Worldwide efforts to improve students’ learning of mathematics have turned educational researchers’ attention to some high-achieving education systems, especially those in East Asia including Chinese Mainland, Hong Kong, Japan, Singapore, South Korea and Taiwan. However, there is much less sharing and learning of educational policy and practices that goes beyond one or two such high-achieving education systems. At this time when educational changes and reforms for improving students’ learning of mathematics are also underway within these high-achieving education systems in East Asia, it becomes timely and important for the world to learn why and how relevant changes take place across these selected education systems. This book has put together a set of papers that individually presents issues on the changing mathematics curriculum and teacher education in the six high-achieving education systems in East Asia. Collectively, the book extends beyond what we can learn about exemplary practices in individual education systems in East Asia. It helps us develop a better understanding of the interplay between various measures for the pursuit of excellence in mathematics curriculum and teacher education on the one hand, and the different system contexts on the other. The intended readers of the book include education policy makers, curriculum developers, researchers, teachers, teacher educators, and anyone else interested in school mathematics curriculum and teacher education.
Reforms and Issues in School Mathematics in East Asia
NEW DIRECTIONS IN MATHEMATICS AND SCIENCE EDUCATION
Volume 19

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Scope
Mathematics and science education are in a state of change. Received models of teaching, curriculum, and researching in the two fields are adopting and developing new ways of thinking about how people of all ages know, learn, and develop. The recent literature in both fields includes contributions focusing on issues and using theoretical frames that were unthinkable a decade ago. For example, we see an increase in the use of conceptual and methodological tools from anthropology and semiotics to understand how different forms of knowledge are interconnected, how students learn, how textbooks are written, etcetera. Science and mathematics educators also have turned to issues such as identity and emotion as salient to the way in which people of all ages display and develop knowledge and skills. And they use dialectical or phenomenological approaches to answer ever arising questions about learning and development in science and mathematics.

The purpose of this series is to encourage the publication of books that are close to the cutting edge of both fields. The series aims at becoming a leader in providing refreshing and bold new work—rather than out-of-date reproductions of past states of the art—shaping both fields more than reproducing them, thereby closing the traditional gap that exists between journal articles and books in terms of their salience about what is new. The series is intended not only to foster books concerned with knowing, learning, and teaching in school but also with doing and learning mathematics and science across the whole lifespan (e.g., science in kindergarten; mathematics at work); and it is to be a vehicle for publishing books that fall between the two domains—such as when scientists learn about graphs and graphing as part of their work.
Reforms and Issues in School Mathematics in East Asia

Sharing and Understanding Mathematics
Education Policies and Practices

Edited by

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INTRODUCTION

The value of exploring curriculum and teacher education in an international context has been well recognized by educators all over the world. For example, the *International Handbook of Curriculum Research* was published in 2003 as the first collection of reports on scholarly developments and school curriculum initiatives worldwide (Pinar, 2003). Similar efforts in learning about teacher education practices in different education systems can also be seen in recent years (e.g., Eraut, 2000; Tisher & Wideen, 1990). Along with the development of learning about curriculum and teacher education practices in general, curriculum and teacher education practices in content specific areas, such as mathematics, have also received more and more research interest over the past decade (e.g., Jaworski, Wood, & Dawson, 1999; Li, 2000; Li & Lappan, 2002; Usiskin & Willmore, 2008).

The growing interest in examining mathematics curriculum and teacher education in an international context is closely related to the sustained interest in documenting students’ mathematics achievement cross-nationally (Li, 2007; Schmidt et al., 1997; Schmidt et al., 2007). As students’ learning of school mathematics is the fundamental training necessary for the development and up-keep of a system’s economic strength, cross-system studies in school mathematics have been valued for informing educators about the effectiveness of their own practices and for suggesting possible alternatives for improvements (e.g., Postlethwaite, 1988; Robitaille & Travers, 1992). In the United States, for example, relevant analyses based on cross-system studies suggest that there is a gap between the United States and some high-achieving education systems in East Asia in terms of school mathematics curriculum, classroom instruction and teacher preparation (e.g., Schmidt et al., 2007; Silver, 1998; Stigler & Hiebert, 1999). Because both curriculum and teachers’ instruction are recognized as vital parts for enhancing students’ academic achievement (e.g., NCTM, 2000; NCTAF, 1996; Schmidt et al., 2001), educational research in the past decade has seen dramatically increased emphasis on improving practices in mathematics curriculum and teacher education. Thus, by focusing on changes and practices in mathematics curriculum and teacher education in different education systems, this book provides a platform for exchange and sharing of educational policy and practices in these two vital aspects that contribute to students’ learning of mathematics.
Worldwide efforts to improve students' learning of mathematics have also directed educational researchers' attention specifically to educational policy and practices in some high-achieving education systems, especially those in East Asia including mainland China, Hong Kong, Japan, Singapore, South Korea, and Taiwan. The superior performance of students from these systems in recent international comparative studies in mathematics achievement such as TIMSS (Beaton et al., 1997; Mullis et al., 1997; 2000; 2004; 2008) and PISA (OECD, 2001; 2003; 2004; 2007) has attracted attention of the worldwide mathematics education community and beyond. For example, when the first TIMSS results (with testing in 1995) were released in 1996, the mathematics education community and the public at large were surprised and intrigued by the superior mathematics achievement of students from Hong Kong, Japan, Korea and Singapore. These four systems occupied the top four positions of all the participating systems in mathematics achievement. Taiwan joined TIMSS from 1999 onwards, and since then these five systems (mainland China has not participated in TIMSS) have been without exception topping the list of all participating systems in terms of mathematics achievement in each cycle of TIMSS (i.e., in 1999, 2004 and 2007). Performance of students from these systems on the mathematics test in PISA is equally impressive. They do not always top the list of all the PISA systems, but they are always the leading ones. Mainland China did not participate in TIMSS and PISA, but mainland Chinese students also did remarkably well in other international studies in mathematics achievement such as IAEP (Lapointe, 1992).

The public usually views these international studies as competitions, and interest is usually focused on the ranking of countries in the league tables generated by the studies. Politicians often made use of the rise and fall of the positions of their countries in the league tables to justify their agenda for educational changes. However, rarely have their justifications been based on information beyond the overall study scores and the league tables. Among the mathematics education community, some attempted to explore factors that are related to achievement (Leung, 2002; Park and Leung, 2003), but there is not much sharing of best practices behind the achievement of students.

SHARING OF BEST PRACTICES

But sharing of best practices per se, and in the context of these international studies, is of paramount importance. The ultimate purpose of any educational research should be the betterment of student learning, and the purpose of comparative studies in education in particular should be for systems under comparison to learn from each other and thus improve their practices so as to effect better learning. But sharing of best practices seems to be absent in the discussion of results in many of these international studies. Studies such as TIMSS, for example, do include some background statistics relating to the practices in participating countries. But for studies of so large a scale, one cannot expect the background information to be
studied and reported in any depth. Consequently, findings of these large-scale international studies usually fail to provide enough details about the practices of the participating countries for them to be able to learn from each other.

On the other hand, rich background information should provide the context based on which results of international comparison of student achievement may be properly understood. For example, a low overall score achieved by students in a country, or a high score in a certain dimension (e.g., Geometry), may not mean much until it is interpreted in the context of the curriculum and teaching and other background variables of the countries concerned. So without an appreciation of the relevant background data, it is not possible to get the best out of the comparative results. It may even lead to misleading conclusions.

The compilation of this book is based on a fundamental belief that cross-system sharing and learning in school mathematics education is highly valuable for informing educators in different systems about the effectiveness of their own practices and for suggesting possible alternatives for improvements. In this more and more globalized world, we believe that collaboration among people of different backgrounds is much more important than competition (Bishop, 2006). But before we can truly collaborate, we must first understand and learn from each other. This book intends to provide in-depth information on mathematics curriculum and teacher education in a number of education systems so as to enable different systems to learn from each other. East Asian systems are chosen for study because of the superior performance of their students in international comparative studies of mathematics achievement as mentioned above.

