



## Chinese Mathematics Curriculum Reform in the 21<sup>st</sup> Century: A Review

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### ABSTRACT

This article provided a comprehensive review of the most recent mathematics curriculum reform in the early 21st century in China. Three components of curriculum reform were identified. The developmental process, the content and implementation of Chinese mathematics curriculum standards, constituted the most important second level of description of a curriculum reform which could reflect the first level (overall societal level) and decide the third level (classroom practice level). It could be the first fundamental step to provided helpful insight to understand the curriculum reform within a certain culture. At last, the future direction of mathematics curriculum reform in China was introduced.

**Keywords:** China, curriculum standard, mathematics, reform

### INTRODUCTION

China is a country with an ancient history and continuous civilization, and is very different from most other cultures in the world, especially from Western cultures (Wang, Li & Li, 2014). It has been suggested that students in East-Asia, e.g. China, outperformed their counterparts in the West in large-scale international studies of mathematics achievement (Wang & Lin, 2009). The mathematics education practice in China has attracted much attention not only from educational communities, but also the entire society.

Curriculum reform is a fundamental factor in pushing forward educational development and reform. The People's Republic of China has undertaken several rounds of curriculum reform for basic education<sup>1</sup> since the late 1970s.

### LITERATURE REVIEW AND RESEARCH QUESTIONS

Movements to reform curriculum of mathematics education were underway in many parts of the world and scholars from educational community made an effort to review, analyze and evaluate these reform activities.

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#### **State of the literature**

- A large amount of studies has introduced, reviewed, and evaluated the curriculum reform in a certain culture.
- The review of curriculum could be classified into three different levels: 1. Overall societal level, 2. Responsibilities, monitoring and control systems and the actual curriculum texts level and 3. Classroom practice level.
- Systematic review of Chinese mathematics curriculum on the responsibilities, monitoring and control systems and the actual curriculum texts level was rare.

#### **Contribution of this paper to the literature**

- To present to the world the current situation and experience of mathematics curriculum reform in mainland China, the current study examined the developmental process, the content and implementation of Chinese mathematics curriculum standards in the most recent round of curriculum reform during the early 21<sup>st</sup> century.

### **Theoretical framework of Analysis, Review and Evaluation of Educational Reform**

Scholars has developed several theoretical frameworks to describe, analyze, review and evaluate curriculum reform in a certain culture, and discuss the curriculum reform from different perspectives.

Alkin (1973) provided a framework of Curriculum and Instruction Matrix which attempted to refine the goal – setting and development components of the curriculum framework. The study addressed the question of reform in education and concerned with the distinction that could be made between various levels within the curriculum development. They used the terms “macro” and “micro” to describe and classify the educational reform activities.

The steps in macro curriculum activities, for example, contained the selection of a pool elements from which the curriculum choices were made. The curriculum specialist would devise procedures to choose from the pool of elements to form a school curriculum. On the other hand, the micro curriculum activities began with the selection of the subset of these elements in the macro curriculum. It developed the hierarchical scheme to depict the constituent elements so as to produce a finalist to represent the micro curriculum. This framework could help researchers to decompose the curriculum and understand the relationships of the change between the overall contents and the nuance within each block.

In order to make connections between what happened in the classroom and in society, the researchers believed that curriculum theory basically works with three different levels. The first level stand on the overall societal level, where the organization of knowledge in a society that matters to its historical period, the labor market structure, the political and social forces in society (Sundberg & Wahlström 2012). At this level, the goal of the theory was to offer an international perspective that illustrated how educational policy in the world interact with national policies. The second level focused on the matters about the actual governing of a national school system. The issues at this level always refer to responsibilities, monitoring and control systems and the actual curriculum texts (Nordin & Sundberg 2015). At the third level, it was discussing about how a certain curriculum controlled the actual educational processes in classrooms.

It could be seen that the second level was the core part of an analysis of curriculum reform which could reflect the first level and partly decide the third level. The following research generally analyzed second level of the curriculum reform based on the Australian context.

Australian government (2014) developed a national report to review and evaluate the development and implementation of the Australian Curriculum, which desired to ensure that Australia was performing well in the international context. The review of the curriculum started from the context of Australian Curriculum and the

purpose of education, gave consideration to both of the international context and the local development of curriculum. The analyzing framework consisted of governance for curriculum design and delivery, the structure of the Australian Curriculum, the evidence of the development and implementation of the Australian Curriculum, the content domain of the Australian Curriculum, as well as the future reforms to governance for curriculum development.

