Impact of curriculum reform: Evidence of change in classroom practice in mainland China

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A B S T R A C T

The study examined the impact of curriculum reform on teaching practice in primary mathematics in mainland China. The participants included 58 fifth grade mathematics teachers from 20 schools. Thirty-two of the classrooms had utilized a reform curriculum for 5 years prior to conducting the study, and the remaining 26 had been using the conventional curriculum. Each of the 58 teachers was videotaped for 3 of his/her classes during a 3-day period and the videotaped class sessions provided the data source for the study. The focus of the study was on the instructional tasks that were implemented in the classrooms and on the teacher and student interaction. Results indicated that a greater proportion of high cognitive level tasks were implemented in the reform classrooms when compared to those in the non-reform classrooms. Numerical symbolic representation as well as single-solution strategies were dominant in the instructional tasks for both groups. However, in the reform classes a higher proportion of instructional tasks were used that involved visual illustrations and hands-on manipulation and multiple-solution strategies. An analysis of classroom discourse showed that most of the teacher questions were related to memorizing exercises and explanations of answers. However, the teachers from the reform classrooms were more likely to ask students to describe the procedure that led to an answer and to inquire further into students’ responses. The results indicated positive changes in classroom practice resulting from implementation of the new curriculum.

The present study addressed the apparent lack of empirical evidence on whether or not the recent curriculum reform in China has influenced classroom practice as intended by this reform. The study focused on two aspects of evidence for changes in classroom instruction: (1) whether or not teachers implemented high-cognitive demand tasks and (2) whether or not teachers fostered productive discussion and provided encouragement for students to share and communicate their ideas. We begin by providing a sketch of the background and conceptualization of the study, then we report the results of the study. Finally, we discuss our interpretations of the results and provide suggestions for future research.

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The reform curriculum was implemented in People’s Republic of China. Thus, in this special issue, all instances of the word ‘China’ refer to the People’s Republic of China.

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1. Background and conceptualization of the study

1.1. Background

The most recent curriculum reform in China, begun in 2001, entails a series of measures to reform the current practices of primary and secondary education that include curriculum standards, textbooks, teaching methods, and assessment systems. According to the Curriculum Reform Guidelines for the Nine-Year Compulsory Education, issued by Ministry of Education (2001a, 2001b), the main objectives of the new curriculum reform include the following:

1. Change of the trend toward overemphasizing knowledge delivery and putting more emphasis on students’ active participation to develop their abilities such as collecting and processing new information, gaining new knowledge independently, analyzing and solving problems, and communicating and cooperating with others;
2. Change in the curriculum structure from an overemphasis on separate school subjects to courses that are more integrated with one another;
3. Change of the difficult, complicated, and outdated curriculum content with its overemphasis on textbook knowledge and replacing it with the curriculum content that reflects students’ reality and the new developments of modern science and technology; and
4. Decrease of control by the central government over curriculum material and encouragement for developing local curriculum by local educational authority and community.

More specifically, the new mathematics curriculum embraces a three-dimensional objective, which includes knowledge and skills, processes and methods, as well as affective demeanor and value. Each dimension is intended to nurture all-around development of students (see Ni et al., in this issue, for detailed information about the objectives). The new reform also is intended to initiate fundamental changes in the function, content, and pedagogy of the curriculum. It seeks to shift the focus away from transmitting knowledge by teachers toward the construction of knowledge by students, enhancing the connection between school subject matter and real-life applications. Finally, the reform curriculum also aims to change the emphasis from passive, reception-oriented learning to an emphasis on participatory, exploratory, and hands-on experiences for students (Ministry of Education, 2001a, 2001b; Xu, 2001).

The new mathematics curriculum was first implemented in 2001 with 38 pilot districts from 27 provinces in China. By the fall of 2006, almost every region in China had started to implement the new curriculum. The ultimate goal of the reform effort is to bring about changes in classroom practice and consequently to improve teaching and learning for large numbers of students. Therefore, the question posed by the present study is whether, in fact, curriculum reform has made a difference in both classroom practice and student learning outcomes. Among the few empirical studies in China that investigated the impact of the new curriculum, Yu (2003) found that teaching practice in the reform classrooms became more varied and included more active participation by students. Classroom teaching included a range of activities such as obtaining knowledge through reading, exploration, reflection, observation, manipulation, and questioning. Ma (2005) conducted a survey in reform classrooms and found that the students in those classrooms were encouraged to state their views, explain their ideas, and respond to the ideas of their classmates.

On the other hand, the studies also found that teachers who were piloting the new curriculum were having significant problems teaching effectively using the new reform approach. For instance, ‘classroom discussion’ was sometimes little more than teacher-centered question-and-answer sessions, where teachers were inclined to pressure students to agree with them. ‘Self-directed’ learning often became situations where some teachers permitted students to do whatever they liked, without guidance, feedback or requirements. Group work was sometimes ineffective, particularly when teachers assigned students to groups for discussion of questions regardless of the difficulty or value of these questions and without purpose, conditions, time limits, or guidance from the teachers (Yu, 2003). There was also a tendency to concentrate on the textbook rather than the standards defined by the curriculum (Shan, 2002). These observations highlight the inherent problems associated with attempts to mechanically apply teaching methodologies without the philosophical intent of the prescribed curriculum goals.

Findings such as those discussed above have provided valuable information on the subject of reform implementation in China. However, these studies had several limitations. The first of these was the lack of comprehensive evaluation frameworks for teacher classroom practice. The studies only examined the changes of teaching methods, teacher questioning, and classroom activities in reform contexts from a single and narrow perspective (Ma, 2005; Shan, 2002; Yu, 2003). However, the classroom is a dynamic place where the interaction between teacher, students, and resources produces engagement and learning (Brophy & Good, 1986). Consequently, it is difficult to present an accurate assessment of changes in teaching practice within the context of reform by simply focusing on one specific dimension of teaching and learning. A second limitation was the obvious omission of non-reform samples as a comparison group in the research design. Thus, there was no direct evidence to demonstrate the impact of the reform on classroom practice. A third limitation was the lack of large-scale video studies to describe the dynamics of teaching and learning in the classroom. Video recording is a powerful tool that enables more precise, complete, and subtle analyses of interactive teaching practice (Janik & Seidel, 2009; TIMSS Video Mathematics Research Group, 2003). Because previous research was limited to data based on self-reporting by teachers and unstructured observations, many important details were overlooked.
1.2. Conceptualization of the present study

One of the central goals of mathematics curriculum reform is for teachers to provide an environment for classroom learning that supports students’ thinking and dialogue related to mathematics (Ministry of Education, 2001a, 2001b). Instructional tasks and classroom discourse are considered to be the key indicators of the nature of the classroom environment because instructional tasks are concerned with content, that is, what is to be learned. This is in addition to classroom discourse where the emphasis is on how the subject of mathematics is to be learned. Therefore, as indicated at the beginning, the present study focused on these two aspects of evidence for changes in classroom practice resulting from the reform. Each aspect is discussed in the following two sections.