At this time when educational changes and reforms are underway within these high-achieving education systems in East Asia, it becomes timely and important for these systems to learn why and how relevant changes take place. The importance of such learning is embedded not only in learning from the success of other high-achieving education systems for the purpose of one’s own capacity-building, but also in learning from the failure of other education systems for the purpose of preventing similar mistakes from happening in one’s own system. Sharing reform efforts in school mathematics among selected high-achieving education systems is even more important for the rest of the world to learn what is happening in these high-achieving education systems while improving students’ learning is still a focal concern for all.

There is a host of diverse background variables that are related to student achievement, but as students learn most of their mathematics in their schools, two most important and obvious factors which contribute to student achievement are the kind of mathematics students learn and the quality of the teachers who teach the mathematics. The quality of teachers in turn depends much on the quality of the teacher education or preparation offered by the systems concerned. So among the characteristics of an education system, the curriculum and the features of teacher education are two key contributing factors to students’ performance in mathematics. It would be important for these high-achieving education systems in East Asia to learn from each other about relevant educational changes in these two areas, as well as for the rest of the world to understand these two important areas which affect student achievement.
Issues in mathematics curriculum and teacher education may be understood and examined at different levels. At the micro level, the key components include specific measures and approaches adopted to address issues encountered in different education systems. It would be instructive to examine whether different systems are facing essentially the same kind of issues, and to what extent the measures and approaches adopted to deal with the issues are similar. At the macro level, the issues faced by different systems and the way they are tackled should be understood in the context of the system characteristics and the cultural values underlying the systems concerned. Stability and change in mathematics curriculum and teacher education should be interpreted taking into account these factors at the macro level before true sharing of best practices can occur.

CURRICULUM

There have been curriculum reforms in practically every system of the world in the past couple of decades or so. The increased ease of flow of information through exchange activities as well as through the internet has meant that systems are increasingly influencing each other. Even as early as the late 1980s, Howson and Wilson suggested that there existed a so-called “canonical curriculum” which was found in nearly all countries around the world (Howson & Wilson, 1986). In the following chapters, readers will surely find a lot of commonalities in the mathematics curricula of the East Asian systems under consideration. But what is more interesting and significant, we believe, is to find out whether there are subtle differences underlying the superficial similarities, and whether there are different understanding and rationale behind the superficial similarities. It is through relating superficial similarities and differences to a deeper level of underlying factors that we can fully understand the nature of the mathematics curriculum of a system and its possible relation to student achievement.

So the questions we are interested in exploring through this book are: Do East Asian systems offer more or less the same mathematics curriculum to their students? Are there essential differences between the curricula in these systems and those in Western systems, or are the within East Asia differences as large as the difference between East Asian systems and Western systems? In recent curriculum changes in East Asian systems, are they roughly moving towards the same direction or are they changing in essentially different ways? More importantly, are the suggested changes based on similar rationales, and what issues do educators in these systems see as significant ones in the area of the mathematics curriculum?

TEACHER EDUCATION

Compared to the curriculum, teacher education in the East Asian systems is even less known to the international community. IEA recently launched a project entitled Teacher Education and Development Study in Mathematics (TED-M) which includes a component studying the characteristics of teacher education programmes.
at primary and lower secondary levels in participating systems (Tatto et al., 2009). Of the East Asian systems, only Singapore and Taiwan are participating in TEDS-M, and the results of TEDS-M are still not available at the moment.

While the curriculum is an important factor affecting student achievement in the sense that it prescribes the mathematics that students are to learn, it may be argued that more important are the agents or people (i.e., teachers) who deliver the content. There are many factors which determine the performance of teachers in the classroom, but without doubt, the preparation they undergo is a major factor that affects their instructional practices. So similar to the case of the school curriculum, the questions we are interested in exploring are: What kind of teacher education programmes are provided for mathematics teachers in the East Asian systems, and are they significantly different from the programmes offered in other parts of the world? Have there been major changes in the teacher education systems and programmes in these systems, and if there have been major changes, what are the rationales behind the changes? What do educators in East Asian systems see as the issues that are significant in the area of teacher education? Do the teacher education programmes in the East Asian systems provide any clues for the high achievement of their students? These are crucial questions, and yet so little is known in this area, and there is not enough basic information available for us to start exploring these questions.

THE PURPOSE OF THIS BOOK

As mentioned above, this book is about sharing of best practices, and the title of the book may suggest that we are merely looking for commonalities in curriculum and teacher education among the high achieving systems so as to “share” them with other countries. Readers may indeed try to gather from what are presented in the coming chapters to see whether there are any shared practices among these high achieving systems, and whether these shared practices may be generalized to some theories of best practices in mathematics curriculum and teacher education. But finding commonalities is not actually the purpose of this book. On the contrary, we want to document the different practices to illustrate the richness of practices in these high achieving systems. Education is a complicated endeavour, and there is an intricate relationship among the socio-cultural contexts of a system, its educational system and educational practices, and student achievement. In order to learn from other systems, it is not enough to look at practices per se, but to understand the complex socio-cultural context within which the practices are located. The last thing we want to see is for a system (e.g., a low achieving one) to reproduce the practices of another system (e.g., a high achieving one) without taking into consideration the differences in socio-cultural contexts between the two systems. Such import of practices will not work. One may import the practices, but one cannot import the socio-cultural environment of the system as well. And “good” practices often produce the desired effect only in a certain socio-cultural context. So the purpose of this book is for us to understand and learn, and not to copy or imitate.
In this book we invited educators from each of the six systems to write about the mathematics curriculum and features of teacher education in their systems. We asked authors to identify and discuss the issues that their systems are facing, in addition to providing some background information for readers to understand the issues. Such juxtaposition of information and ideas may be considered a kind of comparison, but since the intention of the book is not comparison, we allow authors some flexibility to choose the issues which they think are important ones in their systems. Thus, some authors wrote about the primary section in their systems, some about the secondary section, and some wrote about both. For teacher education, some addressed issues in their pre-service teacher education programmes, while some focussed on in-service professional development. A number of authors specifically discussed the issue of subject matter knowledge and pedagogical content knowledge of teachers, showing that this may be a matter of common concern in East Asian systems. In the area of the mathematics curriculum, many authors described recent reform initiatives. Some presented this from a historical perspective, while others followed an “issue approach”. The issue of ability grouping was mentioned by a number of authors. All authors discussed the challenges faced by their systems in designing a curriculum that suits the needs of their students in the contemporary world. So we can see a number of questions of common concern among East Asian systems, as well as a lot of variability in the foci of discussion. Many of the issues raised are similar to those encountered in other parts of the world. This is somewhat expected given the increasing contact of these systems with the rest of the world, especially the English speaking world. But some issues are rather unique to the systems concerned, showing that notwithstanding this trend of globalization, the unique socio-cultural situations in these systems still to some extent determine their education agenda. The very choice of the issues themselves, and how the issues are similar or different from those in other parts of the world, sheds light on what are valued in these systems.

Such seeking of understanding is the purpose of this book, and should be the purpose of any international comparative study. Learning the position of one’s country in the league table generated by an international study of student achievement does not in itself improve the quality of teaching and learning in one’s country. Measures need to be taken to effect changes in educational practices. And before measures are taken, knowledge and understanding of what is happening in other systems in contrast to what is happening in one’s own system are extremely useful. The sharing of ideas and best practices in this book should provide the information needed for different countries to reflect upon their own practices, and hopefully will inform policies on the teaching and learning of mathematics. This is what this book intends to do.

