# Invited Lecture

# Chinese Mathematics Curriculum Reform for Compulsory Education in the 21st Century

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**ABSTRACT** Curriculum reform is a fundamental factor in pushing forward educational development and reform. The aim of this study is to present the current situation of mathematics curriculum reform for compulsory education in mainland China since 2000. In this study, we examine the development and implementation of Chinese mathematics curriculum standards for compulsory education. Based on mathematics curriculum standards, this study introduces the reform of mathematics textbooks, classroom instruction and mathematical achievement assessment.

*Keywords*: Mathematics curriculum reform; 21st century; Compulsory education; Mainland China.

## 1. The Background of New Century Chinese Mathematics Curriculum Reform

From an international perspective, we live in an age witnessing a rapid development of science and extraordinary changes in people's lifestyles. New knowledge, innovative technology, socialization, and globalization have related modern mathematics closely to all areas of human existence (The Research Group of Mathematics Curriculum Standard, 1999). Since the 1980s, many countries around the world have hoped to improve the mathematics literacy of their own citizens through various efforts. Many of the world's major countries and regions have implemented new rounds of mathematics education reform, including the Principles and Standards for School Mathematics in the United States (National Council of Teachers of Mathematics [NCTM], 2000) and the National Curriculum in Great Britain (Cockcroft, 1994).

Social and economic development in China (especially the development of information technology, digital technology, life-long learning, and democratization (The Research Group of Mathematics Curriculum Standard, 2002) have raised the bar for mathematics literacy. New demands for modern citizens have required corresponding changes in public schools, especially in mathematics curriculum and instruction.

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From June 1996 to 1997, the division of basic education in the Ministry of Education organized a survey to investigate the status of the implementation of compulsory education in all subjects, including mathematics, across the nation. The data and facts collected from this survey demonstrated that the curriculum used at that time achieved certain goals (e.g., basic knowledge and basic skills training); however, many problems were identified. For example, the old curriculum was characterized as "complex, difficult, partial, and old." Students suffered from rote memorization and drill practice. At the same time, teachers struggled with "draining students in a sea of problems" (Liu, 2009). There was too much emphasis on using test scores to screen students. The old curriculum was highly centralized, with little flexibility for local adaption, and it did not meet the different social and economic requirements of a diverse student body (Liu, 2009). To address the above issues, the current mathematics curriculum reform in China begin at the beginning of the 21st century.

## 2. The Mathematical Curriculum Reform Since 2001

### *2.1. 2001: The Mathematics Curriculum Standards for Full-Time Compulsory Education (Trial Version)*

The Mathematics Curriculum Standards for Full-time Compulsory Education (draft) was completed and put forth for extensive comments from the community in March of 2000. The mathematics standards research group mentioned above consisted of mathematics and mathematics education scholars, researchers and staff members from local provinces (cities), and school teachers. About 70 percent of the research team members worked in higher education institutes and about 30 percent of them worked in public schools. This research group developed new mathematics standards by studying the research results and best practices from both the Chinese and the international mathematics education communities. The research team members also solicited comments from scholars and experts in various fields including mathematics, psychology, mathematics education, and school teachers. The comments received by the team ranged from discussions of the nature of mathematics and educational goals to issues about methods for handling the definition of multiplication. The development process adopted a procedure of open discussion so that the resulting curriculum policy could benefit from the wisdom of different parties, with a careful consideration of diverse values (Song and Xu, 2010, p. 121). The Ministry of Education formally promulgated and implemented Mathematics Curriculum Standards for Full-time Compulsory Education (Trial version) (MCSFCE 2001) in June 2001.

#### *2.1.1. The new characteristics of the MCSFCE 2001*

The MCSFCE differed from the products of previous curriculum reform in several fundamental aspects, such as the basic curriculum ideas, curriculum objectives, curriculum implementation (including guidance on textbook development), teaching

suggestions, evaluation recommendations, and even curriculum management. It provided detailed descriptions in some dimensions. For example, the traditional syllabus only provided a brief description of teaching content and objectives. Most of the descriptions of teaching objectives were included in the textbook developed by the state. MCSFCE changed both the scope and depth of the role that the state plays in the curriculum by providing descriptions of learning content, learning processes (special attention), and teaching recommendations (including several cases for some content). This provided a standard for the transformation from one single national textbook policy to a policy of diversity; a national committee certificated and authorized the different versions of textbooks, according to the curriculum standards.