1.2.1. Learning task implementation

Current research indicates that pedagogical principles are embodied in the enacted curriculum and instruction as the ways in which students and teachers engage with particular materials or activities. Learning tasks serve as the proximal source of student learning from instruction by directing their attention to particular aspects of content and by specifying ways of processing information (Cai & Silver, 1996; Cai, 2004; Doyle, 1983, 1988; Renkl & Helmke, 1992). Primarily, those mathematical learning tasks that nurture desirable learning outcomes are targeted by this reform and have been identified, based on the research of Doyle (1983, 1988) and Stein and her colleagues (Henningsson & Stein, 1997; Stein, Grover, & Henningsen, 1996; Stein, Smith, Henningsen, & Silver, 2000; Stein, Remillard, & Smith, 2007). Such tasks should utilize multiple-solution strategies and be applicable to multiple representations. These learning tasks should demand high-level cognitive processing, such as explanations and/or justifications from students (Q. Li, 2004; J.H. Li, 2004; Li, 2009; Ministry of Education, 2001a, 2001b). The three cognitive dimensions of mathematics instructional tasks that have been defined – cognitive demands, multiple-representation, and multiple solution-strategies – are considered to be helpful to students in (1) developing a more dynamic view of learning mathematics (Namukasa, Gadadis, & Cordy, 2009; Schoenfeld, 1992), (2) becoming more confident in learning mathematics (Mason & Scrivani, 2004), and (3) performing better in solving mathematics problems (Brenner et al., 1997; Hiebert & Wearne, 1993; Mason & Scrivani, 2004; Stein & Lane, 1996; Stigler & Hiebert, 2004; Vergnaud, 1994).

1.2.2. Norms of classroom discourse

The characteristics of communication and interaction between the teacher and students and also among students themselves have a significant influence on the processes of teaching and learning (Cobb, Wood, Yackel, & McNeal, 1992; Franke, Fennema, & Carpenter, 1997; Leinhardt & Steele, 2005). Questions from teachers and their reactions to student responses have a tendency to shape the way in which classroom discourse takes place. This can also affect the extent to which the utility of the desirable cognitive features of a learning task can be realized. Questions from teachers may serve two primary functions, (Baxter & Williams, 2009; Phillips, 1997; Williams & Baxter, 1996). The first is that of building social scaffolding, described as a tool to help establish expectations for classroom participation and authority over classroom discourse. The other is the construction of analytical scaffolding, providing support for students as they process information in a certain way to construct knowledge. Regarding the social scaffolding dimension, the primary concern is the way in which the teacher reacts to the responses of students. A teacher’s specific reactions clearly convey to the student the source of authority over knowledge during classroom discourse. Therefore, features of classroom discourse in this study were examined along three dimensions: (1) cognitive levels of teacher questions, (2) cognitive levels of student responses, and (3) the way in which teachers responded to students’ ideas and responses (see Section 2 for details).

2. Methods

2.1. Participants

The participants in this study included 58 fifth-grade primary school mathematics teachers, they were from two districts in a city, located in central China. One group included 33 teachers from one district where the new curriculum had been implemented in their schools for 5 years (hereafter referred to as the reform classrooms). Twenty-five teachers were from another district where the schools had not yet implemented the new curriculum when data collection for the study was started and completed (hereafter referred to as the conventional classrooms). As shown in Table 1, the two groups of teachers were relatively similar in terms of their teaching experience, educational level, and teacher training. In addition, the two groups of teachers were also given a measure of teachers’ mathematics knowledge for teaching, which was adapted from Hill, Schilling, and Ball (2004). The measure has four dimensions including conceptual knowledge in mathematics (e.g., the meaning of zero), representational knowledge in mathematics (e.g., alternative ways to represent the fraction 2/3), teacher’s knowledge about students’ thinking processes, and teacher’s knowledge about students’ common errors. The two groups of teachers did not differ in any of the four measured dimensions or in the total scores. Therefore, the basic characteristics of the two groups of teachers were basically the same.

Each of the individual teachers was informed of the videotaping schedule 1 week before his/her lessons were videotaped. They were told that they should just follow their original teaching schedule with regard to what to teach and their original plans about how to teach for the three consecutive days. We were not concerned that some individual teachers might do more
Table 1  
Teacher demographic information.  

<table>
<thead>
<tr>
<th>Demographic information</th>
<th>Reform classrooms</th>
<th>Conventional classrooms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Female</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22–29</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>30–35</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>36–45</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>46–53</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Year of teaching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2–5 years</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>6–10 years</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>11–15 years</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>16–25 years</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>More than 25 years</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Educational level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bachelor degrees</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Associate degrees/normal college for elementary school teachers</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Class size</td>
<td>57 students per class</td>
<td>56 students per class</td>
</tr>
</tbody>
</table>

preparation than others for the lessons to be taped because we were interested in observing their maximum performance regardless of whether or not an individual teacher was using the reform curriculum or the conventional curriculum.

2.2. Data collection and analysis

2.2.1. Videotaping classroom instruction

In order to accurately capture the degree of change in classroom practice, it was necessary to use classroom observations. Data was obtained from videotapes recorded during sessions of classroom instruction.

In each classroom, the video camera was positioned so that the primary focus was the teacher. During sessions that involved either individual or group work, the camera panned across the classroom as the teacher circulated among students. There were videotapes of each teacher’s three mathematics lessons for three consecutive school days in the spring of 2007. There was one exception in which three teachers were videotaped for two lessons. The result was 171 videotaped class sessions. Subsequently, the videotapes were transcribed for the analysis of task implementation and classroom discourse.

Of the 171 videotaped lessons, 96 lessons were from the reform classrooms and 75 sessions were from the non-reform classrooms. There were 146 lessons on new knowledge, 15 review lessons and 10 exercise lessons. Because of the concern that lesson types might influence the nature of task implementation and classroom discourse, our analysis was restricted to the 146 lessons on new knowledge. This included 87 lessons from the reform classrooms and 58 lessons from the non-reform classrooms.

2.2.2. Coding system for the analysis of learning tasks

Identifying a learning task. For the purpose of this study, a mathematical task is defined as a classroom activity or a segment of classroom work, the intention of which is to focus the attention of students on a particular mathematical idea. For instance, during a lesson on the total surface area of a cuboid, students were given the following task to study: ‘Ming Ming wants to make a colorful box with Length = 12 cm, Breadth = 10 cm, and Height = 8 cm as a present to give his sister. What will be the minimum surface area of the gift paper that will completely wrap the box?’ In another example, before introducing the concept of division of fractions, a teacher presented these two tasks in class:

1. What are the reciprocals of the numbers respectively: 1/3, 3/4, 1, 8/7, 2, 5/6, 3?
2. Determine how many 1/7’s are in 4/7? How many 1/8’s are in 5/8? What is the unit of 5/9 and how many units are in 5/9? What is 1/7 of 2?