It could be seen that the analysis on Australian curriculum reform work as the first fundamental step and provided very helpful insight to understand the curriculum reform in a certain culture.

### **Analysis of (mathematics) education reform in China**

Many researches were conducted to introduce the Chinese local curriculum reform including mathematics to the world (Huang, 2004; Zhang, 2009; Tan, 2012).

Several aspects of various levels of curriculum reform which were mentioned above and the alignment across different levels were reviewed and discussed. One single research might come down to relate to one, two or even three levels described above.

Zhang (2009) claimed that the current mathematics curriculum reform in the mainland was to change the recognitions of mathematics and school mathematics, to change the traditional methods of mathematics teaching and learning to the modern methods, and to change the traditional assessment to the modern assessment. But the teaching and learning in mathematics classrooms were still traditional in nature. Stand on the cultural angle, some reasons could be found: Chinese traditional culture made teacher as the bearer of knowledge, Official-Oriented-Mentality as the core value ruler lead to the inequality relationship between teachers and students, understanding the mathematics as absolute truth made negotiating, persuading, and compromising unnecessary and reasonless, and examination culture led to score-centered learning.

Previous researches generally focused on a main perspective to discuss Chinese curriculum reform. From the above narration, Zhang (2009) provided some reasons to support the conclusion that teaching and learning in mathematics classrooms were still traditional in nature from the cultural angle. Huo and Ye (2010) analyzed Hong Kong curriculum design and its implementation dip from the context perspective.

It could be seen that the researches, though, several aspects of different levels of curriculum reform were reviewed and discussed, little comprehensive reviews of certain level existed. Especially for the second level which was essential for understanding and future analysis of curriculum reform since it could reflect the first level (overall societal level) and decided the third level (classroom practice level).

This current review paper will focus on the second level of Chinese mathematics curriculum reform referring to responsibilities, monitoring, control and supporting systems and the actual curriculum texts as Nordin & Sundberg (2015) described.

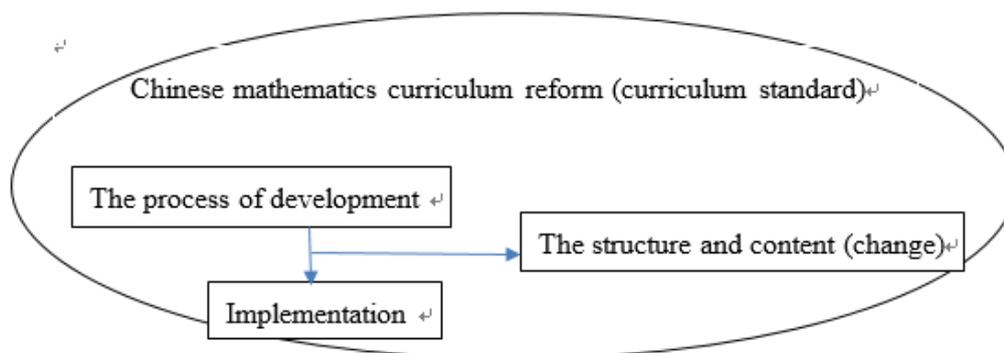
### **Research Question**

Based on the literature review above, the following research questions were generated.

- A. How did the reformed mathematics curriculum in China mainland develop? What was the process like?
- B. What were the structure and content of reformed mathematics curriculum standard, compared with the former teaching syllabus?
- C. How was the reformed mathematics curriculum implemented? What is the control and supporting system like?

### **THEORETICAL FRAMEWORK**

According to the literature review and research questions. The following theoretical framework were developed.



**Figure 1.** Theoretical framework

The theoretical framework of review would focus on the second level of Chinese mathematics curriculum reform referring to monitoring control or supporting systems and the actual curriculum texts as Nordin & Sundberg (2015) described. These aspects of curriculum reform would potentially reflect overall societal level curriculum and decide the classrooms level curriculum.

The official mathematics curriculum policy in China was present through curriculum standard. The standard was designed separately on compulsory level (grade 1-9) and high school level (grade 10-12). For the curriculum reform in early 21<sup>st</sup>, curriculum standard for compulsory level was developed and implemented first and then for the high school level two years later. The following review of curriculum reform would focus on the development, structure as well as content and the implementation of national curriculum standard on basic education.

