IMPLEMENTING MATHEMATICS TEACHING REFORM: A CASE STUDY OF MATHEMATICS CLASSROOMS IN CHINA

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Abstract

This study describes the implementation of teaching reform in secondary mathematics classrooms in a rural poverty school in southwest China where a school-wide teaching experiment took place. Classroom teaching and learning practices are primarily concerned with classroom organizations, interactions and social norms. The results indicate that a collective learning approach was taken in the classroom reform, in which mathematical communications, understanding and engagement of students in learning were promoted. However, there was a lack of diversity of thinking and arguments on solving problems among different level students, which implies the mathematical teaching still focuses on acquiring knowledge over generating knowledge.

Introduction

Since the 1980s, National Council of Teachers of Mathematics (NCTM) has called for mathematics education in the US to shift its focus from gaining factual knowledge to understanding, communicating, reasoning and problem-solving, and developing individuals' dispositions (NCTM, 1989, 1991, 2000). It has advocated the classroom to be a legitimate learning community where learners develop sustainable and all-round abilities to meet the needs of the radically changing society (NCTM, 1991; NRC, 2001). However, the changes of teaching and learning in mathematics classrooms, as the real test of the implementation of reforms, have been difficult to render.

The calling for educational reform in the US is echoed globally. In the East, similarly, a comprehensive mathematics education reform movement has been underway throughout K-12 schools in China. The reform expectations are articulated in the Chinese new mathematics standards by Ministry of Education of the People's Republic of China (MEPRC, 2001), which particularly advocates the development of creativity and practical ability. Since the initial implementation of the reform in 2001, China has emphasized on seeking innovative approaches to carry out the reform ideas in classroom practices. This study describes an attempt of mathematics classroom reform within a junior high school in a city of Southwest China, which is relative less developed area in China. The purpose of this study is to shed light on Chinese mathematics education reform and to provide reference for mathematics classroom reform in the US.

Theoretical perspectives

This research is grounded on socio-cultural and learning community theories. From socio-cultural perspectives, research on classroom teaching practices should address social contexts and interaction patterns as key aspects (Vygotsky, 1978). Theories of the learning community suggest that classrooms are social learning systems. To understand classroom practices is to understand the relationships of its components in the context of a whole (Bielaczyc & Collins, 1999).

Class norms and learning goals

Social norms (Wood, 1998) and socio-mathematical norms (Yackel & Cobb, 1996) play important roles in regulating the teachers' and students' behaviors in mathematics activities in the classroom. Social norms reflect the dynamic relationship between individuals' learning and social contexts. Socio-mathematical norms are especially relevant to the development of students' mathematical thinking and autonomy in learning activities (Yackel & Cobb,1996). Learning community theories, on the other hand, describe classroom norms from the perspective of the whole learning community. As Bielaczyc & Collins (1999) pointed out, learning goals for a learning community play a vital role in developing the individual knowledge and skills through the advancement of collective knowledge and skills.

Interaction patterns and dynamics of interactions

Wertsch and Toma (1995) identified univocal and dialogical interaction patterns as ways to study the nature of classroom interactions. Brendenfur and Frykholm (2000) further suggested interaction patterns as univocal, contributive, reflective and instructive communications. In univocal interactions, the teacher delivers knowledge to students, and ensures students to receive them. In contributive discussions, students have opportunities to share ideas with each other. In both univocal and contributive conversations, the objectives of discussions are to help students acquire certain predetermined information and knowledge rather than to expand students' understanding based on their own ideas (Lloyd, 2008; Brendenfur & Frykholm, 2000; Wertsch & Toma, 1995). In reflective discussions, students not only explain and share their reasoning processes but also they make adjustments and generate a new understanding of their thinking by building on interactions (Brendenfur & Frykholm, 2000). The purpose of instructive communications is not only to generate new meaning from students' utterances but also to lead led the modifications of later instruction.

From community learning theories, interactions function as "formulating and exchanging ideas" (Bielaczyc & Collins, 1999, p. 276). Dynamics and diversity are driving forces of meaningful interactions. Any small changes in utterances may result in dramatically different outcomes. Teaching is to create learning possibilities through interactions (Davis & Simmt, 2003).

Methodology

This study focuses on classroom organizations, interactions, and social norms. Classroom organizations refer to organizational structures of classrooms and arrangement of instructional activities. Classroom interactions are concerned with the nature of interactions and relationships between the whole classroom and small group discussions. Social norms are manifested through the interplay of classroom discourses and instructional organizations. Qualitative methods were used to identify patterns related to the focuses of classroom practices in the study (Miles & Huberman, 1994). Data collection included multiple resources: classroom observations, interviews, student work, and surveys. The researcher observed 13 lessons in three classes with three teachers for about one week in the school including 12 normal lessons and one exemplary lesson that was given by one of the teachers to the principals of all the middle schools in the district.

Results

Class organizations

Small groups were the basic functional units for in-class and out-class activities in the school. The formations of small groups were relatively balanced with genders, learning abilities, and interests. Members in a small group were accountable for the growth of the whole group. Instructional activities included individual studies, small group discussions (20-25 minutes), small group demonstrations, and whole classroom discussions (20-25 minutes). Individual studies were often done at home before the class meeting.

