartes tried to put mathematics back on the path of deduction from accepted axioms. The debate

between the rationalists and experimentalists influenced all the development of mathematics and science from the 17th and 18th centuries (Dossey, 1992). In the 19th century, there were three views about the nature of mathematics: logicism, intuitionism, and formalism. Gottlieb Frege, A. N. Whitehead and Bertrand Russell brought the discussion of logicism. "In logicism, the contents were the elements of the body of classical mathematics, its definitions, its postulates, and its theorems" (Dossey, 1992, p.41). In intuitionism, as L.E. J. Brouwer argued, the contents were the theorems that had been constructed from first principles through logical patterns of reasoning. In formalism, mathematics was made up of the formal axiomatic structures developed to relieve classical mathematics of its shortcomings. However, all three philosophies ended in the view of the contents of mathematics as a product rather than a process (Dossey, 1992).

The nature of mathematics is still an issue that is debated today among mathematicians. The National Council of Teachers of Mathematics (NCTM) Standards (1989 and 2000) and some works of modern mathematical philosophers in recent years present many new views of mathematics and important challenges (Tymoczko, 1986). In order to understand the nature of mathematics and its impact on learning and teaching, mathematics educators need to focus on the nature of mathematics in the development of research, curriculum, teacher training, instruction and assessment. Dossey (1992) observes that in reality most professional mathematicians think little about the nature of mathematics. However, the conception of mathematics held by the teacher has a strong impact on the way in which mathematics is approached in the classroom (Cooney, 1985). There are three key views about the nature of mathematics from classroom teachers. As Paul Ernest (1989) observes:

> First of all, there is the instrumentalist view that mathematics is an accumulation of facts, rules and skills to be used in the pursuance of some external end. Thus mathematics is a set of unrelated but utilitarian rules and facts. Secondly, there is the Platonist view of mathematics as a static but unified body of certain knowledge. Mathematics is discovered, not created. Thirdly, there is the problem-solving view of mathematics as a dynamic, continually expanding field of human creation in invention, a cultural product. Mathematics is a process of inquiry and coming to know, not a finished product, for its results remain open to revision (p. 250).

The perception of first and second views has determined the scope of the content and pedagogy of mathematics curriculum. The role of a teacher is to delver knowledge to students, and students are expected to master the knowledge. This traditional teaching approach "involves only the deployment of a set routine" ( Romberg & Kaput, 1999, p.4) with no room for inquiry and construction of knowledge. Romberg & Kaput (1999) urgent to redefine mathematics and they consider mathematics as a human activity. This view of mathematics is parallel to Paul Ernest's problem-solving view which sees mathematics as a dynamic process and structure connected in a social and cultural context. It was supported by Dewey' belief that education is a social process. Through education, students are brought into social processes and the cultural context; they will be able to apply their knowledge to solve problems in the real world.

**The Development of Mathematics Education in the U.S.**

Mathematics has developed and has been institutionalized in the form of school for thousands of years in the world. Although mathematics education in different countries has different systems influenced by their cultures, the main goal of mathematics education 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 futures by teaching mathematics as a tool for solving practical problems, while secondary and college mathematics teaching has aimed at 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 the university and reforming of the 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 curriculum as the solution for teaching and learning problems; students should be learning organized concepts and not drill in specific and arbitrary material (Smith, 1994). This revolution of studying 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" (p. 7). In 1983, *A Nation at Risk* (National Commission on Excellence in Education, 1983) alarmed the country with problems in the U.S. educational system. *Everybody Counts* (Mathematics Science Education Board, 1989) produced by National Research Council called for reformulating the mathematics curriculum and teacher preparation to focus on reasoning and problem solving and to completely change 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, p. 11). 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 (2000) 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 do 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* (NCTM, 2000) need experimentation, implementation, and updating periodically.

In recent trends in the mathematics education at K-12, under the influence of standards, the United States system emphasizes a variety of newer but less well-tested activities designed to promote creativity and independent thinking over concept mastery. However, as the increasing demands on educators to meet more standards, the focuses on mathematics education shift to enhance testing system in the U.S. at the beginning of 21st century. This has been promoting increasingly controversial, and igniting the fire of "Math War" in the U.S. "Math War" is the debate of the most heated issues such as assessment, standards, and teaching and learning in mathematics education between mathematicians and mathematics educators since 1998. Now scholars are trying to find the balance in mathematics education to end this war.

**China: Historical and Modern Perspectives**

***Historical Perspective***

For many years China has been a myth to the West, especially during the period 1950-1970, when China closed the door to the West. According to Ashmore (1997), "To the Westerner, trying to understand China is a bit like being Alice in Wonderland: Everything strikes one as being 'curiouser and curiouser" (p. 1).

China's five thousand years of civilization is greatly respected and admired all over the world. Alfred North Whitehead states, "the more we know of Chinese art, Chinese literature, and of Chinese philosophy of life, the more we admire the heights which that civilization attained" (cite from *Understanding Curriculum*, Pinar et al., 1995).