For the process of development, the initiation and the mechanism of development process, the manning of the research team of reformed curriculum standard were reviewed based on official material and research papers. And also, the structure (including the curriculum intention) and content of reformed curriculum standard and its revision version was discussed, especially discussing the change compared with the former teaching syllabus.

The implementation of curriculum consisted of the process, control or supporting (institutional) systems of the implementation.

### MATHEMATICS CURRICULUM FOR COMPULSORY EDUCATION (GRADES 1-9)

The national policy document of education: *The 21<sup>st</sup> Century Revival Action Plan in Education* called for the “implementation of cross-century project of quality education, promotion of education to improve the national education quality and students’ innovation capability” and noted the need to “spend about 10 years experimenting with a nation-wide curriculum for basic education in the 21<sup>st</sup> century, we need to reform the curriculum system and the evaluation system based on the experiences we gain.” (Ministry of Education of the People’s Republic of China, 1999).

### An international context

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 in the world make modern mathematics closely related 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, including reflecting on the history of education and developing new curriculum standards (Dong, 2006). 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).

### A local context

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), has raised the bar for mathematics literacy. New demands for modern citizens have required corresponding changes in public schools, especially in mathematics curriculum and instruction (Ma, 2001). 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 former 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 with the sea of problems” (Liu, 2009).

The trends in international and local education pushed the initiation of curriculum reform. Similar to the previous education reforms, the current reform adopted a top-down approach: however, we cannot negate the fact that it also reflected certain concerns raised from the community.

### The Development of Reformed Standard for Compulsory Education

In March 1999, the Ministry of Education first commissioned an existing research group to explore a national curriculum standard for mathematics curriculum ahead of the other disciplines, which hoping to provide first-hand experiences in the curriculum development process for other disciplines<sup>1</sup>.

*Mathematics Curriculum Standards for Full-time Compulsory Education (MCSFCE) (draft)* was finished and put forth for extensive comments from the community in March of 2000. The mathematics standards research team consisted of mathematics and mathematics education scholars, researchers and staff members from local provinces, and school mathematics 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 team developed new mathematics standards by studying the research results and best practices from both the Chinese and the international mathematics education community. 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 (Zhang & Liu, 1999). 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 & Xu, 2010, pp121).

Before the release of *MCSFCE*. A textbook based on the idea of new curriculum had been designed for experiment by a research group (majority of the members had taken part in the development work of *MCSFCE* later). Since 1994, they conduct two rounds of experiments, more than 60000 students from more than ten provinces (including both well-developed school districts to undeveloped school districts) participated it, which provide abundant empirical experience for the later development of *MCSFCE*.

The development of mathematics curriculum played an important role in this round of curriculum reform of fundamental education, which provided the idea of basic value, the mechanism of implement, and the way to develop the standard for other disciplines in fundamental education. The Ministry of Education formally promulgated and implemented *Mathematics Curriculum Standards for Full-time Compulsory Education (Trial version) (MCSFCE)* in June 2001.

<sup>1</sup> The “Prospects in the 21st Century Mathematics Education Project” research group

## Reformed Curriculum Standards for Compulsory Education

The following sections would review the structure and content of reformed standards for compulsory education with a focus on the change with the form teaching syllabus and the curriculum intention.

In addition to focusing on additions and deletions of some content topics, 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 played in the curriculum by providing descriptions of learning content, learning processes, and teaching recommendations. This provided a standard for the transformation from one single national textbook policy to diver textbook policy. And a national committee certificated and authorized the different versions of textbook following the requirement of the curriculum standard.

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

*MCSFCE* 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 former teaching syllabus (Zhang & Song, 2004). *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.

Though in terms of curriculum objectives, *MCSFCE* inherited qualities from traditional Chinese mathematics education which emphasized the training of basic knowledge and basic skills ("The Two Basics") (Zhang, Li & Tang, 2005), *MCSFCE* also emphasized learning goals in the growth of mathematical thinking ability, problem solving skills, attitudes towards mathematics, and the appreciation of mathematics.

*MCSFCE* highlighted the nature of mathematics and the "non-formalized aspect" of mathematics content, including applications of intuitive geometry and a spiral curriculum (Zhang & Song, 2004). At the same time, emphasis was placed on the cultural value of both pure mathematics 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* defined mathematics as a language to describe the real world. Mathematics 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.