In the present study, any self-contained mathematics problem, activity or exercise that students engaged in during a lesson was counted as a learning task. In the above examples, the word problem was counted as one learning task, the set of questions on the reciprocal numbers was counted as one task, and the set of fraction questions were counted as one task.

An issue we faced in the analysis was to determine the boundary of a learning task. In both reform and non-reform curricula contexts, in most cases, a task implemented in class was a sole problem or activity, such as the one above of calculating the total surface area of the box, which was easy to be identified as one learning task. In some other cases, however, a task consisted of a set of similar questions implemented during the same segment of classroom work. Consider the questions about the reciprocals of the numbers and fraction unit. Each of these problems included a group of similar problems. Considering that students solved these similar problems with the same or relevant knowledge and the problems were presented in the same classroom teaching segment, we counted such a set of similar problems on the same content and similar cognitive demands in the same teaching segment as one learning task, as shown above. By defining a learning task in
this way, we were able to produce a self-contained and meaningful “analysis unit.” We considered this way of identifying learning tasks to be “fair” to both the reform and non-reform groups.

**Coding dimensions.** The coding system used to analyze learning tasks includes three dimensions: (1) type of cognitive process that is required for students to engage in solving the task; (2) the existence of multiple-solution strategies, and (3) the extent to which the task lends itself to multiple representations. This coding system is based on the works of Stein et al. (1996, 2000), Renkl and Helmke (1992), and Stigler and Hiebert (1999).

Once identified, the instructional tasks were coded into four types: ‘memorization’ tasks, ‘procedures without connections’ tasks, ‘procedures with connections’ tasks, and lastly ‘doing mathematics’ tasks. ‘Memorization’ tasks involve either reproducing or committing to memory previously learned facts, rules, formulae, or definitions. ‘Procedures without connections’ tasks are algorithmic and have little or no connection to the concepts or meaning that underlie the procedures being used. ‘Procedures with connections’ are tasks that focus students’ attention on the use of procedures for the purpose of developing mathematical concepts. Tasks coded as ‘Doing mathematics’ require students to explore and understand mathematical concepts, processes, or relationships by using complex, non-algorithmic thinking. The tasks were also analyzed along the other two dimensions, types of representation (e.g., symbol, figural or hands-on manipulation) and single or multiple solution strategies encouraged in the tasks. Examples for the coded dimensions of instructional tasks are presented in Appendix A.

**Coder qualification and assignments.** Eight coders were recruited and trained to code the videotaped lessons. Four coders were graduate students majoring in mathematics or mathematics education with the added experience of teaching or classroom observation. The other four were mathematics in-service teachers from elementary schools with more than 5 years of teaching experience. Of the three trainers, two were university researchers in mathematics education and educational psychology and one was an experienced mathematics teacher with 19 years of teaching experience in elementary schools. The trainers developed and discussed coding schemes together and trained the coders. To ensure inter-coder reliability, a stratified random sampling procedure was employed to identify 14% of the videotaped lessons, which contained 24 videotaped class sessions including 14 from the reform group and 10 from the non-reform group, for the double coding. To establish the inter-rater agreement on the number of learning tasks for a same lesson and the agreement on the four types of tasks, a three-step procedure was followed. First, all the problems or activities were picked out of the transcriptions of the 24 lessons according to identified teaching segments (note: Chinese classroom instructional sequences are generally well organized; Wang & Murphy, 2004). Second, the raters identified individual tasks according to the considerations described above in addition to making reference to the teachers’ written lesson plans for the classroom sessions. These lesson plans were very helpful for two coders to reach consensus in identifying what were the specific tasks and how many tasks in a lesson. It was not difficult for them to identify a learning task like the one of calculating the surface area as mentioned above, but a disagreement sometimes occurred with a task that consisted of several similar questions like the one described above involving fractions. Using this procedure, inter-rater agreement for identifying the number of learning tasks in the lessons ranged from 0.84 to 0.93. Third, the identified learning tasks were then classified in terms of the four types: memorization, procedure without connections, procedure with connections, and doing mathematics. Consensus coding was scheduled systematically over a 3-week period such that between consensus sessions each coder independently coded six videotaped lessons, including 18–30 tasks. Consensus was reached by two coders on all disagreements. Inter-rater agreements on the four types of tasks ranged from 0.79 to 0.90. This level of inter-rater agreement was considered to be sufficiently high to warrant confidence in the coded dimensions.

Afterwards, a stratified random sampling procedure was used to assign videotaped lessons to eight coders to ensure that each coder had responsibility for coding approximately the same number of observations from the reform group and non-reform group but the coders did not know the identity of the group. During the coding, frequent consensus sessions were interspersed among individual coders. This minimized the opportunity for individual coders to deviate from the shared understanding of the coding schemes.

**2.2.3. Coding system for the analysis of classroom discourse**

This analysis focused on questions from teachers, answers from students, and the teachers’ reactions to the responses of students. The data were analyzed within these three dimensions (Hamm & Perry, 2002; Stigler, Fernandez, & Yoshida, 1996). Teachers’ questions that were raised in their classrooms were classified into four types: (1) questions that asked students to recall previously learned facts, procedures or formulas, (2) questions that required a description of the procedures that are used to solve a problem, (3) questions that called for an explanation of the reasons for an answer, and (4) questions directed to an analysis of the connection or difference between different strategies. All four types of question formed an integral part of classroom instruction. However, each type required a different response, and facilitated different ways of processing information, resulting in different learning experiences and outcomes. We understood that sources of teacher questions may include, but not be limited to, textbooks, teacher manuals, the exchange in the teacher’s teaching research group, as well as the teachers’ understanding of the topic under instruction and their understanding of their students’ prior learning history.

Student responses were coded into the five categories: (1) giving a ‘Yes’ or ‘No’ answer, (2) describing a procedure that led to an answer, (3) explaining an answer, (4) evaluating another’s response, and (5) raising a question or doubt. The student responses are indicators of the strategies that they use to process information. The appropriation of student ideas on the part of the teachers were categorized as the dismissal of the student’s idea, the acknowledgment of the student’s idea but not incorporating it into the instruction, or probing and connecting the student’s idea to the instruction. (Appendix B provides examples of the coded dimensions.)
Table 2
Instructional tasks of different cognitive levels between the two groups.

<table>
<thead>
<tr>
<th>Cognitive level of tasks</th>
<th>Memorization</th>
<th>Procedures without connection</th>
<th>Procedures with connection*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of tasks used in reform classroom (N=518)</td>
<td>81 (15.6%)</td>
<td>179 (34.5%)</td>
<td>258 (49.9%)</td>
</tr>
<tr>
<td>Number of tasks used in non-reform classroom (N=478)</td>
<td>96 (20.1%)</td>
<td>273 (57.1%)</td>
<td>109 (22.8%)</td>
</tr>
</tbody>
</table>

χ² = 79.84 p < .000

* This level includes both ‘procedures with connections’ and ‘doing mathematics’.