China's civilization had great impact on education in China. For more than two thousand years the Chinese have been following Confucius (551-479 BC) as the father of Chinese education (Ashmore, 1997). Confucianism plays an important role in both the historical and modern education in China. The successful education systems in China, Japan and Singapore are based on their use of Confucianism.

According to Ashmore (1997), there are several components to teacher roles in the Confucian model:

> *Teaching Without Discrimination.* Most people are teachable, regardless of their backgrounds. Education is not only for the privileged.
>
> *Moral Cultivation and Intellectual Development.* Good teachers are not only knowledgeable but also morally cultivated. Education is a process of role modeling.
>
> *Hunger for Learning.* One who dares to teach never ceases to learn. Persistence in learning is the prerequisite for being a teacher. Teaching benefits teachers as well as students.
>
> *Tireless Zeal and Optimism.* Good teachers possess tireless zeal for the profession, no matter how demanding their students may be. Teachers should demonstrate a positive and optimistic attitude toward their students, for the hope of the future lies in them.
>
> *Effective Teaching Methods.* The complete role of teachers is to guide students in the cycle of learning, critical thinking, and practice (pp. 8-12).

Under the influence of Confucian philosophy, people believe that all occupations are base; only book learning is honorable, which means in order to be on the top of society, one has to be a scholar. Since the Sui Dynasty, about 1300 years ago, government officials were chosen on the basis of scholarly "imperial examinations" (Ashmore 1997).

The two Opium Wars, from 1842 to 1846, caused a social and economic crisis. Chinese intellectuals recognized the necessity of learning Western science and technology and new ideas to reform the old education system. According to Ashmore (1997), Chinese intellectuals formulated three tasks that were designed to rebuild the nation and create a powerful, modern China: (a) political reform, (b) the introduction of Western technologies, and (c) the development of universal education. In 1909, the young emperor, Guang Xu, issued a series of documents to reform the old education. These reforms included the establishment of a system of modern schools to be accessible to most of the population, abolition of the imperial examinations for the selection of government officials, and the introduction of a short and practical essay examination.

By the beginning of the century, the more Westernized elements in the country influenced China, and

the moment of transition from the old to the new arrived with the outbreak of the famous May Fourth Movement in 1919 (Su, 1995). Clopton and Ou (1973) claim that among all Western educators, Dewey most influenced the course of Chinese education, both in theory and in practice. They observe that Dewey's philosophy of education dominated the teaching of educational theory in all Chinese teachers' colleges and in university departments of education for many years, and his major works were translated into Chinese, and one of his major books, *Democracy and Education*, was used everywhere (Su, 1995).

However, China suffered a series of wars from 1921 until 1949, and the communists established The People's Republic of China. Although from the 1920s to the 1940s Dewey's pragmatic educational theory dominated the Chinese educational field, his disciples in China failed to promote Deweyism in the political arena, and the followers of Marxism (communists) succeeded in promoting Marxist ideas (Sizer 1966). The leaders of China found it difficult to accept the West as a teacher, but saw in socialism a practical philosophy with which they could reject both the traditions of the Chinese past and the Western domination of the present (Hsu 1970). Under such a social and political climate, Chinese critics condemned Dewey in the1950s for his emphasis on children's interests and experiences in the educational process. He was blamed for the lack of rigorous teaching and learning in the schools. Dewey's ideas that "education is life" and that "school is society" were misunderstood as an attempt to eliminate formal curriculum, systematic knowledge, and formal schooling, which were considered essential elements for a strong education system in China (Su, 1956).

However, after the Cultural Revolution, China opened its doors to the world and established many educational exchange programs with the West. The central government has focused on education reform as one of the key components to achieve the goal of the four modernizations-agriculture, industry, science and technology, and defense (Ashmore, 1997). The political and philosophical pendulum in China has clearly swung from Marxism to pragmatism in recent years. Both policymakers and intellectuals have realized that China should absorb the new ideas, knowledge and skills, and technology from the West and try hard to search for an effective way that would direct China into a better future (Su 1995). Most Chinese scholars recognize the positive role of Dewey's ideas in the reform of Chinese education. In his theory on curriculum and instruction, he emphasizes a student-centered approach, which promotes "learning by doing." However, some Chinese scholars have different points of view about "learning by doing." They believe that student-centered instruction tends to de-emphasize the role of the teacher, the systematically organized curriculum, and teaching materials, thus seriously affecting the quality of education (Su, 1995). So, in the past decades, the majority of classroom instruction in China was traditional, teacher centered. As China approaching new century in 1990s, China has developed the globalization perspective in education (An, 2000). Not only a few experimental schools and private schools are trying to bring a new way of teaching from the West, the majority of schools in China are learning new ways of teaching from all over the world.

***The Characteristics of Chinese Mathematics Education***

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 status. One of the distinctive features of this form of scholar-nurturing education was to build a solid foundation in education by practicing a rigorous examination system (An, 2000).

Traditional mathematics during the early developmental period (200 B. C.) was listed as the sixth of six skills for scholars in China. It was used as a method to select officers in government, as a tool in management, as a 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, as Zhong Chang did. Some of them worked in the different 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 it's teaching in China. It has determined 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, equations, 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 center of this instructional model is 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 a unified way to solve

various kinds of problems. The key of this generalization is to find an accurate and efficient means of computation. That is why the Chinese have called mathematics the "Suan Xue" throughout history. "Suan Xue" means "the study of computation." So the main characteristic of Chinese mathematics is to build a model of the real world situation and to develop methods for solving problems.