NOTES

1 In this book, East Asian systems refer to Hong Kong, Japan, Korea, mainland China, Singapore, and Taiwan.
2 Mainland China and Taiwan did not participate in TIMSS 1995.
3 Mainland China and Singapore did not participate in PISA.
REFERENCES


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2. MATHEMATICS CURRICULUM REFORM IN THE CHINESE MAINLAND

Changes and Challenges

ABSTRACT

In this article, we aim to summarize the changes of mathematics curriculum in the context of the Chinese mainland, with a special focus on its curriculum reform movement over the past decade. Current curriculum reform in the Chinese mainland reflects a dramatic change that goes beyond the scope of content to include all aspects of teaching and learning mathematics. This article highlights these changes in five aspects: teaching materials, classroom instruction, examination and assessment, teachers’ professional development, and students. Along with changes that have been taking place, we also discuss relevant challenges and issues in this curriculum reform movement. The process of curriculum reform in the Chinese mainland should provide a good example for mathematics educators in other education systems to reflect on their own practices and possible potentials in what curriculum reform can bring in a high-achieving education system.

INTRODUCTION

As is the case in many other education systems, curriculum is a key component in school education in China. It provides a guideline for all teaching and learning activities at different grade levels, and serves as a direct channel for major education reforms in this centralized education system. Recent school curriculum reform movement in China reflects its efforts to improve the quality of school education for all students. In particular, China established and put into effect immediately the law of nine-year compulsory education back in 1986. However, it has been a gradual process to implement the law in such a big education system, starting from large cities, small cities, and eventually to rural areas. In fact, the law of nine-year compulsory education was first implemented as an administrative measure to ensure that all eligible children have access to school education. It soon became an important concern about the nature and quality of school experience that all students in grades 1–9 should have. In 1999, the Ministry of Education began to design the new basic education curriculum system for the 21st century. And in 2001, the new Curriculum Standards for the nine-year compulsory education in all school subject areas were formally launched for experimentation.
In particular, school mathematics in China has experienced dramatic changes over the past decade, especially since 1999. Changes went well beyond simple addition and deletion of specific content topics but included many different aspects of mathematics education ranging from what is valued for all students to learn, how mathematics should be taught and learned, and how the assessment should be viewed and used. The unprecedented changes have undertaken a unique developmental trajectory accompanied by some successes as well as challenges. However, most of these changes and challenges in mathematics curriculum reform still remain unknown to outsiders. As these changes over the past ten years have been fundamental and irreversible, we believe that curriculum reform in China provides a rich case and lessons for mathematics educators in many other education systems to reflect on their own practices and policy changes.

It is not possible to depict a detailed picture of the curriculum reform process in China in one article, thus we present and discuss the reform of mathematics curriculum in China from the perspective of policy changes supplemented with evidence obtained through document analysis as well as case explanations. In particular, curriculum changes and their effects are summarized and discussed in five aspects: teaching materials, classroom instruction, examination and assessment, teachers’ professional development, and students. Similar to education reforms that take place in many other education systems, curriculum reform in China also experienced many challenges throughout the process. To provide a better picture of what has been happening, we will also discuss some major concerns and even strong oppositions to the approach and implementation of curriculum reform in China.

The chapter is organized into four parts. The first part presents a brief history of mathematics education in China. It provides a contextual background about the needs and challenges for current changes in mathematics curriculum in the Chinese mainland. The second part is the main body of the article, and it provides detailed information about changes in five aspects. Accompanied with the implementation of the new Mathematics Standards, China started to develop and use new curriculum materials in 2001. Summaries of changes and case analyses of using the new curriculum materials will be presented. In part three, we will summarize and discuss some major challenges to the approach and implementation of school mathematics reform, which also reflect different thinking on school mathematics changes in China. Finally, the implication of curriculum changes and challenges in China will be discussed in the international context.

MATHEMATICS CURRICULUM IN MAINLAND CHINA: SYSTEM CONTEXT AND BRIEF HISTORY

The Situation of School Mathematics Education in China: Ten Years Ago

Mathematics education in China has presented a two-sided picture for years. On one hand, Chinese students performed quite well in mathematics competitions, and large-scale international mathematics studies (e.g., Lapointe, Mead, & Askew, 1992;
Stevenson & Stigler, 1992). Chinese students’ mathematics performance is often taken to suggest that mathematics education practices in China helped generate good outcomes on the part of students (e.g., Perry, 2000; Stevenson & Lee, 1995; D. Zhang, 2006).

On the other hand, mathematics education in China held an important but simplified objective: acquisition of knowledge and skills. Chinese educators perceived some major problems in selecting and structuring the content and its requirements. The content of mathematics curriculum was deemed to be out of date and needed to be revised. Mathematics instruction was dominated by lecture and memorization (e.g., Guan, 1985). The results from a large-scale investigation in 1997 suggested that over 90% of middle school students did not have any experience of learning that requires “finding references, small group collaborations and discussions” (see Division of Basic Education, Ministry of Education, 1997). Another big problem was that Chinese students, in comparison with their counterparts in many other education systems, spent dramatically more time in and outside of their classrooms to study mathematics, but Chinese students often did not like mathematics and lacked confidence in doing well in mathematics (e.g., Chen & Stevenson, 1995; Hiebert, Gallimore, Garnier, Givvin, Hollingsworth, et al., 2003; Stevenson, Chen, & Lee, 1993). As it was not emphasized in curriculum and instruction, Chinese students didn’t see the connections between mathematics and people’s daily lives, other disciplines and social development.

The deficiencies observed in Chinese students’ learning outcomes call for a change in what is valued in students’ school experience. When individual students’ development becomes a high priority, traditional emphases on students’ knowledge acquisition and getting a high score in paper-pencil tests are not enough. The focus shift envisioned in the current curriculum reform made it different from the seven curriculum changes which had taken place previously in China since 1949. Inevitably, such a shift requires fundamental changes, not patch work, at both the policy and practice levels with unprecedented challenges and difficulty. Thus, the curriculum reform was not undertaken abruptly, but underwent periods of preparation and experimentation as discussed below.

Preparing for Changes in 1996–2001

To better understand the situation of school mathematics in China, some research efforts were taken from 1996 to 1998 to set the stage for undertaking mathematics education reform. In particular, Chinese education researchers and mathematics educators were organized by the Ministry of Education to

- study the situation and development trend of mathematics education in a variety of countries including England, the United States, Germany, Japan, Australia, Korea, Finland, Russia, Brazil, and India.
- conduct empirical research to collect and analyze relevant data. For example, the Ministry of Education organized educational researchers from 1996 to 1997 to investigate the implementation of nine-year compulsory education in China. The research team included researchers and curriculum development experts
from six major universities and the central educational research institute. The investigation covered 72 counties in nine provinces and collected data from more than 16000 students, 2500 school principals and teachers, and 50 members of a central government agency in charge of education. The investigation focused on the extent of implementing curriculum objectives, the adequacy of instructional content, problems or issues identified in the teaching and learning process, and problems or issues emerged in examination and evaluation (see Division of Basic Education, Ministry of Education, 1997).

- organize seminars to deepen discussions and exchange of ideas.
- promote public awareness of the importance and applications of mathematics, etc.

Extensive preparation and discussions led to a general consensus on many issues among Chinese mathematics educators and researchers. In comparison with students in the West, many differences in students’ learning and development were identified between China and the West. We summarize different aspects of these perceived differences in the following Table 1.

Cross-cultural differences reflected in students’ learning and development suggest that school education in China lagged behind in its conception of what is important for students to learn. Teachers tended to provide tons of mathematics

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<thead>
<tr>
<th>Table 1. Perceived differences in students’ learning and development between China and the West</th>
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<tbody>
<tr>
<td><strong>Students in China</strong></td>
</tr>
<tr>
<td>Focusing on knowledge and skills</td>
</tr>
<tr>
<td>Learning relied on memorization, reception, and imitation</td>
</tr>
<tr>
<td>Problem-type training</td>
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<tr>
<td>Hard-working with a serious attitude</td>
</tr>
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<td>Diligence and perseverance</td>
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<table>
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<th>Table 2. Perceived differences in school curriculum between China and the West</th>
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<tr>
<td><strong>School curriculum in China</strong></td>
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<tr>
<td>Content not rich</td>
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<tr>
<td>Emphasizing on textbooks</td>
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<td>Emphasizing traditional content</td>
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<td>Emphasizing mandatory courses and common requirements</td>
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<td>Having strict requirements</td>
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<td>Emphasizing paper-and-pencil testing</td>
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exercises for students to practice and to develop skills. Students were accustomed to learning through memorization with hard work, but not independent thinking and creativity. The traditional focus on knowledge acquisition and the approaches used wouldn’t meet the needs of the development of society.