The schemes were applied to the analysis of teacher questions and responses to students that were collected from the same 24 videotaped lessons used for checking the reliability test of learning tasks. The coders and assignments of videotaped lessons of the classroom discourse were the same as the above coding of instructional tasks. Compared to the coding of instructional tasks, classroom discourse coding was more challenging because of the dynamics of classroom interaction. The preliminary percentage of inter-rater agreement of the dimensions of classroom discourse ranged from 0.63 to 0.81. After many consensus discussions of the trainers and the coders, the final percentage of inter-rater agreement of the dimensions of classroom discourse ranged from 0.80 to 0.89.

3. Results

3.1. Features of instructional tasks implementation in two groups of classrooms

As explained in Section 2, three characteristics of instructional tasks were analyzed. These are the cognitive levels of instructional tasks, types of representations involved in the tasks, and single or multiple strategies encouraged in the tasks. The results for each of the three dimensions of instructional tasks are reported below.

3.1.1. Cognitive levels of instructional tasks

A total of 996 learning tasks were coded from the observed 146 lessons. Five hundred and eighteen tasks were from the reform group and 478 from the non-reform group. Table 2 shows the percentage distribution of three types of tasks implemented in both reform and non-reform lessons. ‘Doing mathematics’ tasks were added together with that of ‘procedures with connections’ tasks because a very small proportion of these tasks were identified. It was found that 77% of the instructional tasks in the non-reform group, compared to 50% of the tasks in the reform group, were those involving memorization or procedures without connections. By contrast, 50% of the tasks in the reform classrooms were implemented at the higher cognitive level of procedures with connections. This was significantly more than the 23% of the tasks in the non-reform classrooms (χ²(2) = 79.84, p < .000).

Consider the following example of the 5th grade reform group teacher, who taught a lesson on the volume of rectangular prisms. The teacher first reviewed the content related to the area of rectangles and let students calculate the different areas through changing the length and width. Then students were asked to think about how to determine the area of a rectangle. Based on this, the students were asked to think about how to determine the volume of a rectangular prism. The teacher demonstrated three types of rectangular prisms: the same length and width, but different heights; the same length and height, but different widths; the same height and width, but different lengths. The students could find each length, width or height that determines the volume of a rectangular prism using direct visual aids. Then the students were given the following task:

**Instruction:** Each group has 40 cubes with sides of 1 cm, please design different rectangular prisms using the small cubes and complete the form below.

<table>
<thead>
<tr>
<th>Prism 1</th>
<th>Prism 2</th>
<th>Prism 3</th>
<th>Prism 4</th>
<th>Prism 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length/cm</td>
<td>Width/cm</td>
<td>Height/cm</td>
<td>Number of cubes</td>
<td>Volume/cm³</td>
</tr>
</tbody>
</table>

(1) Observe the data in the above form, what do you find?
(2) How can you get the volume of a rectangular prism?

In this task, students need to explore, conjecture, experiment, and make arguments in order to find the volume of the rectangular prisms. The task was truly problematic for students, which is in contrast to when the teacher simply tells or shows the students how to find the answer and then has them practice an already-demonstrated algorithm. Thus, this teacher had chosen to engage her students in this task of higher cognitive demands.
Table 3
Types of representation for instructional tasks between the two groups.

<table>
<thead>
<tr>
<th>Representations</th>
<th>Mathematical symbols</th>
<th>Pictures or diagrams</th>
<th>Manipulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of tasks used in reform classroom (N=518)</td>
<td>82.2%</td>
<td>37.3%</td>
<td>46.7%</td>
</tr>
<tr>
<td>Number of tasks used in non-reform classroom (N=478)</td>
<td>91.2%</td>
<td>10.5%</td>
<td>5.4%</td>
</tr>
</tbody>
</table>

χ² = 181.36 p < .000

Note: A learning task could be coded with more than one type of representation. Therefore, the percentages across the three types of representation within a group add up to more than 100%.

By contrast, consider an example from one teacher of the non-reform group who engaged students in a lesson on prime factorization. The teacher spent 25 minutes of the class working out the following tasks:

(1) Find the prime factors of 6. Examine the feature of the factors.
(2) Find the prime factors of 28. Observe if the factors can be factorized further.
(3) Is 5 a factor of 10? 3 is a factor of 15?
(4) Is 4 a prime factor of 8?
(5) Use upside-down division to find the prime factorization of 28.
(6) Use upside-down division to find the prime factorization of 72.

Then, students were given an additional five tasks similar to these six as practice. The tasks she gave the students required them to find the factors and use upside-down division to find the prime factorization. Students worked on the practice tasks for the remaining 15 minutes of class. These ‘procedures without connections’ tasks occurred more frequently in observations of the non-reform classrooms than of the reform classrooms.

3.1.2. External representations of instructional tasks
The observers in both reform and non-reform classrooms looked for instances of the three kinds of external representations: mathematical symbols, diagrams or pictures, and hands-on manipulatives. Table 3 illustrates the percentage of each representation type. The results indicated that numerical symbolic representations were dominant in the instructional tasks for both groups, which, perhaps, is understandable. In particular, 82.2% of the instructional tasks in the reform group and 91.2% of the tasks in the non-reform group used mathematical symbols. However, significantly more instructional tasks that were implemented in the reform classrooms involved representation of visual illustrations and hands-on manipulation of material.

Consider the following example from a reform classroom. The topic being taught was fraction division. Firstly, students were asked to draw pictures and write the mathematical expression, then they were expected to summarize how to calculate the fraction division.

Divide 1/2 of the following rectangular paper into two equal parts. How much is each box of the total paper?

Another example was a lesson on unit of volume in a reform classroom. One of the teachers encouraged students to participate in order to help them understand different units of volume through a hands-on activity. For instance, the teacher had the students cut the cubes with 1 cm³ and 1 dm³ with play dough. The teacher then had the student build a space of 1 m³ with a wood box in the corner of the classroom to find out how many students could be in the space occupying 1 m³. One group of four students joined hands standing in a circle that they calculated to be about 1 m² in volume.

3.1.3. Single or multiple solution strategies for the instructional tasks
Table 4 indicates the percentage of single or multiple solution strategies for the instructional tasks used in the classrooms. The majority of the instructional tasks were implemented using a single-solution strategy in both groups. The results
revealed that 64.1% of the instructional tasks in the reform group and 84.3% of the tasks in the non-reform group used single strategies. However, the reform classrooms implemented significantly more instructional tasks that involved multiple-solution strategies.

To illustrate, one of the reform group teachers focused on eliciting students’ multiple strategies to help them think conceptually and to make connections between mathematics ideas. The following is an example of classroom scenarios on fraction division.