In terms of specific curriculum content, *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, *MCSFCE* added the concept of negative numbers, applications of calculators, and strengthened the role of estimation. *MCSFCE* decreased the emphasis on the use of the abacus, complicated operations, and the use of simple numbers (Kong & Hu, 2002). In terms of geometry (Space and Shape section), *MCSFCE* increased the content of translation, rotation, symmetry and other geometric transformations to a certain extent to replace the traditional Euclidean geometry system. *MCSFCE* also increased coverage of topics in orientation, measurement, space and shapes. *MCSFCE* also emphasized the real-world application of measurement and estimation, and the application of mathematics topics

in everyday life. For example, from the first stage (grades 1-3), students began to encounter a variety of geometric shapes (cars), which were observed from different perspectives (front, left/right side and above) (Kong, Liu, & Sun, 2001). *MCSFCE* especially increased attention to probability and statistics, reflecting the basic mathematical literacy requirements for citizens in modern society.

In general, the intensity of this curriculum reform was greater than in all previous reforms. Some innovative features served as an important impetus for the curriculum reform, but this also brought greater challenges and difficulties in the implementation of the reform. The central characteristic of new curriculum was the development of students, which provided the inner motivation for the pursuit of fairness and prompting quality in new century educational curriculum.

### **The Implementation of Reformed Standards for Compulsory Education**

The government held the responsibilities of the implementation of new curriculum standard. And the implementation process was "from up to down" with a new-designed supporting system.

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 of 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 curriculum standards necessitated a multi-stage process for spreading the new curriculum. First set up the goals, then experiment before a nationwide implementation, and finally gradually increase the experiment.

In the initial round of experimental implementation of the curriculum, counties were the units for recruiting school participants in 2001. First, applications to be a volunteer school 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 7<sup>th</sup>-grade participants (0.5% of 7<sup>th</sup> 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 Chinese 7<sup>th</sup> 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 from these pilot tests, the new curriculum entered the phase of nationwide promotion. By 2004, 90% of school districts in China used the new curriculum. As of 2005, except for a few places, the new curriculum has been implemented all over mainland China (Ma, 2009).

The education administrators launched an institutional system to support the curriculum implementation. The central part of the support system was teacher professional development, which included centralized large-scale teacher training, school-based teaching, research activity, and online training as a high-efficient supporting system.

The Ministry of Education issued several documents addressing teacher training: *Suggestions on Basic Education Teacher Training for New Curriculum*, *Guidance on Further Strengthening Basic Education Teacher Training for the New Curriculum*, and *Suggestions on Accelerating the National Teacher Education Network and a New Round of Teacher Training*. The teacher training courses for the new curriculum proposed several requirements, e.g., "training first, teaching later; no training, no teaching"<sup>2</sup>. The Ministry also made a policy to advance the National Teachers Education Network Alliance Program within the next five years. This followed an approach of "thinking about every teacher, highlighting the experienced teacher, favoring the rural teacher" to organize a new round of staff training featuring new ideas, new programs, new technology and character

<sup>2</sup> [http://www.moe.gov.cn/publicfiles/business/htmlfiles/moe/moe\\_631/200710/26612.html](http://www.moe.gov.cn/publicfiles/business/htmlfiles/moe/moe_631/200710/26612.html)

education, thus improving the overall quality of teachers<sup>3</sup>. The Division of Teacher Education of the Ministry of Education organized two key state-level teacher training programs (including mathematics) to promote the teacher training programs for the new curriculum at the local level (province, county, and district level). The state allocated a special fund for underdeveloped area teacher training. From the beginning of the curriculum development process, research team members had advocated a professional development system based on developing the cultural characteristics of equality, mutual communication, and cooperation.

In order to make up for the shortcomings of short-term intensive training, and especially to enhance teachers' understanding of the new curriculum and motivate their creativity in using it, the Ministry of Education advocated a school-based teaching and research system at the province and state level. In this model, every teacher became a researcher to build a reflective, communicative, and innovative school culture. This greatly motivated the teachers and principals (Liu, 2009).

Meanwhile, online training emerged as an efficient training method because of several advantages of computer technology. For example, on-line training was not limited by time and space. Its low cost, high efficiency, and effectiveness made it attractive to large scale professional development (Jiang, 2006). Most of the provinces set up a curriculum reform steering group consisting of experts from universities and education research institutes. They used several strategies for teacher training including involving teachers in research projects, sending experienced teachers to support teachers in rural areas, establishing a curriculum hotline, and building a network of virtual teaching and research systems (The Implementation of New Curriculum and Assessment Research Group, 2005).