Many differences in school mathematics curriculum were also identified between China and the West. We summarize these perceived differences in curriculum in the following Table 2.

The differences in curriculum suggested that school mathematics in China was simplistic in its structure and presented a closed knowledge system. It did not reflect the new knowledge development in science and technology, and was disconnected from students’ experiences and society. Its content can be characterized as heavy, difficult, uncommon, and outdated. The curriculum was further restricted with strict and common requirements for all students, and thus made it difficult to accommodate diverse needs of students’ development in various regions. Evaluation also placed too much emphasis on the differentiation and selection of students based on their exam performance.

These differences in students’ development and school curriculum led Chinese educators to further their determination in making curriculum changes. Because curriculum outlines students’ learning experiences and requirements through schooling, Chinese educators believe that it is necessary to change all aspects of teaching and learning, including what to teach as well as how to teach and assess, through curriculum reform. School curriculum needs to be changed from focusing on content based knowledge acquisition to focusing on individual students’ development. In particular, it has been generally recognized that obtaining a high-quality mathematics education in grades K-12 is very important to one’s life. In mathematics education, we need to emphasize not only students’ learning of knowledge and skills but also the process of students’ knowledge development, and provide students with opportunities to connect mathematics with their daily lives.

1999 to 2001 was a period when relevant Curriculum Standards for the nine-year compulsory education were discussed and developed, and its experimentation prepared. In January 1999, the Chinese Ministry of Education put together more than 40 experts as an expert panel in basic education and over 3000 professionals as working groups of curriculum standards in different subject content areas. They are educators and researchers in curriculum, education, and psychology from normal universities, teaching research institutions and schools. This expert panel organized more than 100 working sessions and forums to discuss and develop curriculum objectives, structure, examinations, evaluation, curriculum standards for each school subject, the design of a comprehensive curriculum, curriculum reform in rural areas, and reform of curriculum policy. These efforts resulted in a guideline for reforming national curriculum in basic education (draft) and a curriculum design for the nine-year compulsory education (draft). These efforts led to initial work to first develop curriculum standards for a few selected school subjects including Chinese and mathematics. The development of curriculum standards and relevant documents (e.g., about curriculum material development, implementation, evaluation, and administration) was first carried out with some basic research,
which helped put some ideas together to form a draft. The draft was then disseminated to schools and different communities for feedback, which was then used to guide revisions. The development process involved many experts and scholars from all over the country. For the mathematics curriculum standards alone, feedback was collected from over 60,000 persons at various positions. The overall curriculum reform and curriculum standards for each school subject were finally approved in principle and released on June 1, 2001, and experimentation started from fall, 2001.

In general, there are six aspects in reforming the school curriculum for basic education:

1. Curriculum objectives: moving away from over-emphasizing knowledge acquisition to emphasizing the formation of students’ positive attitudes toward learning, so that students can learn how to learn and develop positive attitudes in the process of learning basic knowledge and skills.
2. Curriculum structure: moving away from over-emphasizing content-based subjects, having too many school subjects and lack of integration. School curriculum needs to be structured with balance, comprehensiveness, and selectivity.
3. Curriculum content: moving away from being heavy, difficult, uncommon, outdated, and over-emphasizing the knowledge as stated in the textbooks. Curriculum content needs to emphasize its connections with students’ life and knowledge development in science and technology, pay close attention to students’ interests and their experiences, and carefully select those basic knowledge and skills needed for students’ life-long learning.
4. Curriculum implementation: moving away from over-emphasizing students’ acceptance, memorization, drill and practices. Students should be encouraged to learn through active participation, exploration, and manipulation, in order to foster their abilities in collecting and analysing information, obtaining new knowledge, analysing and solving problems, and ability in communication and collaborations.
5. Curriculum program evaluation: moving away from over-emphasizing differentiation and selection. Evaluation, as aligned with curriculum, should promote students’ development and help teachers improve their classroom instruction.
6. Curriculum administration: moving away from being over-centralized. To help adapt the curriculum to different regions, schools and students, the curriculum needs to be administrated at three different levels: national, regional, and school.

CURRICULUM REFORM OVER THE PAST DECADE: WHAT CHANGED?

Over the past decade especially since the release of new Curriculum Standards in 2001, curriculum reform in China has brought dramatic changes in many different aspects. The following sections are organized to present and discuss these changes in five aspects: teaching materials, classroom instruction, assessment, teachers’ professional development, and students.
Teaching materials are a concrete format of presentations that embody the ideas of the curriculum. With the release of the new Curriculum Standards for nine-year compulsory education in 2001, new teaching materials have been developed in alignment with the curriculum standards and they differ from traditional teaching materials in terms of both content and format.

In terms of the teaching material compilation, it is commonly perceived that compiling textbooks should be based on teaching and learning principles and instructional methods should be embodied in the teaching materials (e.g., Guan, 1985). As pointed out by Guan many years ago, however, traditional teaching materials did not have any major breakthrough in terms of style and teaching methods. They always adopted the ways in which traditional teaching materials used to be written: first, providing a direct introduction of the concept, theorem, formula and principles, then presenting several typical examples, and finally supplementing exercise problems, review problems and so on. Teaching materials written in this way did nothing good for teachers to improve their teaching methods and for students to strengthen their mathematics capabilities, especially their independent study capability and creative thinking ability, since in traditional textbooks, ready-made conclusions were presented in a direct and narrated format. This presentation format provides very little encouragement for students to think about questions independently. Students had to understand and digest the ready-made conclusions passively through studying or previewing on their own. It means that students did not come to the conclusions that can possibly be found by themselves through their own thinking. It is, in essence, asking students to take in everything presented. Thus, previous generations of teaching material compilers already noticed the deficiencies of the traditional teaching materials and their negative influences in fostering students’ creative thinking.

The following shows two contrasting examples of textbooks in presenting the same content topic – “Division of powers with the same base”. One textbook is a newly developed “Experimental curriculum materials” that follows the 9-year compulsory education curriculum standards. And the other is a traditional textbook that was compiled and published before releasing the curriculum standards. The following is an excerpt from the new “experimental curriculum materials” for seventh graders (Mathematics Curriculum Standards Preparation Group, 2003, p. 19):

There is a type of liquid that contains 10^{12} bacteria in a liter. To test the effects of a bactericide, scientists undertook an experiment. They found that every drop of the bactericide can kill 10^9 bacteria. In order to kill all bacteria in a liter, how many drops of the bactericide would be needed? How did you calculate?

Try it out

Compute the following expressions, and explain your reasons \( m > n \)

\[
\begin{align*}
(1) \quad 10^8 & \div 10^5 \\
(2) \quad 10^m & + 10^n \\
(3) \quad (-3)^m & + (-3)^n
\end{align*}
\]
The following is an excerpt from a traditional-style textbook for seventh graders (Mathematics Section, 2001, pp. 137–138):

….. Likewise

\[ a^2 \cdot a^3 = a^5 \]

\[ a^5 \div a^3 = a^2 \]

That is,

\[ a^5 \div a^3 = a^{5-3} \]

In general,

\[ a^m \div a^n = a^{m-n} \ (a \neq 0, m, n \text{ are positive whole numbers, and } m > n). \]

That means, when dividing powers with the same base, the base stays the same, and the exponents subtract each other.