**Teacher (T):** (demonstrate a rectangular paper with colored boxes 4/7 of the total)

> Look, this represents 4/7 of the paper. If we divide 4/7 of the rectangular paper into two equal parts, how much would there be? (Students began to work on the task.)

**Students (S):** Divide 4/7 of the rectangular paper into two equal parts, each part is…

> T: How do you find the solution?
> S1: Divide 4/7 into equal two parts, that is, 4/7 ÷ 2 = 2/7.
> S2: Use the numerator divided by this whole number, keeps the denominator unchanged, and gets 2/7.
> S3: 4/7 means four 1/7, divide four 1/7 into two equal parts, that is, two 1/7 and gets 2/7.
> T: So how much we will get if we divide 4/7 into three equal parts?

……

### 3.2. Features of classroom discourse

For the analysis of classroom discourse, the focus was on three variables that reflected ways the teacher interacted with students: The cognitive level of teacher questions, types of student responses, and the way that teachers responded to students’ ideas.

#### 3.2.1. Cognitive levels of teacher questions

Teachers’ questions were coded into four types for further analysis. These were identified as the requests for: (1) a known answer, (2) describing a procedure, (3) an explanation, and (4) an evaluation. These question types are defined and exemplified in Appendix B. On average, teachers asked 23 and 29 questions on average in a single lesson in the reform and the non-reform classrooms respectively. As shown in Table 5, most of the teacher questions were those that asked for memorizing and explaining answers (types 1 and 3). However, the teachers from the reform classrooms were more likely to ask students to describe a procedure (type 2) and to call for explanations that led to an answer (type 3).

Here is an excerpt from a reform classroom.

> T: What is the reciprocal of 0?
> S: (all students) 0
> T: Ok, talk among yourselves about your ideas.
> S1: 0’s reciprocal is still 0
> T: Why?
> S2: I consider 0 has no reciprocal.
> T: Could you explain it?
> S2: Because 0/0 is not logical, I think 0 has no reciprocal.

### Table 4

Single or multiple solution strategies for instructional tasks between the two groups.

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Single strategy</th>
<th>Multiple strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of tasks used in reform classroom (N=518)</td>
<td>332 (64.1%)</td>
<td>185 (35.9%)</td>
</tr>
<tr>
<td>Number of tasks used in non-reform classroom (N=478)</td>
<td>403 (84.3%)</td>
<td>76 (15.7%)</td>
</tr>
</tbody>
</table>

$\chi^2 = 51.00 \ p < .000$

### Table 5

Types of teacher questions between the two groups.

<table>
<thead>
<tr>
<th>Types of questions</th>
<th>Answer known</th>
<th>Describing procedure</th>
<th>Request for explanation</th>
<th>Request for evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbers of teacher questions in reform classrooms (N=2051)</td>
<td>760 (37%)</td>
<td>258 (13%)</td>
<td>780 (38%)</td>
<td>253 (12%)</td>
</tr>
<tr>
<td>Number of teacher questions in non-reform classrooms (N=1731)</td>
<td>771 (44%)</td>
<td>125 (7%)</td>
<td>605 (35%)</td>
<td>230 (13%)</td>
</tr>
</tbody>
</table>

$\chi^2 = 42.7 \ p < .000$
T: Why is 0/0 not logical?
S3: I mean 0 cannot be in the denominator, it can only be in the numerator, so 0/0 is not logical.

In contrast, teachers from the non-reform classrooms presented more questions with known answers that require only memorization. Here is an example.

T: What is cubage?
S: Volumes such as boxes, bottles and warehouses that can hold things is called cubage.
T: Boxes, bottles and warehouses, we say, what do we call it?
S: A container
T: What?
S: Container
T: The volume that a container can hold
T: Well, could you say it again?
S: The volume that an object can hold
T: Who can tell us?
S: The volume that a container can hold is called cubage.
T: What can a container hold?
S: Volume
T: It is called?
S: Cubage.

In terms of the extent that a teacher’s questions can promote students’ thinking, the questions that ask for known answers to be lower cognitive level questions and the questions that ask for describing a procedure to be slightly higher, but still low cognitive level questions. In contrast, questions calling for explanation and for evaluations are considered to be high cognitive level questions. In both the reform and non-reform classrooms there were about 50% low and high cognitive level questions.

3.2.2. Types of student responses

Table 6 displays the types of student responses to the teacher questions for the two groups. The results showed that for both groups, the largest number of student responses was to questions from the teacher that asked simply for Yes or No answers or only giving an answer. By comparison, there were relatively few student responses that involved evaluating each other's answers or raising questions. However, compared to the students in non-reform classrooms, those from reform classrooms produced more responses evaluating each others' answers, \( (T_{56} = 2.47, p < .05) \), and posing questions, \( (T_{56} = 3.81, p < .000) \), but fewer simple Yes or No answers \( (T_{56} = -2.00, p < .05) \). This indicated that students in reform classroom had more opportunities to discuss and evaluate different ideas and to pose questions.

Here is a scenario from one reform lesson in which the teacher encouraged the students to share their thoughts about whether or not weight has anything to do with the volume of an object.

T: Zhang Ming said we could find which is bigger for the space held by an object by weighing, for example, a stone or a piece of play dough. Do you have different ideas?
S1: If we put the stone into water, the water that came out of the vessel is less than what came out by putting play dough into the water.
T: So, she told us which was heavier of the objects: a piece of play dough with big volume or a stone with small volume. Which is heavier?
S2: A stone.
T: Could you say that the volume of a stone is larger than that of cotton candy?
S3: No

Table 6

<table>
<thead>
<tr>
<th>Types of student response</th>
<th>Yes or No answer</th>
<th>Describing a procedure</th>
<th>Explaining an answer</th>
<th>Evaluating other’s response</th>
<th>Raising a question or doubt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of student responses in reform classrooms (N = 3773)</td>
<td>1932 (51.2%)</td>
<td>443 (11.7%)</td>
<td>1109 (29.4%)</td>
<td>109 (2.9%)</td>
<td>180 (4.8%)</td>
</tr>
<tr>
<td>Number of student responses in non-reform classrooms (N = 2953)</td>
<td>1770 (59.9%)</td>
<td>271 (9.2%)</td>
<td>848 (28.7%)</td>
<td>41 (1.3%)</td>
<td>23 (0.8%)</td>
</tr>
</tbody>
</table>

\( \chi^2 = 137.66 \ p < .000 \)
T: So, there is no relationship between the weight and volume. Ok, what is another solution method to find out which object has larger or smaller volume?
S4: My method is to calculate the surface area.
T: Do you mean the larger the surface area, the larger the volume?
S4: I am not sure.
T: Why?
S5: I consider it is not certain.
S6: Not certain. For example, a piece of paper is very thin, but the area is big. However, another object, with less area than the paper, is much thicker than the piece of paper.
T: That is very good. Other ideas? Zhao Lin, please.
S7: Cut the two pieces of play dough into 1 cm² small cubes. See which cuts out more 1 cm² cubes.
T: Oh, his solution is to cut the two pieces of play dough into 1 cm² small cubes and count the numbers of small cubes. The greater the number of cubes, the greater the volume of the object.