In the summer of 2006, the professional development program, National Distance Teacher Training for New Curriculum, was established by the Ministry of Education. The teacher training program was divided into three sessions: student learning, teacher development, and classroom teaching. They aimed to address the concerns raised by teachers and to guide the development of lesson plans that used the new curriculum by focusing on selecting appropriate problems that connected to real world situations.

### **The Revision of Reformed Curriculum Standards for Full-time Compulsory Education (Trial version) and the Implementation**

Since the implement of the MCSFCE (Trial version), the work of developing it had never been interrupted. After the first round (3 years) of mathematics curriculum reform, the revision process of MCSFCE (Trial version) had begun. Based on the experience, problem get from the implement of standard, as well as comment from the society (including severely criticism from some mathematicians). In the May of 2005, the Ministry of Education organized the revision group of mathematics curriculum standard for compulsory education, and officially began the revision process.

There were 14 members in the revision group with different backgrounds, who come from university, coach office and publish schools. About half of them had ever worked on the design of MCSFCE (Trial Version). Through the process of survey, situation analysis, discussion on special issues, etc. the Mathematics Curriculum Standards for Compulsory Education (2011 Version) (MCSCE2011) was finished in 2010, and was approved in May of 2011.

It was officially published in December of 2011. (Revision Group of Mathematics Curriculum Standard for Compulsory Education (2011 Vision) 2012, pp 34)

MCSCE2011 was inherit and development of MCSFCE (Trial Version), several revisions were made (Zhu, 2012), such as the basic curriculum ideas, curriculum objectives, the content standard, and curriculum implementation suggestion, etc.

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<sup>3</sup> [http://www.moe.gov.cn/publicfiles/business/htmlfiles/moe/moe\\_601/200507/8705.html](http://www.moe.gov.cn/publicfiles/business/htmlfiles/moe/moe_601/200507/8705.html)

The following several paragraphs summarized the important revision on several aspects, such as the structure, the expression, the concrete content and the curriculum implementation suggestion, etc. (Revision Group of Mathematics Curriculum Standard for Compulsory Education (2011 Vision) 2012, pp 34)

1. For the value of mathematics and the function of mathematics education, MCSCE2011 discussed the research objective of mathematics and the relationship between mathematics and human society, and then gave the fundamental characteristic of mathematics, which was different from the statement of MCSFCE (Trial version).

2. MCSCE2011 expanded the 6 core concepts (Senses of Number, Senses 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, Ability of Operation, and change the Idea of Statistics into View of Data Analysis.)

The new concepts were very important concepts in mathematical education researches. For example, the Perceptual Intuition of Geometry was considered as one of the important factors which impacted the mathematical develop of primary and secondary students (Kong & Shi, 2012).

3. For the curriculum objective, MCSCE2011 gave the "Four-Basics": Fundamental Knowledge, Fundamental Skill, Fundamental Idea and Fundamental Activity Experience from the "Two-Basics": Fundamental Knowledge, Fundamental Skill. The Fundamental Idea generally included Idea of Mathematical abstraction, Idea of Mathematical Inference and Idea of Mathematical Modeling. Fundamental Activity Experience stand for the individual experience the students got by personally experience the mathematical activities.

The Fundamental Activity Experience was the one of the characteristics of MCSCE2011. This issue was noticed by Chinese scholars since 1980s. Until the MCSCE2011, many scholars began to explore this issue (Guo & Shi, 2012).

4. There were revisions on the concrete contents and the requirements, across all the domains (Shi, Ma & Liu, 2012). The content domain of "Space and Figure" and "Practice Synthetic Application" were revised into "Space and Geometry" and "Synthetic and Practice". The word of Geometry emphasized the abstraction of concrete figures and space also it explained the general laws behind figures and space. The word Synthetic emphasized that knowing the relationship among knowledge and concepts the students learn was the important stage of learning, and Practice was a higher requirement. MCSCE2011 cancelled some concrete content, such as the requirements on trapezoid and position relationship between circles, etc.

With the base established by the implement of MCSFCE (Trial version), the MCSCE2011 was implemented in one time. Since the autumn semester, all the beginning grades (for primary school and middle school) began to implement the new curriculum standard (not only mathematics).