These two different textbooks adopted different ways to present the same content. “Experimental curriculum materials” were developed as follows “Problem situations—Mathematical models—Explanation, application and development”. In contrast, the traditional curriculum materials were organised as “Concepts, formula, rules—exercise and enhancement”. Comparing these two versions, the “Experimental curriculum materials” contains three valuable “blanks” on purpose. As previous users of the traditional textbook and designers of the new experimental textbook, we can summarize the advantages of the new experimental textbook in terms of the following four aspects.

1. **Provide opportunities for students’ independent explorations.** In fact, based on their prior learning, most students were able to solve mathematical problems and construct mathematical models from solving practical problems through independent explorations. In this way, students’ creative thinking was developed and their confidence to learn mathematics well was enhanced. Last but not least, it helped students understand and memorize what they need to learn.

2. **Give prominence to connections with students’ experiences.** For a long time, traditional mathematics curriculum materials seemed to be uncreative in structure, boring in content and unable to inspire students. It is likely that it led to students’ dislike of mathematics, or their low learning efficiency through rote leaning or mechanical memorization.
In contrast, the new curriculum materials are diversified in content with illustrations, enriched with stories of famous mathematicians and mathematics problems that are closely related to students’ real-world experiences. It is a new and fresh approach, giving a prominence to mathematical connections with students’ experiences.

(3). *Provide possibilities for “exploration-oriented” teaching.* The intentions of the design of different curriculum materials are different. With the use of traditional curriculum materials, a lot of students tended to memorize conclusions in their preview but did not necessarily understand them. At the time when teachers led students to find out the presumed new conclusions, the students might be able to respond quickly with the answers through their memorization without thinking.

In contrast, the design of “Experimental curriculum materials” is meant to let teachers enlighten students, and students make quests. Therefore, the new ideas of curriculum, namely, “to experience, to learn through one’s experience, and to explore” are embodied in the curriculum materials.

(4). *Provide teachers with more options for teaching.* The new round of curriculum reform has brought about higher requirements for teaching activities. The reform of teaching methods is multi-faceted, in which the way to present the content of teaching materials is very important. The new curriculum materials have played an active driving role in promoting the reform of teaching methods and in leading teachers to actively explore new teaching methods. For example, the meaning of “leaving blanks” in “Experimental curriculum materials”, as shown above, is far beyond the value of being ‘blank’ itself. It actually reflects the ideas of new material compilation and the intended usage of curriculum materials in this time.

In compiling “Experimental curriculum materials”, the arrangement of knowledge is not a simple recombination, but renewal in views and improvement of ideas. Students are provided opportunities to find out the process of mathematics development in the teaching materials. It means that students are instructed to discover, to experience and to study the practicality of mathematics. Therefore, students can learn to develop a good thinking habit and how to use mathematics, improve their ability in analyzing and solving problems, develop their interests in mathematics creation and enhance their confidence in learning mathematics (e.g., Z. Zhang, 2006). Through this approach, it is intended to make mathematics a powerful instrument for exploring the truth and exercising the mind. Consequently, students will develop fully, continuously and harmoniously in their thinking ability, attitudes and value toward mathematics.

The Decade of Mathematics Curriculum Reform - Changes in Classroom Instruction

Since 1980s, educators have criticized the Chinese traditional classroom instruction as teacher-dominated knowledge delivery (“duck-feeding”), student passive acceptance, and lecture only (e.g., Zhou, 1999). Since 1990s, teaching with questioning
has gradually replaced “duck-feeding” teaching. Zhou reported his observation of such a lesson, which was a geometry lesson on the definition and property of a square taught by a middle-age teacher to seventh graders. The lesson had a traditional “five-stage” teaching design: review with questioning, introduction of new content, examples, reinforcement and exercise, lesson summary and homework assignment. Within the 45-minute lesson, the teacher and students had 105 questions and discussions that took 25 minutes and 37 seconds (55% of the 45-minute lesson time). Thus, the lesson was dominated with questioning and discussion. However, when these questions were classified into different types, Zhou found that 74% of the questions required students’ fact recall (memorization) and only 2% required creativity. In responding to students’ answers, 13% had the nature of interrupting students’ answers, answering by the teacher himself, or disregarding students’ answers. Another 13% were to repeat the question or students’ answers. 74% of the teacher’s responses were positive comments and encouragement to students’ answers.

These results revealed a positive aspect of the change and aspects that still need to be improved in classroom instruction. On the positive side, the teacher made a quite extensive use of questioning in his lesson, tended to promote students’ thinking and participation. However, most of the teacher’s questions required students’ recall of their memorized knowledge, or required quick responses from students. Although the teacher frequently provided encouragement and praise to students’ responses, the teacher never encouraged students to raise questions. The results suggested that the teacher tends to ensure students’ acquisition of factual knowledge, but not the development of students’ thinking through the process of knowledge discovery. Students’ creativity and motivation to discover was not nurtured through the classroom instruction. Essentially, the classroom instruction was still well under the teacher’s control, and students basically followed the instruction of the teacher.

Many teachers also reflected on this type of classroom instruction. The following is an excerpt of a teacher’s reflection:

“I can organize the lesson with a clear mind, and manage the classroom well. I can also have a sense of humor sometimes to bring up students’ attention. Based on my teaching experience, I can make it explicit on concepts that students can easily make mistakes and provide a broad range of methods wherever possible. I am confident about this type of lessons and won’t think they are ineffective. But there are always some students who cannot get it. Every time after class, I have two different feelings. One is that I eventually delivered the prepared problems and different solution methods. I feel relieved and satisfied. Another feeling is that I am exhausted with chalk dust all over my hands and thirsty. This is an interesting contrast to students who often are lackadaisical. The teacher feels tired, and students are suffering.”

With the implementation of curriculum standards, changes are evident in classroom instruction. One rural secondary school explored a new teaching model that contains three phases: preview, display, and feedback. In this type of lessons, students took
the stage to pose questions and discuss either in small groups or a whole class after some previews. Students were actually teaching each other often with multiple solutions generated and justified by students themselves. After observing such classes, a teacher wrote,

“These classes were not shows but authentic ones. They were different from high-quality classes or open classes we attended before, which resulted from rehearsals and group preparations. The classes were attended by us randomly without contrived plans. The class schedules of 20 classrooms in the school were displayed in front of the building. Without a guide, it is up to teachers who were going to observe classes to choose classrooms, subjects and time. In each classroom, there was no platform or instruction desk. Such a design narrows down the distance between teachers and students, gets rid of the traditional awe for teachers, and enables students to communicate with each other. Walking into each class, observers noticed that exciting students were discussing, commenting and debating. It was hard to find the teacher of the class. After searching for a few minutes, observers suddenly found that the teacher stood there in a leisured manner. It seemed that the teacher had nothing to do in the class but, in fact, such a class was a result of the teacher’s bringing up students carefully and transforming the traditional teaching-and-learning notion.”

Another teacher provided some more detailed descriptions in his reflection.

“This was a demonstration class of reviewing the 9th grade mathematics at a junior secondary school about the location relationship between dots and circles. When I entered the classroom, members of each group were discussing the fundamental knowledge and essential concepts. They built up a knowledge system with words of one and another. Different from teaching by one teacher to many students, such a discussion was similar to chat or discussion of several people in real life. After the discussion within groups, they discussed with members of other groups. Each group was in charge of a problem written on the blackboard. The group members analyzed the problem together and made clear how to solve it. The participation of each member enabled all to understand the problem. Then a speaker was named to deliver their thought to other groups later. After solving the problem designated for their own group, students moved to other problems and discussed how to solve and what knowledge might be useful. The next step is the explanation of problems by the speakers of each group. There were not a mere speaker and many listeners; instead, all students were involved, talking about the essential knowledge, different methods and potential mistakes. The talk was not in disorder, but a participated discussion. Students expressed their views one by one, showing respect for other speakers as well as grasping chances to express their own opinions. Like snowballs, all students stood, sat or even stood on stools and desks around the blackboard, and naturally took part in the activities in front of many observers. The process of one step followed by
another step was automatically done by students without directions of the teacher. The whole class became a lively, happy one. I noticed that the teacher observed the activities of the students, talked with group members occasionally, and summarized and gave directions during students’ explanations when necessary.”