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

In the 1950s, Chinese mathematical curriculum and textbooks were influenced by the Soviet Union. The mathematics curriculum formed a rigorous, logical and purely deductive system. Mathematics teaching and learning emphasized strong skill and accuracy in computation and the rigor of deduction to meet the high competition of the examination. This exam-driven system not only isolated mathematics learning from applications and modeling and problem solving in the real world, but also puts tremendous pressure on the teachers as well as the students and their families. According to An (2000), educators in China have noted the problems in such high stake examination system. Scholars and educators have called for a reform of the education system. As the result, most schools have abolished the requirement of taking middle-school entrance examinations. Furthermore, in Spring 2000, State Education Commission of China issued a document to abolish middle-school entrance examinations in the whole nation (An, 2000).

***The Reform of a National Curriculum from a Globalization Perspective***

. In the past few decades, China has had one national curriculum and one unified set of textbooks. This is observed by Spring (1998) who indicates that under traditional Confucianism, the school system becomes authoritarian, rigid, and antidemocratic. However, under the impact of global education, China began the process of reforming curriculum during 1990s in the following way (An, 2000):

1. Allowing various textbooks under one curriculum. In recent years, various textbooks was 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.
2. Curriculum planning and decision-making are becoming more democratic. In curriculum planning, there are two levels of planning, the national and the local level. At the national level, curriculum planning determines the major kinds of courses, hours, contents, and requirements of instruction. This level provides the basic requirements of compulsory education from the Department of Education in China and it ensures the quality of education. At the local level, states and cities may adjust curriculum plans according to their needs, and then report to the central government for the record. The state education department determines how to follow the national curriculum and makes the guidelines of the curriculum plans for schools in their states. Based on the national and state curriculum plans, schools make detailed action plans for the major and the elective courses according to their own situation and get approval from the state education department. The process of curriculum writing becomes more democratic. The "Law of Compulsory Education of the People's Republic of China" in 1992 shows an example of this new trend. In 1985, the education commission formed a team to produce the first draft curriculum plan in all subject area, which was called the suggestions draft. It was sent to education departments of states, cities, and schools all over the country to obtain feedback. In 1986, a draft trial edition of the curriculum plan was issued. Several research symposiums were held to debate the draft trial edition curriculum plan; research institutions studied and examined it; different level conferences among principals, teachers, and specialists were held to discuss it; finally it was extended to the whole country to get suggestions for the plan. The trial edition curriculum plan of compulsory education was promulgated in 1992.
3. Decision making of curricula followed scientific methods. The process of the trial edition curriculum plan of compulsory education applied investigation, experiment, special topics of discussion, and comparative study with other countries during eight years. In 1987, "The Regulations of Examining and Approving K to 12 Textbooks in China" had clear and scientific rules about the process of examination of textbooks. One is that a textbook should be used on a trial basis before submitting it to examination and approval (p.132).

In order to achieve success in the high competition of global economies in the 21st century, China is reforming the national curriculum from the new perspective. An (2000) observes that since 1986, the National Center for Education Development Research (NCEDR) formed the Research Division of Comparative Education to prepare for the education reform. Its objectives are to conduct research and analysis in

comparative education, and undertake studies on lessons of experiences and trends in the development and reform of international education, in connection with research for macro educational policy-making. In addition, a close attention was to focus on the latest development and reform of education in selected countries, including the United States, U.K., France, Japan, Germany and Russia and other developed countries. NCEDR also has undertook and engaged in international academic exchanges and collaborations (NCEDR, 1999). The revision of the national curriculum for mathematics reflects China's effort to learning from others to strengthen its education system. According An (2000), in order to develop the new national curriculum for mathematics, the Department of Education in China has formed various research groups to examine the mathematics curricula in different countries. The group, which studied the United States, not only examined NCTM Standards, but also conducted research to discover the reasons for revision of the NCTM standards, and explored the trends of development of NCTM standards in the 21st century. By learning from other countries, China has created a new mathematics curriculum with Chinese characteristics in 2001.

**Conclusion**

In summary, comparative study can increase our understanding of how to produce educational effectiveness and enhance our understanding of our own education and society (Kaiser, 1999). Specifically, 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 (Romberg, 1999). Jiang & Eggleton (1995) state, "now is the time for mathematics educators to learn from cultural differences and gain insight into cross-cultural practices" (p. 193). The results of this study indicate that the development of mathematics education in the two countries differ markedly. There are problems in mathematics education in both China and in the United States: China needs to 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. The United States are looking for new approaches to improve on its weakness regarding the lack of strong basic conceptual understanding and skills by enhancing testing system. The practices of each country may be partially adapted to help overcome deficiencies in the other, but wholesale transplantation of curriculum & instruction without regard to the cultural environment and cultural tradition is not applicable and even harmful to each other' mathematics education development.

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