For the high-risk examination, some change had appeared for the adoption of new standard. For example, the entrance examination to high school in Beijing had not only adapt the concrete content, but gave new rubrics focusing on the Mathematical View, Mathematical Activity Experience and Mathematical Ability. (Wang, 2013)

The two versions of standard have consolidated and persist the achievement the new century mathematics curriculum reform and played an important role in impetus of healthy and continuous development the mathematics education in China.

## MATHEMATICS CURRICULUM FOR HIGH SCHOOL EDUCATION (GRADES 10-12)

After the implementation of compulsory standard, mathematics curriculum reform for secondary education was inspired by the same educational beliefs that motivated the compulsory education reform.

### The Development of Reformed Curriculum Standards for High School Education

The core secondary mathematics curriculum committee was formed in June 2000. The committee included 13 members with different backgrounds. They were mathematicians and mathematics educators from universities,

mathematics education scholars from research institutes, mathematics teachers, staff members from national testing centers, and delegates from publishing houses (Song & Xu, 2010).

In the process of, the research team studied mathematics curriculum in several developed and developing countries around the world. The study included the following topics: trends of current research in mathematics, current demands on public education, learning in secondary school, international comparison studies, and current teaching and learning in China (Song & Xu, 2010). The team conducted surveys, interviews and classroom observations in several provinces. The participants in these initial studies were teachers, students, principals and guidance officers in secondary schools.

The results indicated that China had accomplished a great deal in mathematics education through cultivating talented students. However, several challenges in secondary mathematics education also confronted the mathematics education community, such as too much emphasis on basic knowledge and basic skills. The learning objectives were focused on three skills (mathematics, logical reasoning, and spatial imagination). Due to the impact of the former teaching syllabus regulations on learning objectives, teaching materials, examinations, and practical concerns of teachers, the high school mathematics curriculum was characterized as complex, difficult, deep and narrow. It raised public concerns of limited real-world connections. The curriculum was outdated with limited electives, and there was no room for modern mathematics teaching strategies. The primary evaluation methods came from test scores on final examinations, which had a significant negative impact on students (Lv & Zhong, 2001).

The research team formalized the reform theory, curriculum objectives and corresponding high school mathematics curriculum standards based on the research results of previous studies. The development process for secondary school curriculum standards was similar to the process for compulsory education. The research team solicited suggestions from all parties including mathematicians, math education experts, scholars from research institutes, secondary school teachers, and experts from related disciplines such as educational psychology (National High School Mathematics Curriculum Standard Group, 2002). At the same time, the research team conducted several studies in more than 30 high schools on some newly added content (such as algorithms, etc.) and mathematical investigations (including curriculum design, and pilot teaching, etc.). These research results provided both evidence and experiences for the later development and revisions of the standards (Song & Xu, 2010, pp 123).

The draft version of Mathematics Curriculum Standards for Secondary Education came out at the end of 2002. The final version MCSSE (Trial version) was formally published and released in April 2003, after the Ministry of Education completed authorization.

### **Reformed Curriculum Standard for High School Education**

As the compulsory standard, the following section would review the structure and content of high school standard with comparison to the former teaching syllabus.

*Mathematics Curriculum Standards for Secondary Education (MCSSE)* is fundamentally different from the curriculum guidelines developed in previous reforms. It shared similar characteristics to the *MCSFCE*, including the outline of structural changes. It deepened and specified some dimensions (e.g. curriculum content descriptions). MCSSE also included teaching suggestions, teaching materials, suggestions and recommendations (Ministry of Education of the People's Republic of China, 2003).

MCSSE proposed "student-centered" curriculum ideas, such as cultivating mathematics literacy, increasing active learning, mastering basic knowledge and basic skills, integrating mathematics and information technology, developing critical thinking skills, developing application and mathematics modeling skills, and the significance and values of a mathematics culture. MCSSE advocated that high school mathematics curriculum should include a mathematics culture, through which mathematics literacy could be achieved.

MCSSE also advocated a modular structure (36 classes per module), with each module mutually independent, but also with logical connections. The new curriculum offered a variety of selections to meet the needs of individual students. The former curriculum only provided two elective courses at the high school level—

mathematics for liberal arts majors and mathematics for science majors. The new curriculum provided more options. Students needed to take five required modules before the elective courses. There were four elective series, where Series 1 (targeting students majoring in humanities and social science), and Series 2 (targeting students majoring in science, engineering, and economics) were basic elective courses. Students could continue to select Series 3 and Series 4 after finishing courses in Series 1 and Series 2. Series 3 and Series 4 had a number of topics, with each topic requiring 18 classes. They were designed for those students who were interested in mathematics and hope to learn more. They involved several topics aimed at some important mathematical ideas, scientific value, application of mathematics, and the understanding of a mathematics culture, which reflected some important mathematical ideas, hoping to provide mathematical base for life-long development of students. Selective topics in Series 3 included the history of mathematics, information security and passwords, spherical geometry, etc. (six topics). Selective topics in Series 4 included geometric proofs, matrices, transformations, etc. (10 topics).