To examine some of the differences between the old Syllabus and MCSFCE 2001 in more detail, consider the following descriptions of how students and teachers should approach the Pythagorean Theorem (see Tab. 1).

Tab. 1. The Pythagorean Theorem in the old Syllabus and the MCSFCE 2001

| **The old Syllabus** | **The MCSFCE 2001** |
|---|---|
| (1) Master the Pythagorean Theorem. (Students) know how to use the Pythagorean Theorem to solve for the third side given the measurement of the other two sides. | (1) Explore the proof process of the Pythagorean Theorem. |
| (2) (Students) know how to use the converse of the Pythagorean Theorem to determine if a triangle is a right triangle. | (2) (Students) know how to use the Pythagorean Theorem to solve simple problems. |
| (3) Conduct patriotic education by introducing the research on the Pythagorean Theorem done by ancient Chinese mathematicians. | (3) (Students) know how to use the converse of the Pythagorean Theorem to determine if a triangle is a right triangle. |
| | (4) The recommendations for textbook development suggest introducing several well-known proofs (such as the Euclidean proof, Zhao Shuang's proof, etc.) and some well-known problems so that students are aware that mathematical proof can be flexible, beautiful and sophisticated. |
| | (5) Students should also be aware of the Pythagorean Theorem's rich cultural connotations. |
| | (6) Some teaching suggestions include guidance on the teaching activities and teaching process of the Pythagorean Theorem. |

### *2.1.2. The basic reform idea in the MCSFCE 2001*

As mentioned above, the MCSFCE 2001 proposed a basic reform idea: "Mathematics for All." In other words, "Everyone can learn valuable mathematics; everyone can learn the necessary mathematics; different people benefit from different mathematical development" (Ministry of Education of the People's Republic of China, 2001). This concept was totally different from the underlying idea of the old Syllabus (Zhang and Song, 2004). The MCSFCE suggested following the psychology of learning mathematics and using real-life experience to motivate student development. Students were to experience the process of mathematical modeling, which would allow for the interpretation and application of the problem-solving process. Thus, as was the hope of mathematics education reformers elsewhere in the world, students would be enabled

to grow in mathematics understanding, mathematics thinking ability, attitudes towards mathematics, and appreciation of mathematics (National Council of Teachers of Mathematics [NCTM], 2000).

### *2.1.3. The curriculum objectives in the MCSFCE 2001*

Even though, in terms of curriculum objectives, MCSFCE inherited qualities from traditional Chinese mathematics education which emphasized training in basic knowledge and basic skills ("The Two Basics") (Zhang et al., 2005), the MCSFCE also emphasized learning goals for the growth of mathematical thinking ability, problem-solving skills, attitudes towards mathematics, and the appreciation of mathematics.

### *2.1.4. The nature of mathematics and the "non-formalized aspect"*

The MCSFCE highlighted the nature of mathematics and the "non-formalized aspect" of mathematics content, including applications of intuitive geometry and a spiral curriculum (Zhang and Song, 2004). At the same time, emphasis was placed on the cultural value of both pure and applied mathematics, real world applications of mathematics, the importance of human development, the technical attributes of mathematics, and the connections between mathematics and calculators (and computers). MCSFCE 2001 defined mathematics as a language to describe the real world. It was considered a process of theory abstraction from nature using qualitative/quantitative methods that also involved the application of theories to solve real world problems.