In contrast, the type of teacher questioning and students’ response in another classroom appeared to focus on simply asking for Yes or No answers. In a lesson on division, students were first asked to write the divisors of 1–12, then to make categories according to the number of divisors. One student made the following three categories: one containing the number 1 because it has exactly one divisor, a second showing that there are numbers with two divisors, and a third showing that there are numbers with more than two divisors. The following questions were then raised.

T: How many categories are there?
S: Three
T: What is the smallest divisor?
S: The smallest is 1 and the largest one is the number itself.
T: Besides 1 and the number itself, there are other divisors. Now we have made three categories, and the numbers that have only 1 and themselves as divisors are called prime numbers. What numbers are called prime numbers?
S: The numbers that have only 1 and themselves are called prime numbers.

The types of classroom discourse in the above two classrooms were quite different. The students in the first classroom were provided the opportunity to reason and to communicate their thoughts about whether weight has anything to do with the volume of an object. However, those in the second classroom were limited to reciting the abstract definition of prime numbers provided by the teacher.

3.2.3. Teachers valuing students’ ideas in classroom discussion

There are several ways that teachers could respond to students’ ideas. In particular, the teacher could (1) dismiss or reject a student’s response; (2) acknowledge but not incorporate student ideas into instruction; (3) acknowledge by restating student ideas; and (4) probe and connect student ideas to the content of the lesson.

The descriptive statistics showing the kinds of responses by teachers to students’ responses are presented in Table 7. Both groups of teachers indicated a positive response to students’ ideas because the responses of dismissing or rejecting were low. Both groups of teachers primarily responded to students’ ideas or explanations by probing and connecting student ideas to the content of the lesson. Teachers in the reform groups were more likely to acknowledge the students’ contribution by restating their response, whereas teachers in the non-reform group were more likely to acknowledge the student without restating the response.

The following example is from a reform classroom, in which the teacher worked with students to solve word problems on fraction division.

T: Look, this represents 4/7 of the paper. If we divide 4/7 of the rectangular paper into two equal parts, how much would there be?
S1: Divide a piece of paper into 7 parts equally, get the 4 parts, then divide the four parts into 2 and get 2/7 That is, 4/7 ÷ 2 = 2/7
S2: My solution is different from his. I make 2 become 1/2, that is 3/2 × 1/2, then 4/7 ÷ 2 = 3/2 × 1 = 4/7

<table>
<thead>
<tr>
<th>Table 7</th>
<th>Types of teacher reactions to student ideas between the two groups.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Types of teacher response</strong></td>
<td><strong>Dismiss or ignore</strong></td>
</tr>
<tr>
<td>Number of teacher responses in reform classrooms (N=946)</td>
<td>26 (2.8%)</td>
</tr>
<tr>
<td>Number of teacher responses in non-reform classrooms (N=602)</td>
<td>29 (4.8%)</td>
</tr>
<tr>
<td><strong>χ² = 51.11 p &lt; .000</strong></td>
<td></td>
</tr>
</tbody>
</table>
Among classrooms, curriculum questions. The reform of mathematics education is challenging and higher mathematics education is about for comfortable disagreeing with their peers. Asking students to share what they think provides the class with information about how others solve mathematics problems and shows students that their opinions are valued.

3.3. Relationship between teachers’ demographic variables and the measured aspects of classroom practice

In order to determine whether or not the differences between the two groups of teachers with the measured features of the instructional tasks and those of classroom discourse, were associated with their years of teaching and educational levels, MANOVA analysis was performed. With regard to the features of instructional tasks, results showed the main effect of curriculum on the variables of instructional tasks were related to the feature of procedure with connection \( F(1) = 7.14, p < .01 \), graphic representation \( F(1) = 16.10, p < .001 \), hands-on manipulation \( F(1) = 4.96, p < .05 \), single solution strategy \( F(1) = 11.27, p < .001 \), and multiple-solution strategies \( F(1) = 11.27, p < .001 \). There was neither a main effect of years of teaching nor educational levels and also no effect was seen on their interactions with the curriculum used.

For the variables of classroom discourse, the main effect of curriculum was observed on the variables of classroom discourse concerning teachers’ questions requesting for a known answer \( F(1) = 7.71, p < .01 \), teacher questions asking for a description of procedure \( F(1) = 10.88, p < .001 \), student response to evaluate each other’s answer \( F(1) = 4.14, p < .05 \), and student response to questions or doubts raised \( F(1) = 4.78, p < .05 \). In addition, there was neither a main effect of years teaching nor of levels of education. However, there was an interaction between curriculum and educational level on the percentage of teacher questions requesting for a known answer \( F(1, 45) = 4.71, p < .05 \) and the percentage of teacher questions asking for an explanation \( F(1, 45) = 6.90, p < .05 \). The difference in the percentage of teacher questions asking for a known answer and that of teacher questions asking for an explanation, between the reform and non-reform classrooms, was found mainly in those teachers with a bachelors’ degree but not in those with associate degrees or less. Among the teachers with a bachelors’ degree, the percentage of teacher questions asking students for an explanation was higher for the reform teachers than for non-reform teachers but the reverse was true for the percentage of memory questions.

4. Discussion

The present study investigated the effects of curriculum reform, specifically questioning whether teachers in a reform curriculum context created a positive learning environment in the classroom where students participated in meaningful, challenging mathematical tasks and productive discussions. Below, we summarize the main findings and then discuss possible implications of the findings for further improving classroom practice and student learning.

4.1. Evidence of the influence of curriculum reform on classroom instruction

Researchers in this field (e.g., Cai, 2005; Schoenfeld, 1992, 2002; Stein et al., 1996) consistently have recommended the exposure of students to meaningful and worthwhile mathematical tasks that are truly problematic, rather than students simply practicing algorithms. Their research indicates that meaningful and cognitively demanding tasks are more likely to provide authentic opportunities for students to explore mathematical ideas and as a result, develop competence in mathematics.

Findings from this study show that reform teachers used a significantly higher proportion of instructional tasks with high cognitive demands, when compared to the teachers of the classrooms using the conventional curriculum. In addition, in the reform classrooms, students were given a higher proportion of mathematical tasks that encouraged them to use multiple-solution strategies and multiple representations.

As described above in a lesson on the volume of rectangular prisms, the teacher engaged the students in the task of exploration of the factors that determine the volume of an object. As a result of their exploration, students were able to devise multiple strategies to measure the volume of an object. Tasks such as these have the potential to engage students in sophisticated mathematical thinking and reasoning. One of the central goals of mathematics curriculum reform is for
teachers to develop positive learning environments in the classroom where teachers and students work together on challenging and worthwhile mathematical tasks (Ministry of Education, 2001a, 2001b).