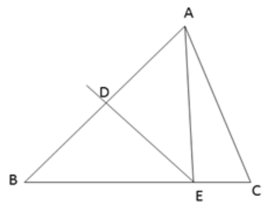
Class norms and learning goals

The classes attempted to develop a common language of articulating thoughts. For example, the teachers often articulated their expectations for classroom activities and discussions. Then, In group presentations, each group would articulate what they aimed to do with problem by explaining what the problem's conditions were and what they needed to do to solve the problem. The class social norms primarily included emphases on sharing, reflections, and learning skills. One of popular socio-mathematical norms was simplicity and efficiency of problem solving. When students presented different approaches to solve a problem, the teachers compared the approaches and highlighted the simplest or the most efficient approach. The small groups had accountability for the learning of the groups. The classes conducted on-going evaluations on small groups. The criteria of evaluations on small groups were flexible and included multiple aspects of classroom and school activities so that each student in the group had a way to contribute to the group.

Interaction patterns and dynamics

The following episode occurred in seven grade class, which illustrates univocal conversation in small groups, where one student told other four members of the group about the solution to the math problem:

Given that DE is the perpendicular bisector of AB. It intersects AB, BC at D and E, if angle B= 40^0 , angle BAC = 70^0, then angle CAE = ?



S1: angle BAC = 70^0, and we know angle B is 40^0; We also know by ASA theorem that triangle BDE is congruent with triangle ADE, so angle DAE is congruent to angle B, is 40^0 . This is 70^0(refers to angle BAC); this is 40^0(refers to angle DAE); so this is 30^0. So, angle CAE = 30^0
Ping: AC=4, and BC=5, (she marked the length of AC and BC on the figure). Since the two parts are congruent, so BE = AE, and this plus this equal to 5. to solve for the perimeter of triangle AEC, which is 5 +4 = 9. Understand?

S2: Why did you solve CAE?
S1: because it is asked.

Seeing some members were confused, the student explained again on how she got he user.

S1: let see, it is given that DE is the perpendicular bisector of AB. That meant AP=BP (she marked them equal on the figure), and congruence. Since congruence, so these two angles are congruent. This is 40^0 (refers to angle B), and this 40^0 too (refers to angle BAE). this plus this is 70^0, 70^0 minus 40^0 is 30^0, so this angle is 30^0, angle CAE equals 30^0

After that, everybody in the group now wrote down 30^0 on their worksheet. In general, the primary patterns of interactions observed in small groups are illustrated in Figure 1– Figure 4. In Figure 1, the advanced student (ST1) played the role of a person who conveyed his/her solution to other students in the group. If a member (e.g. ST4 in Fig. 1) had question to the solution, the advanced student (e.g. ST1) would explain and re-deliver the solution to the group. Sometimes, two or three students in the group developed the solutions and then they explained to the rest of the group (Fig. 2). Figure 3 reflects contributive interaction in which the two students exchanged their thoughts to reach to a consensus on a solution or shared different approaches of solving the problem.

The nature of discussions was primarily univocal and contributive. Students whose mathematics learning abilities were closer in the group tended to show contributive or dialogical interactions. However, dialogical interactions were very few in group interactions. The purpose of small group interactions focused on ensuring the members' understanding of how to solve the given problems and then they were able to present the solving process to the class. In general, small group discussions functioned as a place for a group to reach solutions to the given problems and to ensure each member with an understanding of solutions.