### *2.1.5. The curriculum content in the MCSFCE 2001*

In terms of specific curriculum content, the MCSFCE was arranged in several sections, including "Number and Algebra," "Space and Figure," "Statistics and Probability," and "Practice and Synthetic Application." The focus was on the development of students' number sense, symbol sense, space concepts, statistical concepts and the application of awareness and reasoning abilities. In the number and algebra section, the MCSFCE added the concept of negative numbers and applications of calculators, and strengthened the role of estimation. The emphasis on the use of the abacus, complicated operations, and the use of simple numbers was decreased. In terms of geometry (Space and Shape section), the topics of translation, rotation, symmetry and other geometric transformations were increased to a certain extent to replace the traditional Euclidean geometry system. The coverage of topics in orientation, measurement, space and shapes was also increased, as was emphasis on the real world application of measurement and estimation, and the application of mathematics topics in everyday life. The MCSFCE especially increased attention to probability and statistics, reflecting the basic mathematical literacy requirements for citizens in modern society.

### *2.1.6. Critical-thinking skills, inquiry, and cooperation*

The MCSFCE proposed the use of critical-thinking skills, inquiry, and cooperation in mathematics teaching and learning (Zhang, 2008), pointing out that the mathematics learning process is full of observation, experiment, simulation, inference and other exploratory and challenging activities. One emphasis of the MCSFCE was that textbooks should make connections with other disciplines by incorporating science, social studies, and other relative subjects to teach mathematics. The textbooks should also provide space for student investigations and communication. Accordingly, teachers were urged to use concrete examples and demonstrations to guide students in the learning process and encourage them to communicate ideas via discussions. According to the MCSFCE, teachers should encourage students to think critically and independently. Also, they must recognize individual differences generated by the culture, learning environment, family background and different thinking styles.

### *2.1.7. Mathematics learning assessment in the MCSFCE 2001*

The MCSFCE additionally put forward clear guiding principles for development and evaluation by focusing on the process and different assessment methods, notably recommending that assessment should be used to inform teaching (Kong and Sun, 2001). It also provided recommendations for evaluation according to grade bands. For example, the evaluation schema for grades 1-3 emphasized the assessment of students' mathematics learning processes, mastery of basic knowledge and basic skills, and their ability to identify and solve problems. In particular, it was felt that multiple evaluation methods should be used.

### *2.1.8. The Implementation of the MCSFCE 2001*

Before the release of the MCSFCE a set of textbooks based on the idea of the new curriculum had been designed by a research group for experimental use (the majority of the members were to part in the development work of the MCSFCE later). Since 1994, this group had conducted two rounds of experiments; more than 60,000 students from more than ten provinces (including both well-developed school districts to undeveloped school districts) participated, which provided abundant empirical experience for the later implementation of the MCSFCE.

The Ministry of Education started a national curriculum reform conference to convene the implementation of the new curriculum in July 2001. Several decisions were made at the conference. First, the overall objectives and strategies for the implementation of the new curriculum in public schools were determined. Second, the strategies to spread the curriculum reform to all Chinese public schools were developed. Third, professional development and teacher training programs were set up. The positioning of the trial version of the curriculum standards necessitated a multi-stage process for spreading the new curriculum. The first stage was to set up the goals, then

to conduct preliminary experiments before the nationwide implementation, and finally to broaden the experiment gradually.

In the initial round of experimental implementation of the curriculum, school participants were recruited on a county basis in 2001. First, applications to be volunteer schools were submitted by counties and were examined before being approved by the Ministry of Education. Forty-two regions (3,300 elementary schools, 400 secondary schools) participated in the first round of the national curriculum reform with about 270,000 first graders (1% of the population of first graders nationwide) and about 110,000 seventh-grade participants (0.5% of seventh graders) in 2001. Starting in 2002, each province developed a curriculum reform plan at the province level and determined their experimental regions. There was a total of 570 experimental regions with 20% of Chinese first graders and 18% of the seventh graders participating in the new curriculum. Subsequently, more schools from an additional 1,072 counties became experimental regions at the province level, bringing in about 40% -50% of the student population of each grade. Including the earlier participants in 2001 and 2002, there were 1,642 experimental regions with about 35,000,000 students participating in the new curriculum in 2003. Based on the results of these pilot tests, the new curriculum entered the phase of nationwide promotion. By 2004, 90% of the school districts in China were using the new curriculum. As of 2005, except for a few places, the new curriculum had been implemented all over mainland China.