These teachers’ observations and descriptions reflect dramatic changes in the organization and process of classroom instruction. Here, we try to summarize some important changes in classroom teaching over the past decade of curriculum reform.

(1). Changes in the teaching model. The teaching model is changed from the previous deduction model to the “problem-situation, setting up models, interpretation and application” induction model. In the deduction model, classroom instruction can generally be characterized as a teacher-centered and textbook-based instruction process that proceeds from concept differentiations, formula deduction, mathematical rule explanation, example demonstration, practice and drill. In the induction model, students are encouraged to take an active role in exploration to obtain mathematics knowledge. Different ways to obtain knowledge reflect different classroom cultures. In a dominating culture, we have to consider the long-term impact upon the development of students’ characters. For instance, deduction type of instruction leads to mindless obedience, while induction type of instruction encourages students to think independently and study collaboratively.

(2). Changes in instruction organization. The instruction format was changed from “teacher teaches and students listen” to “teacher questions and students answer”. The teacher no longer leads the class on the platform. Instead, involved in students’ study groups, the teacher plays the role of an organizer, guide and coordinator, and focuses on students’ thinking and problems. This form of group cooperative learning is emerging and teaching becomes a mutual activity between teacher and students. In the sample classes observed by other teachers, we can see that students spoke for most of the class time to share and discuss different ideas.

(3). Changes in the relationship between teacher and students. The teacher respects the students, pays attention to individual differences, and satisfies the cognitive need of different students. Values such as “Everyone is equal”, “Personality should be respected”, and “The dignity of human beings is not allowed to be impinged” are embodied in students’ participation. It is the personal experience of the teacher, students and each observer in the classroom that matters.

(4). Changes in the relationship among students. In the newly emerged type of classrooms, the teacher focuses on cultivating the independence and self-determination of students by instructing them to question, investigate, explore and learn from practices. Learning becomes an active and personal process with the teacher’s guidance. Students cooperate, communicate and share information with each other.
(5). Changes in learning goal and content. The goals of students’ mathematics learning are well beyond “acquisition of knowledge and skills”, but include understanding mathematics and life. Mathematics instruction enables students to enjoy mathematics and life, and interweave mathematics content with daily life experience.

(6). Changes in teaching format, providing students with more development opportunities. The teacher creates a learning environment that guides students to actively get involved in the teaching and learning process. The teacher stimulates students’ learning interest, helps students build up the attitude and ability to master and use knowledge, and lets every student have opportunities to develop their full potentials.

The ideas advocated in curriculum standards are not only embodied in classroom teaching and learning, but reached out to a broader learning environment outside the classroom. In fact, practice activities and topic-based projects are provided with different requirements in the textbooks for each grade level. Some topics are given by in the textbooks. Some require students and teachers to decide what specific topics they would like to study. Students need to figure out how to pursue the topics by themselves. In this process, students need to cooperate, discuss, write research plans, and carry out relevant investigations in and out of the classroom.

The Decade of Mathematics Curriculum Reform – Changes in Examination and Assessment

Concerning school/university entrance examination, two comments came to our minds. First, “In teaching, we should take responsibility for the up-coming entrance examinations of students. In addition, we should be responsible for the future development and the whole life of our students. We must not get so-called excellent examination scores at the expense of students’ development in the future.” Second, “Not to aim at exams, but beat exams.” These two comments were provided by principals in two different middle schools. We may ask, “why did they think that examinations contradict with students’ development?” Anyone who was familiar with the situation knew that this is the reality. The two principals were actually insightful since they realized the disharmony between entrance examination and students’ development. From these two comments, we can see that the majority of teachers have been looking for a connection point between examinations and students’ development, and that they have been eagerly expecting a reform.

Over the past ten years of mathematics curriculum reform, examination has also experienced some changes. We took one examination developed and used in 1995 and compared it with another developed and used in 2005. These two examinations were all used at the end of middle school (ninth grade). We found that the examination used in 2005 differs from the one used ten years ago. We highlight their differences in the following ten aspects.
(1). In the format of the examination, objective problems decreased and subjective problems increased. Objective problems are the type of standardized items that focus on students’ final answers and do not require much subjective judgments about students’ responses. In contrast, subjective problems are the type of problems that ask for students’ solution processes. The percentages of objective and subjective problems were 58% and 42% respectively in the 1995 examination, but 30% and 70% correspondingly in 2005. The differences reflect a change in the examination focus from the final result to the process of students’ thinking (see, Mathematics item evaluation group for middle school graduation examinations, Ministry of Education, 2005).

(2). In terms of the content, problems are not harsh or tedious any more. For example, in the 2005 examination, friendly instructions for students and lovely cartoons were added to the front and end of the examination paper. This shows the spirit of the examination in making connections with students.

(3). The types of problems became more diversified than before. Besides the traditional four typical types of examination problems (i.e., multiple choices, filling blanks, problem solving, and proof’), more types of problems have been developed and used in examinations, such as open-ended problems, application problems, reading and analysis problems, and exploration problems. In the 2005 examination, mathematics reading problems, justification problems, problems that require manipulations, and topic study were included.

(4). The examination places more emphases on mathematics application in real life. There was a problem examining students’ knowledge in statistics. In the 1995 examination, the problem was provided as a fill-in-the-blank item:

Problem 4 in the 1995 examination: The total variance is an indicator of total_______

In contrast, the problem in the 2005 examination was to test students’ ability to read a pie chart to get information and then solve the problem.

Problem 10 in the 2005 examination: A school’s rule specifies that students’ final grade is composed of the examination grade, research-oriented study grade, and in-class grade. The three parts have different percentages as shown in the pie chart (i.e., examination grade – 60%, research-oriented study grade – 20%, in-class grade – 20%). Ming’s mathematics grades for the three parts are as follows: 90, 80, and 85. Then Ming’s final grade should be______.

In comparison with the problem used in the 1995 examination which was to test students’ memorization of the concept, the 2005 item focused on students’ ability to acquire information and apply mathematics. We believe that the essence of studying statistics is not only about statistical concepts, computation and parameters, but also the ability to analyze data with a statistical perspective. Statistics is not equal to computation.
(5). Creating a setting to show the connections between mathematics and real life. In the 1995 examination, there was not much content about ordinary life. Even though there were some application problems, they were far from real life. They were more like practicing problems, not real application problems. For example, the following are two problems used in the 1995 examination:

Problem 9 in the 1995 examination: One person starts from point A toward 60 degrees east of north, and then from point B to point C in the direction of 15 degrees west of south. What is the angle ABC?

Problem IV in the 1995 examination: There are two inlet pipes for a pond. It takes 10 hours less if we use pipe A only to fill the pond instead of pipe B only. If we use both pipes it takes 12 hours to fill the pond. How much time will it take respectively if we use only one pipe to fill the pond?

The 2005 examination included more problems in life scene, emphasized on problem solving, and focused on real life application of mathematics knowledge. The following is one such example:

Problem 16 in the 2005 examination: In order to attract more customers, a shop has two kinds of shopping promotion. The first one is: when a customer spends over $100, then the customer gets a chance to spin a game wheel. The game wheel gives a chance to win gift coupons worth $100, $50, $20 or nothing. The second promotion is: customers can just choose to get a $10 gift coupon instead of playing the game wheel. According to the statistics, there are 1000 people who choose to play the game wheel one day. And the wheel stops at $100 for 50 times, at $50 for 100 times, and at $20 for 200 times.

(1) What is the probability of the wheel hitting different reward areas?
(2) Which promotion is more economical?

Problems like this can make students experience the usefulness of mathematics and mathematics learning. It is also helpful to test students’ ability to model different situations and use mathematics to solve real problems in life.