Genuine classroom discourse promotes dialogue between teachers and students, encourages students to contribute and also facilitates positive interaction (White, 2003). The results suggest that the students in the reform classrooms had more opportunity to share, hear and participate in valuable mathematical discussions. Reform teachers were less likely to ask questions requiring recall of known answer, but more likely than the non-reform teachers to ask questions that require students to describe a procedure leading to an answer. Students in the reform classrooms were more likely to evaluate each other’s responses or pose questions. Teachers from both groups showed a positive response to students’ ideas. However, teachers in the reform group were more likely to reiterate students’ ideas as acknowledgment of their contribution.

When considering the earlier example of the reform teacher teaching a fraction division lesson, the teacher placed more emphasis on students’ thinking and their various solution strategies and less on the correct answer. The teacher found that by asking students to explain their answers and by restating students’ ideas, she not only learned the process the students used to work through the problem but also this exercise provided the class with multiple ways to solve problems. Another advantage was that all the students knew that their ideas were valued. Regardless of their academic ability, students were encouraged to share their opinions and no answer was regarded as trivial. Meanwhile, students’ sharing their ideas provides them the opportunity to experience the process involved in solving mathematics problems. From these observations, it is clear that teachers in the reform group have attempted to create a classroom environment that encourages students to share, evaluate and question their ideas with one another.

Again, the differences in the examined learning tasks and teacher questions between the groups were considered to reflect the curricular influences more than individual differences between the teachers, which was how the present study was framed. The findings supported this understanding: only the curricular factor, not the teachers’ demographic characteristics, demonstrated an effect on the observed difference. There was converging evidence showing that curriculum materials, particularly textbooks, are the main instructional resources that teachers rely on to make content selection and how to teach. Teachers were found to use textbooks in the classroom on a regular basis. For example, in the U.S., 89% of eight graders reported doing mathematics problems from their textbooks (Lindquist, 1997) and nearly three fourths of eighth-grade teachers reported using their textbook on a daily basis (Grouws & Smith, 2000). Classroom observation also indicated the frequent use of textbooks in both reform and non-reform classrooms in USA (Tarr et al., 2008). Similarly, more than 80% of eight-grade Chinese teachers indicated that they used the mathematics textbooks all the time (Fan, Chen, Qiu, & Hu, 2004). There also exists in Chinese schools a strong atmosphere of analyzing teaching content and studying from the designated textbook and teachers’ manual (Q. Li, 2004; J.H. Li, 2004; Zheng, 2002). This probably resulted in the observation made by Cai (2005) about distinctive features between Chinese lesson plans and American lesson plans. In his study a group of Chinese mathematics teachers and a group of American mathematics teachers were asked to prepare two introductory lesson plans on arithmetic average and on ratio and proportion respectively. It was found that the lesson plans produced by the Chinese teachers had very similar details in teaching contents and procedures, in comparison to the greater variability in the lesson plans by the U.S. counterparts. It might be also of interest to note that in our study involving 58 classrooms from 20 schools, all the reform classrooms used one common set of textbooks and the non-reform classrooms employed the other common set of textbooks. This is in contrast to the situation in the comparative study by Tarr et al. (2008) where the participating 87 classrooms from 10 schools used 10 different sets of textbooks that were grouped under two curriculum types: National Science Foundation founded or publisher developed. Therefore, to a large extent, the effect of a strict and normative curriculum system in China may make the impact of curriculum materials on Chinese teachers’ instruction more homogenous and greater.

While assuming the influence of the curriculum materials, particularly the textbooks on the observed differences in instruction practice between the groups, we did not analyze to what degree that the implemented tasks and teacher questions were directly drawn from the designated textbooks. This may be done in a separate study. We have obtained the lesson plans for each of the videotaped lessons. Further study can examine links between the curriculum materials and the teachers’ lesson plans and then between the lesson plans and the implemented learning tasks and teacher questions. Such study will provide more explicit associations between curriculum, lesson plan, and implemented classroom instruction.

4.2. Reflections on the findings in the context of reform

The question posed by this study is whether or not the changes in the mathematics curriculum have made a difference in classroom practice. As the findings of the present study have shown, there have been changes to instructional tasks and to classroom interaction. However, there are limitations to the findings, as these differences in teaching practice do not portray the entire picture of the changes in classroom instruction that have occurred in reform classrooms. In the following discussion, some of the problems and challenges related to changes in teachers’ classroom practice are examined, based on the present findings as well as previous literature in the context of the current reform.

The goal of the reform curriculum is for teachers to foster productive classroom discourse (Ministry of Education, 2001a, 2001b). The results of the current study indicate that creating and maintaining genuine interactive classroom environments is a complex endeavor for teachers. Regardless of whether teachers were in the reform or non-reform classrooms, a majority of the teacher questions were the type that required merely Yes or No answers. Also, a majority of the teachers simply repeated students’ answers, giving approval. There were very few student responses that evaluated the answers of other
students or raised questions. Understandably, tension exists because on one hand teachers are asked to encourage students to share their ideas and to use these ideas as the basis for classroom discussion. However, at the same time, teachers are supposed to ensure that the discussions are consistent with the goal to achieve targeted learning content. The tension arises in trying to find a balance between having a classroom environment that is open to student ideas and one whose purpose is to learn specific mathematical content as required by the curriculum (Sherin, 2002; Smith, 1996; Zaslavsky, 2010). This tension has brought challenges for teachers. For instance, often ‘discussion’ appeared to be meaningful but was sometimes little more than teacher-centered questions and answers. As a result, classroom discussion became only a means to cover required content but in essence, without substantial student participation. Creating a classroom environment that enhances productive classroom discourse requires considerable time and effort in order that teachers can create and maintain legitimate classroom interactions. The aim of the reform curriculum must be measured in terms of eliciting students’ ideas and drawing out or filtering their suggestions (Sherin, 2002; Zaslavsky, 2010). These strategies will facilitate deep conceptual understanding and problem-solving abilities in students. Understandably, they present a considerable challenge for the Chinese teachers who teach large numbers of students in their classes. The problem is also compounded by the tradition of orthodox teacher-centered instruction.

In order to build such an interactive learning community, not only is there change required in teachers’ behavior but also in the behavior of students. In the present study, whether the students were in the reform classrooms or in the conventional classrooms, they rarely asked questions or expressed doubt about other students’ responses or the teacher’s response. These observations seem to indicate that the nature of student responses is often shaped by the nature of the teachers’ questions. However, this passive tendency has also been established throughout the students’ years of learning, both in and out of Chinese classrooms. Such entrenched behavior makes it difficult for the students to adapt to the changes required by more interactive classroom practice. In the reform context, a student has the responsibility to express his/her interest, ideas and questioning. For the students, this is a radical change. One of the difficulties that a teacher has to overcome in creating an interactive classroom is not to return to the way of teacher-centered instruction. This may occur when changes in teaching practice are met with resistance from the passive tendency of students. The challenge for teachers is to find ways to enable students to become active participants in learning.