### *2.2. The Revision of Mathematics Curriculum Standards: from MCSFCE 2001 to MCSCE 2011*

Since the implementation of the MCSFCE (Trial Version), the work of developing it has never been interrupted. After the first round (3 years) of mathematics curriculum reform, the revision process began. Based on the experience, account was taken of the problems arising from the implementation of the standards, as well as comments from society (including severe criticism from some mathematicians). In May 2005, the Ministry of Education organized the revision group for mathematics curriculum standards for compulsory education, and officially began the revision process.

There were 14 members in the revision group, from different backgrounds including universities, coaching offices and primary and secondary schools. About half of them had worked on the design of MCSFCE (Trial version). Through the process of surveys, situation analysis and discussions of special issues, the Mathematics Curriculum Standards for Compulsory Education (2011 Version) (MCSCE 2011) were finished in 2010, and approved in May 2011. The standards were published officially in December 2011. (Ministry of Education of the People's Republic of China, 2012, p. 34).

*2.2.1. The new characteristics of the MCSFCE 2011*

MCSCE 2011 was developed from the trial version; several revisions were made (Zhu, 2012), such as the basic curriculum ideas, curriculum objectives, content standards and suggestions for curriculum implementation. The following several paragraphs summarize several aspects of the important revisions, such as the structure, the expression, the concrete content and suggestions for curriculum implementation (Ministry of Education of the People's Republic of China, 2012, p. 34).

1) For the value of mathematics and the function of mathematics education, MCSCE 2011 discussed the research object of mathematics and the relationship between mathematics and human society, and then gave the fundamental characteristic of mathematics, which were different from the statement of the trial version.
2) MCSCE 2011 expanded the 6 core concepts (Sense of Number, Sense of Symbol, Idea of Space, Idea of Statistics, View of Application and Ability of Inference) into 10 core concepts (add Perceptual Intuition of Geometry, Idea of Modeling, Operations Ability, and changing the Idea of Statistics into View of Data Analysis.). The new concepts were very important in mathematics education research.
3) For the curriculum objective, MCSCE 2011 used the "Four-Basics" (Fundamental Knowledge, Fundamental Skill, Fundamental Idea and Fundamental Activity Experience) to expand the "Two-Basics" (Fundamental Knowledge and Fundamental Skill).
4) The Fundamental Idea generally included the Idea of Mathematical Abstraction, the Idea of Mathematical Inference and the Idea of Mathematical Modeling. Fundamental Activity Experience refers to the individual experience the students gain by experiencing mathematical activities personally. The Fundamental Activity Experience was the one of the characteristics of MCSCE 2011. This issue was considered by Chinese scholars since the 1980s, but did not receive due attention. After the introduction of MCSCE 2011, many scholars began to explore this issue.
5) Revisions were made to the concrete contents and the requirements, across all the domains (Shi et al., 2012). The content domains of "Space and Figure" and "Practice Synthetic Application" were revised into "Space and Geometry" and "Synthetic and Practice". The word "Geometry" emphasized the abstraction of concrete figures and space, and also explained the general laws behind figures and space. The word "Synthetic" emphasized that an important stage of learning was knowing the relationship between the knowledge and concepts that students learned, and "Practice" was a higher requirement. Some concrete content was omitted, such as the requirements of the trapezoid and position relationship between circles.

### *2.2.2. The implementation of the MCSFCE 2011*

With the base established by the implementation of the MCSFCE (Trial Version), MCSCE 2011 was implemented at one time. Since the autumn semester, all beginning grades (for primary and middle schools) began to implement the new curriculum standards (not only mathematics).

Some changes appeared in the high-risk examinations. For example, the entrance examination to high school in Beijing adapted the concrete content and new rubrics were introduced focusing on the Mathematical View, Mathematical Activity Experience and Mathematical Ability.

MCSCE 2011 discussed the relationship between plausible and deductive reasoning, and the relationship between the real-life world and systems of knowledge. Its objectives highlighted the development of students' creative and application abilities, and added the ability to discover and raise problems (Ministry of Education of the People's Republic of China, 2012, p. 84).

The two versions of standards consolidated and perpetuated the achievements of the new century mathematics curriculum reform and played an important role in giving impetus to the healthy and continuous development of mathematics education in China.