(6). Emphasizing on students’ creativity and understanding of the essence of mathematics. For example, to examine students’ knowledge about inverse number, the examinations in 1995 and 2005 used different problems. The 1995 examination used the following fill-in-the-blank problem:

\[
\begin{align*}
\frac{1}{2} & \text{ is the inverse number of } \quad \ldots
\end{align*}
\]

This problem tended to examine students’ memorization of the concept of inverse number. By contrast, the 2005 examination used the following problem with a number axis that can better examine students’ understanding of inverse number.

2005 examination problem: In the following figure, the inverse number of the number at the point M on the number axis is ( \_ \_ \_ \_ \_ \_ \_ \_ \_ \_).
(7). **There is relatively more flexibility, more attention to students’ subjective expression.** For example, in the 2005 examination, problem 15 asked students: “What do you think about the tendency based on the result you got from problem (2)?”

(8). **Placing more emphasis on students’ research ability and creativity.** For example, in the 2005 examination, problem 22 was designed as the process of a topic study. The process showed how a mathematics rule is discovered: starting from the question, exploration and discovery, experiment and validation, to conjecture and proof, expansion and extension. In the process of research, students not only went through the process of question set-up, exploration and deduction, but also fully experienced the general mathematical methodologies such as from special cases to generalization, analogy, conjecture and extension. Such a problem can examine several knowledge levels so that different students can do different work on it. It is a good problem to examine students’ ability to use mathematical methodology to explore mathematical rules, obtain new knowledge, and apply the knowledge to solve the problem. Such kind of problems did not exist in the examinations back in 1995.

(9). **Optional problems appeared recently in examinations.** There are several different ways to include and use optional problems in examinations. For example, to choose one from each type of optional problems or to choose one from problems with different difficulties or levels are good trials. But how to grade optional problems in a fair manner is a topic that still needs research.

(10). **Not using old problems anymore.** In the past, the examination often used old problems from former examinations or supplementary curriculum materials. This impaired the fairness of the examination and led students and teachers to prepare for the examination by practicing tons of old problems. This was not a good trend for teaching. Now, the examination adopts new problem situations, new problem formats, and seldom uses old problems. So the new examination discourages a problem-practicing oriented way of teaching. It is also helpful to relieve students’ burden in their study.

Based on these changes, we can see that the new examination paid more attention to students’ mathematics understanding, their application of mathematics, their creativity and their comprehensive mathematical ability. These changes address the needs of students’ further development. It is a huge step towards the integration of the examination, student development, and teaching.
The Curriculum Standards (Draft version) points out that the main objective of assessment is to comprehensively understand students’ mathematics learning process, promote students’ learning and improve teachers’ teaching. Now that the main objective of assessment is to diagnose learning and teaching, it should provide help for students and teachers instead of acting merely as a judgment criterion. There is a need for a multi-object and multi-method assessment system to get as much information as possible about the students. This requires that when assessing students’ mathematics learning, we should focus on students’ learning outcomes and more importantly their learning process as well. We should care about not only their achievement level but also their emotion and attitude towards mathematics. The assessment should help students and teachers locate the obstacles to students’ development as well as students’ strengths, find the direction for further development, gradually build up students’ confidence, and help students to be aware of their ability for self-development. We have to look for reliable information from multiple channels and methods, make accurate judgments and promote students’ and teachers’ development.

Many teachers tried new methods to assess students’ performance, for example portfolio assessment, mathematics paper, mathematics log, and class observations. These were almost non-existent in the assessment practice before 1995.

The Decade of Mathematics Curriculum Reform – Changes in Teachers’ Professional Development

This curriculum reform has taken teachers’ professional development as an important part of the compulsory education reform. That is because the curriculum reform eventually needs to be completed by the teachers. We hope that school-based education research will promote teachers’ professional development and improve teachers’ ability to handle new courses.

China is still a developing country and it needs to undertake a large-scale education for its huge population. China lacks resources not just in terms of funding, but also teachers whose competence needs to commensurate with the curriculum reform in the country. In general, there are four aspects of teacher knowledge: subject matter knowledge, knowledge in educational psychology, practicing knowledge and general knowledge. When reflecting on school teachers’ knowledge to meet the needs of curriculum reform, we found that teachers need professional development assistance as outlined below.

For subject matter knowledge: there was a saying of “double forgetting” several years ago, which means that you forget the secondary school mathematics when you go to college and then you forget the college mathematics when you go back to school to teach. That is because when you go to college, the knowledge obtained in the secondary school will not be used in the college. And when going back to the school for a teaching position you do not use the knowledge learned from college. The main reason for this phenomenon is due to the teaching approach in college that does not help pre-service teachers build a higher perspective to look at the elementary mathematics system.
For knowledge in educational psychology: knowledge in educational psychology should not be memorized as conclusions. Relevant course instruction should base on the cases, the methods for doing research and applying knowledge in our own social-cultural context to help teachers understand educational psychology. However, elementary and high school teachers received the whole system of knowledge in educational psychology from abroad.

For practicing knowledge: besides solid subject content knowledge and knowledge of educational psychology, teachers should have personalized practical knowledge of teaching style, teaching wisdom and so on. It requires the gradual accumulation of teachers’ knowledge. In the past, most accumulation was done through peer communications, lacking experts’ guidance and conscious self-reflections.

For general knowledge: the teaching objectives of mathematics instruction in the past were simplified and not closely related to other subjects and students’ daily life. The value of emotion and attitudes is mostly confined within patriotism education. It was not a requirement for each teacher to have general knowledge about the culture and society. Now, this should also be changed.

At the same time, the impact of curriculum reform upon teachers is huge and impressive. Some teachers admitted that although the direction of the reform is correct, they felt the pressure as well as the opportunities for school teachers to develop their subject content knowledge (e.g., Huang & Li, 2008). More diversified and effective ways are also needed to update and improve teachers’ knowledge in other aspects.

To facilitate teachers’ professional development, besides training provided at different levels and school-based research on teaching, the use of online lesson planning and online discussions enable communications among teachers, and between teachers and experts. This goes beyond the limitation of space and time, and provides much broader space for teachers’ professional development.

The Decade of Mathematics Curriculum Reform – Changes in Students

After the implementation of mathematics curriculum reform, students tend to make more of their own sense. They often do not rely on what is written in textbooks or said by teachers, and begin to raise questions and learn on their own.

The following is a case that is taken from a student’s mathematics log (Shao, 2002):

In today’s mathematics class, the teacher told us that if we roll two dice, the most probable sum of the two numbers is 7. It may not be the case if we roll them 10 times, but if we roll 50 times, it is more likely to happen. The more times we roll, the more likely we get that outcome. I am kind of suspicious about it. Why is the most probable outcome 7, not 6 or 8 when we roll two dices and count the sum? Is it going to happen exactly as what is predicted? How can it be true without any test?

After going home at noon, I found two dice ready for the test. However, an idea occurs to me suddenly: if my test result is against what is said by the teacher, others may think that I am making up a story. A better way is to take
the dice to school and ask my classmates to do the test together with me. In this way, I can save time and have a witness as well.

After lunch, I went to school earlier than before and asked my classmate Q to help. I asked him to write down 11 whole numbers from 2 to 12. Then I rolled the dice and he counted the numbers of each outcome by tallying. Q became bored after a while. Then I exchanged roles with him. I recorded the sum and he threw the dice. We continued to try 50 times, 100 times, 150 times, 200 times. According to the teacher, the more times we throw the dice, the more likely we get the sum of 7. At last, the winner is not other numbers but 7! But I am not totally convinced. Another classmate G and I tried another 200 times, which turned out to be 8 as the winner! The competition score between 7 and 8 was 1 to 1. I decided to try again for the last time. If it was 7, I would take that as the most probable outcome. This time, I asked classmate Z to give me a hand to throw the dice for 200 more times. However, the outcome is 8 instead of 7! Why did it happen? I did not understand and wrote down my question on a piece of paper and put it on my teacher’s desk, in which I described my test ……

From this case, we can see that the student did not blindly follow what was stated by the teacher. Instead, he chose to test the idea. He did the same test more than 700 times. We can also tell from this that his quest for scientific knowledge involves scientific method, scientific thought, scientific spirit and scientific thinking. What is fully displayed in this case is the advocacy for bringing up the integrated quality and creativity of students.