As part of the reform, the new mathematics curriculum calls for emphasis on building new knowledge, based on the reality of the students’ life (Ministry of Education, 2001a, 2001b). Tasks relating to real-life situations could help students to explore the problems of daily life with mathematical perspectives. This would provide added meaning to the task and give value to mathematics, acquiring knowledge to be used throughout their lives. In the present study, the instructional tasks were only analyzed in terms of cognitive demands. However, it was observed that while some instructional tasks in reform classrooms were situated in a real-life context, the majority of instructional tasks utilized only the abstract world of mathematics. Earlier educational practice overemphasized abstraction and formalization of mathematics in the school setting. This resulted in the disconnection of school mathematics from the real life of students. In this context, there are advantages in making the teaching content of mathematics closer to the real life of students, as reflected in the new curriculum. Conversely, it should be recognized that there are limitations with a student’s personal life experience for acquiring an understanding of mathematics. Consequently, this presents a considerable challenge for teachers to develop curriculum materials that are not only based on the life experience of students. The greater challenge is to extend this knowledge and incorporate it into the content of school mathematics and to integrate this at a higher level in mathematics teaching and learning (Zheng, 2003), that is, to incorporate students experience in the context of their daily lives into the regularity, preciseness and logicality of mathematical knowledge. These are important questions to be addressed by researchers and mathematics educators, important subjects for future study.

The present study employed a systematic classroom observation to reveal the changes in classroom practice resulting from implementation of the new curriculum in the Chinese context. Further research is needed in order to establish more explicit links between curriculum and instruction, and further to examine the way in which the changes in instruction have influenced student–learning outcomes (see Ni et al., in this issue). In the present study, the units of analysis were the discrete codes of instructional tasks, as well as teacher and student dialogue. This discrete form of analysis was useful in establishing the basic information of classroom instruction and for conducting the quantitative examination. However, the discrete analysis was not able to capture the actual conditions that affect the ways that instructional tasks were implemented. In addition, it was often hard to define the richness of the relationships between the features of a learning task and that of classroom discourse. Consequently, further research is certainly needed in order to identify more meaningful and mixed methods of analysis that will help to better understand the dynamics of the classroom processes that shapes teachers, teaching practice, and students’ learning of mathematics.

Acknowledgements

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Appendix A. Coding System for Analyzing Instructional Tasks (adapted from Stein et al., 2000).

<table>
<thead>
<tr>
<th>Cognitive demands of mathematics Instructional tasks</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Memorization:</strong> requiring the recall of given facts, rules and formulas</td>
<td>‘Do $\frac{1}{4}, \ 0.25, \text{and } 25%$ stand for the same amount?’; Expected student answer: $\frac{1}{4} = 0.25 = 25%$</td>
</tr>
<tr>
<td><strong>Procedure without connection:</strong> Requiring to follow a correct procedure to achieve the correct results</td>
<td>‘Transform $\frac{3}{8}$ into a decimal and percentage.’; Expected student answer: Fraction Decimal Percentage $\frac{3}{8} = 0.375 = 37.5%$</td>
</tr>
<tr>
<td><strong>Procedure with connection:</strong> Requiring to make the connection between procedure and concepts, and/ or between concepts, and/ or between representations</td>
<td>‘Shade the area standing for $\frac{3}{5}$ of a 10 x 10 grid. Indicate the size of the area with fraction, decimal and percentage respectively.’; Expected student answer: $\frac{60}{100} = \frac{3}{5}$; 60 = 0.60 = 60%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>External representations of mathematics instructional tasks</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Numerical/arithmetic symbol</strong></td>
<td>$\frac{6}{7} + \frac{1}{3} = ?$</td>
</tr>
<tr>
<td><strong>Figural</strong></td>
<td>What fraction of the whole is for the shaded area?</td>
</tr>
<tr>
<td><strong>Hands-on manipulative</strong></td>
<td>Using the given play doo to build a cubic of 1cm³ and 1mm³ respectively.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Single strategy or multiple solution strategies of mathematics instructional tasks</th>
<th>Example (multiple solution strategies)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Whether a learning task implemented that allows for multiple solution strategies</strong></td>
<td>T: ‘The teacher asked the students to find out the answer to the question ‘How much will be when 4/7 of a whole is divided into two equal parts? After the students reached the answer, T: What procedure did you use to find the answer? S1: 4/7 stands for four 1/7, four 1/7 divided into two equal parts leads to each part containing two 1/7. S2: Diving 4/7 into two equal parts means 4/7 x 1/2. S3: .....</td>
</tr>
</tbody>
</table>
Appendix B. Coding system for Analyzing Classroom Discourse

<table>
<thead>
<tr>
<th>Request for a known answer</th>
<th>Request a single correct answer, such as facts, rules or a definition established;</th>
<th>&quot;How many equal pieces in that whole?&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Request for a procedure</td>
<td>Request students to describe the procedure or prescribed solution methods</td>
<td>&quot;If we multiply the numerator by 2, what do we do with the denominator to get an equivalent fraction?&quot;</td>
</tr>
<tr>
<td>Request for explanation</td>
<td>Request students to explain his or her solution or to justify a mathematical idea with mathematical evidence.</td>
<td>&quot;Could you explain why you divided by 3 here?&quot;</td>
</tr>
<tr>
<td>Request for evaluation</td>
<td>Request students to evaluate the different solution methods or ideas.</td>
<td>&quot;What do you think of the difference in the two solution methods?&quot;</td>
</tr>
</tbody>
</table>

Codes for the teacher’s appropriation of student ideas (adapted from Hamm & Perry, 2002)

<table>
<thead>
<tr>
<th>Appropriation type</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dismiss or reject student ideas</td>
<td>The teacher dismisses or reject student ideas</td>
<td>T: which is bigger, 1/2 and 1/4? S: 1/4 T: No. (Teacher moved on with lesson)</td>
</tr>
<tr>
<td>Acknowledge but not restating student ideas</td>
<td>The teacher acknowledges the student’s response but not restate it to draw the others’ attention</td>
<td>The teacher commented a student’s response as ‘good’ or ‘correct,’ and moved on with the lesson.</td>
</tr>
<tr>
<td>Acknowledge by restating student ideas</td>
<td>The teacher restates a student idea to draw the others’ attention without altering the substance of the idea.</td>
<td>T: How do we know that is 19? S: Because it has 9 ones and 1 ten. T: 1 ten and 9 ones.</td>
</tr>
<tr>
<td>Probe and connect student ideas to the content of the lesson</td>
<td>The teacher asks for clarification of a student idea and makes a connection to the development of mathematical concepts.</td>
<td>T: How did you think out this different solution method? S: Multiply by 3 both numerator and denominator. T: Are they equal? Can you show us your method with this number line?</td>
</tr>
</tbody>
</table>

References