## *2.3. Reform of mathematics textbooks*

The curriculum reform has led to many new ideas for developing textbooks. The reform also supports the transformation from one single national textbook to authorizing different versions of textbooks, according to the curriculum standards.

The curriculum standard provides guidance and principles for the mathematics textbooks. Based on the guidance, Chinese new century mathematics textbooks have some common features.

1) These mathematics textbooks place emphasis on the relationship between knowledge learning and its applications.
2) These textbooks pay attention to knowledge development, heuristics, and investigation, which can give students more chances to explore and discover knowledge.
3) These textbooks increase the content presentation to inspire students' interest in mathematics.
4) These textbooks provide mathematics context knowledge to embody mathematical cultural value.
5) These textbooks stress the integration of information technology and mathematics curriculum to improve the effectiveness of mathematics teaching and learning.

## *2.4. Reform of classroom instruction*

Teachers and classroom teaching are the critical factors to maintain the effective implementation of new curriculum reform. As mentioned before, the new mathematics

standards provide some teaching recommendations. Teachers are advised to change and improve their teaching methods based on the MCSCE 2011.

1) teachers should take account of students' learning styles in classroom teaching.
2) teachers are advised to provide students more opportunities and guidance for independent, cooperative, and inquiry-based learning.
3) teachers should consider and meet students' psychological needs for cognitive development.
4) teachers should try to arouse the students' desire to learn and inspire them to think actively. Teachers need to help students establish specific learning aims and strong learning motivation, and guide them to explore knowledge actively.
5) teachers are advised to integrate classroom teaching with information technology.

### *2.5. Reform of mathematical achievement assessment*

It is well known that China has a large population but relatively scarce high-quality educational resources. Under such conditions, primary and secondary mathematics selection examinations play an increasingly important role. The examination process has been described vividly as "crossing a single-plank bridge", which demonstrates the fierce competition in the examination in China.

It is worth noting that a lot of changes have occurred in the ideas, content methods, and evaluators in mathematics learning assessment in the new curriculum reform.

1) The mathematical achievement assessment has changed from a traditional identification assessment to a developmental assessment based on modern teaching concepts.
2) The traditional mathematical achievement assessment mainly focuses on basic knowledge and abilities. Based on the new curriculum objective in MCSCE 2011, the new assessment methods pay more attention to learning processes and methods.
3) The traditional mathematical learning assessment mainly relies on the written examination. The new mathematical learning assessment expands to various methods including class observation, homework analysis, and student files.
4) The traditional mathematical learning assessment is mainly based on teachers' evaluations. The new methods encourage students to assess their learning performance and process by themselves and their classmates.

Overall, the assessment under the current reform emphasizes the evaluation of students' overall abilities, the application of mathematics in real life and interdisciplinary context, mathematical culture, and the history of mathematics.

## 3. Looking Ahead to the Next Decade

As the implementation of the curriculum reform, the revision of curriculum standards

never stops. In 2019, the Ministry of Education began a new round of curriculum standard revision[2]. There are some important directions in the new round revision.

1) The new curriculum standards will pay attention to developing key competency for the compulsory education stage.
2) The new revision will promote the integration of interdisciplinary knowledge.
3) The new curriculum standards will advocate unit-based teaching design, project-based, collaborative and inquiry learning.
4) The new curriculum standards will highlight the incorporation of technology in teaching and learning.
5) The new curriculum standards will focus on competency-oriented assessment.
6) At present, the newest curriculum standard is still under revision and consultation. The new curriculum standards will be officially released in 2022.

The curriculum reform in the last two decades led to changes in ambitions, curriculum content, teaching methods, textbooks, and assessment methods. These changes played an important role in promoting the development of mathematics education in China.

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[2]A new version of the curriculum standard — *Compulsory Education Mathematics Curriculum Standard (2022 Edition)* — has been issued and textbooks based on the new curriculum standard are currently being compiled. For the new standard (Chinese Version only), please refer to: Ministry of Education of the People's Republic of China (2022). *Compulsory Education Mathematics Curriculum Standard (2022 Edition)*. Beijing: Beijing Normal University Press. — The editor

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