The intention was to expand these elective topics gradually with careful monitoring of the quality of these courses. MCSSE encouraged schools to set up certain topics in Series 3 and 4 according to the preparation of their faculty. Schools also had opportunities to enrich and improve various additional elective courses based on the school-based curriculum and faculty resources (18 classes for each credit).

In addition to the new electives (which mostly appeared in Series 3 and 4), the MCSSE also contained several new topics, including orthographic views, spatial coordinates, algorithms, block diagrams, random numbers, and statistics. It also presented this new content using new ways of representation. For example, in three-dimensional geometry, the new textbook took the whole-part approach, rather than the traditional logical approach of point, line, plane and solid. In terms of geometry objectives, the new textbooks followed a cognitive order from overall perception to the details of point, line, and plane. The new curriculum also presented probability and statistics in the order of statistics, probability, and counting techniques, rather than the traditional order of counting techniques, probability, and statistics (Cao & Huang, 2008, pp34).

Besides the curriculum based on mathematical knowledge, the MCSSE designed the series of Mathematical Exploration, Mathematical Modeling and Mathematical Culture, which was required to be integrated into the regular curriculums.

### **The Implementation of Reformed Curriculum Standards for High School Education**

With the release of the MCSSE, the high school curriculum reform entered its experimental deployment stage. The high school curriculum policy was promoted under a step-by-step experimental expansion model which was generally similar as the compulsory standard. Different from the compulsory education case, the high school reform began its experimental deployment in large regions such as provinces, self-regulated regions, and municipalities. In fall 2004, four provinces, self-regulated regions and municipalities became the first experimental zones of the high school curriculum. By fall 2012, the entire entry grade in high schools had adopted the high school curriculum.

Similar institutional and supporting system was built as the compulsory standard for the MCSSE such as on-line and offline teacher training program.

### **The Revision of Reformed Curriculum Standards for High School**

With the release of MCSSE2011, the revision work of the MCSSE was started 10 years after its release.

In November of 2014, the Ministry of Education approved the "Curriculum Plan of High School (Revision)", and then the revision of MCSSE was started.

The revision raised a new central concept of "core literacy," which was one of the tendency of international curriculum reform. The model of student's core literacy of was applied to promote the curriculum reform (Xin, Jiang & Wang, 2013). Mathematical core literacy was the most fundamental component, which decided the main line of curriculum. Then core literacy in high school level were mathematical abstraction, operation, deductive reasoning, mathematical modeling, intuitive imagination, data analysis, etc.

Based on existing published literature (Hong et al., 2015), the “Curriculum Plan of High School (Revision)” set the module by system of subject, and did not distinguish the students by the science series and the social liberal art series. The requirement of graduation credit was 144, and 88 for essential curriculum and no less than 42 for selective series 1, and no less than 14 for selective series 2.

For the plan for comment, the new curriculum would include essential series, selective series 1, and selective series 2. 8 credits for essential series including “Preparing Knowledge” (Set, Logic Language, Equivalent and Inequality, etc.), “Function and Sequence” (The concept of Function and the Principles, Fundamental Function, Sequence, and The application of Function), “Vector and Geometry” (Solid Geometry, Two-Dimension Vector, and The application of Vector: Solving Triangles), “Statistics and Probability” (Random Sampling, Error Model, Estimation, Classical Probability, and Geometry Probability), which emphasizing the fundament and modernization of the contents.

Series 1 included 0-6 credits including “Function and Derivative” (Derivative and application, Optimizing, Inequality), “Vector and Geometry” (Solid vector and Solid geometry, Analytical geometry, Conic, etc.), “Statistics and Probability” (Counting Principle, Conditional Probability, Discrete Random Variable, Bernoulli Model, Linear Regression), which emphasizing the fundament of the contents.