CURRICULUM REFORM IN THE PAST DECADE: WHAT ARE THE CHALLENGES?

As discussed above, the curriculum reform did bring many important changes to school education in China. Compared with school education ten years ago, students now receive more respect in classrooms and the relationship between the teacher and students has become more harmonious than before. School mathematics now bears a closer relationship with students’ experiences, and acquisition of knowledge is no longer the only purpose of students’ mathematics learning. Students and teachers become more engaged in the teaching and learning activities, and the professional development for teachers has had an unprecedented improvement.

At the same time, however, the current curriculum reform in China is still an ongoing process with many other aspects virtually unchanged. In fact, it has been a rocky journey over the past decade with many serious concerns and challenges to the reform ideas, approaches, and implementation. These concerns and challenges have surfaced during many different meetings and in some public media over the past several years, and they can be summarized in five aspects: (1) concerns about the reform direction and curriculum structure, (2) concerns about the reform of the geometry curriculum, (3) challenges in curriculum administration, (4) challenges in reforming examination and assessment, and (5) challenges faced by teachers in implementing the reform curriculum. We provide some further explanations below.
(1). Concerns about the reform direction and curriculum structure. With an emphasis on connecting mathematics with students’ experience, many mathematicians voiced their concerns on whether school mathematics will be changed to the extent that the mathematics gets lost. They believe that students should be inspired to learn mathematics in terms of its simplicity and the beauty of its logic, but not from tedious events in daily life.

Moreover, the curriculum standards aim to replace the traditional subject content divisions (e.g., algebra, geometry, and trigonometry) with a new curriculum content structure including “number and algebra”, “space and graph”, “statistics and probability”, and “experience and comprehensive application”. This content re-structure led to questions and concerns about its scientific quality and feasibility for teaching and learning mathematics. Many mathematicians believe that school mathematics reform should respect mathematics as a scientific subject and should take gradual steps in making careful changes. These concerns led to broad discussions about mathematics curriculum reform in China. Such discussions are still on-going and have led to much needed reflections about school mathematics and some adjustments in changing school mathematics.

(2). Concerns about the reform of the geometry curriculum. One big change made to the traditional school mathematics is the content on Euclid geometry. The change originally intended to bring in concrete and visual experiences with geometry figures for students, and consequently decrease the training on students’ logical reasoning. This change brought very strong challenges from many mathematicians. They believe that logical reasoning is a fundamental character of mathematics. It cannot be replaced by students’ concrete and visual experiences. The whole mathematics is built upon logical reasoning. Euclid geometry is a very important subject that provides students with a good training in logical reasoning, and it must be included in secondary school mathematics.

The mathematicians’ concerns are a revisit of the issue on how to best deal with geometry content in school mathematics. In fact, this is still an unsolved issue not only in China but also in many other education systems.

(3). Challenges in curriculum administration. It was proposed as one of the six reform goals to change the centralized curriculum administration to a three-level administration (i.e., national, regional, and school). It was anticipated that such a decentralized administration will empower and energize educational authorities at the regional and school levels. However, there are still virtually no specific set-ups and personnel at all three levels to develop and administer school curriculum. It now becomes an important task to develop and regularize relevant policy and practices to facilitate the implementation of curriculum reform. Specific requirements and responsibilities should be clearly stated for different personnel at various levels, including school principals and teachers.

(4). Challenges in reforming examination and assessment. The current curriculum reform aimed to bring changes in the ways of assessing students and using the
assessment to differentiate and select students. Although it was well accepted that assessment is not equivalent to paper-and-pencil examinations, the notion of assessment for students’ development and learning based on multiple sources of information is seemingly not feasible either. Local education administration authorities and schools now still care much about students’ performance in the paper-and-pencil tests, and the ranking of schools, classes, and students in terms of test results. It becomes a serious challenge to reform paper-and-pencil examinations to ensure their alignment with the curriculum standards. The selection of students needs to be based on a comprehensive assessment rather than one single traditional test.

(5). Challenges faced by teachers in implementing the reform curriculum. To a great extent, the success of curriculum reform relies on the teachers’ capability in implementation. Although there has been much improvement in teachers’ professional development, it is still common that teachers simply put the curriculum standards aside and carry out their classroom instruction in a traditional way to pursue students’ high test scores. This phenomenon is due to many different factors, including the training and support needed for teachers to implement the new curriculum standards. The successful implementation of the new curriculum standards requires changes in teachers’ conceptions of school mathematics and effective teaching, and in their ability to carry out student-centered classroom instruction. Relevant support should also be made available from peers, the school, education administration at different levels, and the society at large.

CONCLUDING REMARKS
Curriculum reform in China, as discussed above, shares many objectives and approaches with what has been proposed in the NCTM (National Council of Teachers of Mathematics) standards in the United States (e.g., NCTM, 1989, 2000). With a focus of providing quality school education for all children, the curriculum reform emphasizes the accessibility of school mathematics to all students and not just the elite few. It places individual students’ school experience and their future development as the most important consideration. Students’ acquisition of knowledge and skills is still important but not the only and ultimate consideration as in the case of traditional school mathematics in China.

Different from the case in the United States, the curriculum reform in China presents a fundamental change in what is valued in and through school education including mathematics. The most important and fundamental change through the curriculum reform in China has been to build a new curriculum culture, a new classroom culture, a new teaching research culture and a new management culture. For example, it proposes to empower regional and school education authorities to be part of the curriculum development and administration. The proposed change presents a tendency of de-centralizing educational administration in China, which differs from what has been proposed in the United States to help ensure accountability with the establishment of common standards (e.g., Leung, 2004). In China,
it is also hoped that the curriculum reform and related changes can help build new
democratic, open, scientific, equal, communicating and collaborating relationships
among various agents - students, teachers, schools, administrators, and society. It is
believed that the reform will have its influence on the school and then from schools
a new culture will emerge in society. It is further believed that a person who grows
up in such an environment, which combines the merits from both eastern and
western cultures, will develop his/her self-esteem, confidence, sense of responsi-
bility, teamwork spirit and creativity. Students will have a happier school life and a
better personality with a broader mind. Hopefully, such expectations can become a
reality through the process of the curriculum reform.

With the unprecedented depth and scale of this current curriculum reform in
China, it is understandable that there are and will be challenges and concerns.
While some challenges and concerns may be unique to the context in China,
others will likely emerge in many other education systems as well. The discus-
sions in this chapter can provide a better picture about curriculum reform in
China and also help mathematics educators and researchers in other education
systems to reflect on their own policy and practices in school mathematics (e.g.,
Li, 2007).

NOTES
1 If not specified otherwise, China in this article refers to the Chinese Mainland.

REFERENCES
of Asian American, Caucasian-American, and East Asian high school students. Child Development,
66, 1215–1234.
Division of Basic Education, Ministry of Education. (1997). The report of investigating the
implementation of nine-year compulsory education curriculum. Beijing: Author.
Guan, C. (1985). Reflections and suggestions about reforming secondary mathematics teaching
Teaching mathematics in seven countries: Results from the TIMSS 1999 video study. Washington,
DC: National Center for Education Statistics.
Huang, R., & Li, Y. (2008). Challenges and opportunities for in-service mathematics teacher
tional Testing Service.
presented at the APEC educational reform summit, Beijing, China. Retrieved October 2, 2008, from
http://ott.educ.msu.edu/apec/downloads/LeungSystemicReform.doc
materials in their system and cultural contexts. The Mathematics Educator, 10(1), 21–38.
Mathematics Curriculum Standards Preparation Group, Ministry of Education. (2003). Experimental
curriculum materials for nine-year compulsory education: Mathematics for seventh grade (3rd ed.,


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