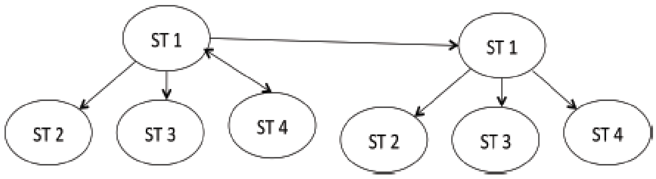


Figure 1

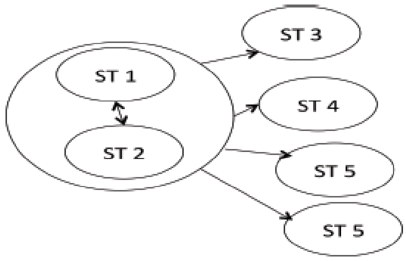


Figure 2

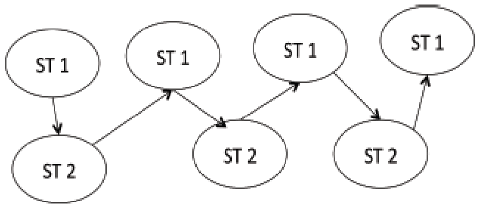


Figure 3

The whole classroom discussions were primarily contributive discussion which consistently revealed the following patters: Students presented and explained their solutions, and the teacher elicited key aspects of solving the problems; students presented and explained their solutions, and the teachers evoked alternatives and compared different approaches; students presented, explained, and reflected on their solving processes, and the teachers extended the understanding of knowledge and strategies. Univocal interactions occurred when the teachers wanted to emphasize the mastery of fundamental mathematical concepts and theorems. Reflective interactions occurred only when unexpected approaches appeared in the whole classroom discussions. Both univocal and reflective interactions were showed fewer times than contributive interactions. There were almost no instructive interactions. The whole classroom discussions appeared as a combination of contributive interactions with some univocal and few reflective interactions. Figure 4 shows the interaction patterns in the exemplary lesson given to the principals from all middle schools in the district, which can be viewed as a typical model of interactions in the whole classroom discussion. Overall, the whole classroom discussions functioned as a place where students demonstrated their gaining and understanding of the predetermined knowledge and skills and a place where the teachers monitored and regulated students' learning processes. Seeking strategies and skills to solve problems prevailed in the whole classroom discourses. It is obvious there were rare explorations and negotiations of mathematical ideas in the whole classroom discussion.

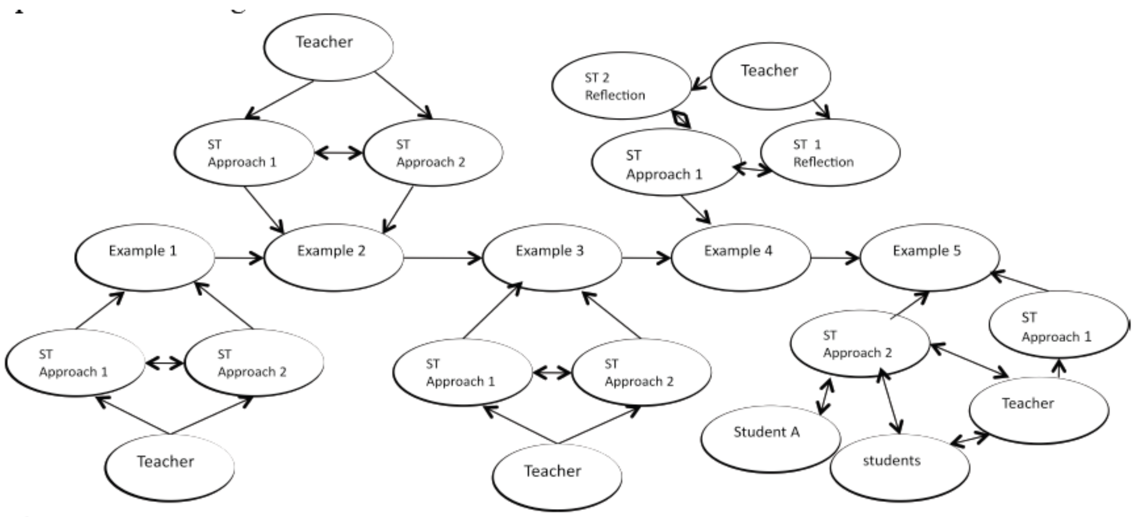


Figure 4

In both small groups and the whole class discussions, there were few occasions in which students had dynamic exchanges of ideas or ideas that were built off one another. Students shared alternatives, however, their struggles or failed attempts in solving a problem were ignored in most of situations.

Relationship between individual learning, small group learning, and the whole class

Discussions

It is evidenced that individual learning, small group discussions and whole classroom discourses enhanced and reinforced each other. In addition, teaching and learning reinforced and enhanced each other. In the presentation, students presented and explained their solutions to the class and reflected the key knowledge and strategies they used in their problem solving in which the students as a group played the role of a teacher to demonstrate and to guide the class learning. The teacher and other students listened to the small group presentation.Simultaneously, the teacher and others further elicited the key points and provided alternatives to extend understanding. The teacher and the class evaluated the small group performance. In both the small group and the whole classroom interactions, students seemed to play the roles of both students and the teacher.

Conclusions

The results of the study indicated a collective learning approach was taken in the classroom reform where students solved the given problems and shared understanding in small groups, and then demonstrated in the whole class. In the whole classroom demonstration and discussions, students in groups articulated their solutions to the problems and understanding of related mathematics knowledge while the teachers played the main role to monitor the problem-solving processes and to highlight difficulties and essential aspects of knowledge, skills, and strategies in lessons. It seemed that the interactions across small groups and the whole classroom, and the playing of teacher-student dual role enhanced and reinforced understanding and knowledge gaining. However, the dominated patterns of in both the small groups and the whole classroom discussions were contributive and univocal interactions. The lack of inquiry and argumentations in the interactions indicated that mathematical learning is primarily focused on the mastery of mathematical knowledge and skills rather than on exploration of mathematical ideas. The class norms emphasized perfectness and effectiveness of solutions rather than possibilities of emerging ideas. These aspects might diminish dynamic interactions and further limited the development of creativity and practical abilities.

Overall, the study revealed that changes occurred and issues of classroom practices accompanied with the reformed approach in the school. On the one hand, this approach promoted mathematical communication, understanding and students' participation in learning, in particular lower level students; on the other hand, the nature of interaction has not changed essentially. The study's findings imply the complexity of changing mathematical classroom practices, which requires a comprehensive consideration of classroom organizations, norms and interactions as a whole.

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