Series 2 included 0-6 credits and was divided into A, B, C, D, E 5 categories. Category A was for students who selected science direction, including Calculus with one Variable, Three-Dimensional Geometry and Three-Dimensional Linear Algebra, Model of Statistics and Probability. Category B included Calculus, Linear Algebra, Statistics and Probability, which had less contents than A, and emphasized application and mathematical model. Category C (social science) included Logic, Social survey, and Mathematical model which emphasized application. Category D was “Beauty and Mathematics”, which included Mathematics in sports, Mathematics in music, and Mathematics in art. Category E was school-based curriculum, which adapted AP in Chinese background, including Calculus with one Variable, Integration with one Variable, Linear Algebra and Statistics and Probability.

Based on existing published literature, revised high school standard would change a lot from MCSSE, including the organization of curriculum, the division between science and liberal art as well as the introducing of AP. The teaching method and other direction would change according to the change of curriculum.

To be noticed that the revision was still ongoing, the comprehensive revision needed to be analyzed after final version.

## THE FUTURE DIRECTION OF MATHEMATICS CURRICULUM REFORM IN CHINA

The curriculum reform in early 21<sup>st</sup> century have deep changed in the ambition, content of curriculum, teaching method, the edition of textbook and assessment method. These changes has promoted the development of the mathematics education of China. And also, both the preparation and deployment process of the curriculum reform has caused various theoretical and practical contentions in the mathematics education community.

The first two decades of the 21<sup>st</sup> century has almost passed. Mathematics curriculum reform in China has accomplished significant achievements; at the same time, it also faces many challenges. In 2010, the Ministry of Education established a special committee for curriculum and textbook development for basic education. The development and implementation of curriculum standards demands professional knowledge from experts. By establishing a national committee for such highly specialized tasks, China is demonstrating progress in the decision-making system in education.

Also in 2010, the Chinese government released the National Long-term Educational Reform and Development Plan (2010-2020)<sup>4</sup> to regulate national education reform and development activities in the next decade. This 10-year development plan emphasized improving the quality of compulsory education. It also

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<sup>4</sup> [http://www.moe.gov.cn/publicfiles/business/htmlfiles/moe/A01\\_zcwj/201008/xxgk\\_93785.html](http://www.moe.gov.cn/publicfiles/business/htmlfiles/moe/A01_zcwj/201008/xxgk_93785.html)

emphasized the strict enforcement of national curriculum standards and teacher qualification standards. It promised to continue curriculum reform and teaching methodology reform. Many specific recommendations were included in this plan. For example, small-classroom teaching was advocated. Homework assignments for middle school and elementary school students will be reduced. Textbook contents will be adjusted. Curriculum difficulty levels will be appropriately designed. In the next decades, evaluation systems for student and school performance will be revised. Students will have more recreation time and more opportunities to improve their critical thinking skills, to solve real world problems, and to advance hands-on activities. Teachers will be required to improve their teaching skills, to enhance classroom teaching effectiveness, to reduce the amount of student assignments and examinations, and to strictly follow the course syllabus. Schools will facilitate students to finish required courses in different disciplines. Scientific evaluation systems will be established to assess school proficiency tests and overall student quality. Student development guidance systems will be built to provide students moral advice, psychological advice and academic advice.

Based on this plan, scientific research and teaching practice in mathematics education will focus on developing educational theory and practice with Chinese characteristics. This will include digesting the experiences of other countries, developing China's voice considering the educational resources and reality in this country, defining the characteristics of China's mathematics education, conducting comparative studies in mathematics education, promoting the spirit of independence and freedom of thought in academics, creating a set of measurement criteria and assessment systems suitable for China, emphasizing both qualitative and quantitative research in mathematics education, preparing well-trained scholars with good teaching experience, and emphasizing the combination of theory and practice to promote the role of math teachers in mathematics education theory and practice (Zhang, 2010; Zheng, 2006).

China's system of mathematics education has taken up a heavy responsibility and a long course, regardless of what direction it eventually takes. The challenges ahead come from and will have to address the social changes brought by rapid economic development, the demands for talent as a consequence of economic globalization, and the educational problems caused by social development.

Experiences told us that the path of reform were also the process of exploring. Theories and practice of mathematics education needed to synthesize the research and idea from mathematics, education, psychology and many other disciplines, pooling resources from all areas and levels, from the top (academic frontier) to the bottom (classroom in rural side). The success of the curriculum reform demands rigorous academic attitude, national responsibility and steady efforts.

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