

TRANSFORMING KOREAN ELEMENTARY MATHEMATICS CLASSROOMS TO STUDENT-CENTERED INSTRUCTION

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Educational leaders have sought to change the prevailing teacher-centered pedagogy to a student-centered approach. Despite the widespread awareness of the reform agenda, there is an increasing concern of whether a real instructional change happens in a way to promote students' mathematical development. This paper deals with successes and difficulties a teacher goes through as she moves on to student-centered instruction. The analysis draws on classroom observation and interviews to illustrate how the teacher and students establish social and sociomathematical norms that emphasize mathematical sense-making and justification of ideas. As such, this paper paves a way by which teachers and reformers open toward possibly subtle but crucial issues with regard to implementing reform agenda.

BACKGROUND

The current mathematics education reform requires substantial changes towards student-centered instruction wherein students' contributions and participations, rather than a teacher's explanations and ideas, constitute the focus of classroom practice (NCTM, 2000). The teacher's role in a reform mathematics classroom is to implement new social norms that foster all students' mathematical learning. For instance, the teacher manages classroom discourse in ways that probe various mathematical ideas and deepen students' conceptual understanding.

In contrast to the widespread awareness of the reform agenda and teachers' positive self-evaluation to their teaching practice, there has been a growing concern that many teachers do not quite grasp the vision of the reform (Research Advisory Committee, 1997; Ross, McDougall, & Hogaboam-Gray, 2003). Teachers too easily adopt new teaching strategies such as the use of manipulative materials or cooperative learning. However, this does not guarantee that students are engaging in worthwhile mathematical activities. Teachers then need to re-conceive their new teaching processes with respect to students' learning processes. What kinds of mathematical and social exchanges occur and in what ways such changes promote students' mathematical development?

In recent international comparisons Korean students have consistently demonstrated superior mathematics achievement not only in mathematical skills but also in problem solving (Beaton et al, 1996; Mullis et al, 2000; OECD, 2004). Despite the high performance, a teacher-centered instruction in Korea has been critiqued as a main factor resulting in learning without deep understanding, negative mathematical disposition, lack of creative mathematical thinking, etc. Broad-scale efforts have been launched to influence the ways mathematics is taught.

Korean reform centers around revision of the national mathematics curriculum and concomitant textbooks and teachers' guidebooks (Ministry of Education, 1997). Main characteristics of the recent reform documents include relating mathematical concepts or principles to real-life contexts, encouraging students to participate in concrete mathematical activities, proposing key questions of stimulating mathematical reasoning, emphasizing problem solving processes, and assessing students' performance in a play or game format (Pang, 2004). These characteristics for enriching learning environment are intended to support student-centered teaching methods.

Whereas typical teaching practices in other countries have been extensively studied through microanalysis of video-recordings of mathematics instructions, those of Korean mathematics classrooms have been little studied in the international contexts. An exceptional study conducted by Grow-Maienza, Hahn, and Joo (1999) reports:

Teacher behaviors are dominated by question/answer patterns and demonstration of operations in many modes and patterns which lead students through the procedures and conceptual development of the problem, at the same time facilitating student thinking. Student behavior is characterized by choral responses and choral evaluation of individual responses which keep students on task. (p. 6)

Although focusing on typical classrooms makes a valuable contribution to understanding the dynamics of teaching in Korea, it may not always contribute directly to attempts to implement teaching reform. By looking closely at a reform-oriented classroom, this study attempts to understand better what constitutes the process of implementing reform ideals into actual classroom contexts. The study provides a detailed description to explore how the teacher and students establish a reform-oriented mathematics microculture. Given the challenges of substantial implementation of student-centered instruction, in particular, this study probes successes and obstacles a reform-oriented teacher goes through.

THEORETICAL FRAMEWORK

A general guideline to the understanding of mathematics teaching practices is an "emergent" theoretical framework Cobb and his colleagues developed that fits well with the reform agenda (Cobb & Bauersfeld, 1995). In this perspective, mathematical meanings are neither decided by the teacher in advance, nor discovered by students. Rather, they *emerge* in a continuous process of negotiation through social interaction.

Along with the emergent perspective, two constructs of *social norms* and *sociomathematical norms* are mainly used to characterize each mathematics classroom (Yackel & Cobb, 1996). General social norms are the characteristics that constitute the classroom participation structure. They include expectations, obligations, and roles adapted by classroom participants as well as gross patterns of classroom activity.

Sociomathematical norms are the more fine-grained aspects of these general social norms that relate specifically to mathematical discourse and activity. The differentiation of sociomathematical norms from general social norms is of great significant because interest is given to the ways of explicating and acting in mathematical practices that are embedded in classroom social structure. The examples of sociomathematical norms have included the norms of what count as an acceptable, a justifiable, an easy, a clear, a different, an efficient, an elegant, and a sophisticated explanation (Yackel & Cobb, 1996).

METHOD

The data used in this paper are from a one-year project of understanding the culture of elementary mathematics classrooms in transition. The project is an exploratory, qualitative, comparative case study (Yin, 2002) using *constant comparative analysis* (Glaser & Strauss, 1967) for which the primary data sources are classroom video recordings and transcripts. As a kind of purposeful sampling, the classroom teaching practices of 15 elementary school teachers eager to align their teaching practices to reform were preliminary observed and analyzed. An open-ended interview with each teacher was conducted to investigate his or her beliefs on mathematics and its teaching. This extensive search was needed, given the recency of the reform recommendations, and the infrequently of teachers' explicitly advocating reform allegiances.

Five classes from different schools were selected. Two mathematics lessons per month in each of these classes were videotaped and transcribed. Individual interviews with the teachers were taken three times to trace their construction of teaching approaches. These interviews were audiotaped and transcribed.

Additional data included videotaped inquiry group meetings in which the participant teachers met once per month and discussed mathematics, curriculum, and pedagogy. Through the group meetings, the teachers had lots of opportunities to analyze their own teaching practices as well as others, which might help them develop a keen sense of what student-centered teaching practices look like at each classroom level. The interview and inquiry group data were to understand the successes and difficulties that might occur in the process of changing the culture of primary mathematics classrooms, as well as the recursive relationship among the teachers' learning, beliefs, and classroom teaching.

Classroom data were analyzed individually and then comparatively in terms of general social norms and sociomathematical norms. Interview data were included in the analyses whenever they provided useful background information in relation to classroom teaching practices. Because case study should be based on the understanding of the case itself before addressing an issue or developing a theory (Stake, 1998), teaching practices are very carefully scrutinized in a bottom-up fashion. The central feature of these analyses is to compare and to contrast preliminary inferences with new incidents in subsequent data in order to determine if

the initial conjectures are sustained throughout the data set. The successes and difficulties that occur in the process of making substantial movement toward reform teaching in classrooms were highlighted in order to explore the issues and obstacles that might point to generic problems of reform.

RESULTS

For the purpose of this paper, one reform-oriented classroom is analyzed in order to examine the extent to which the teacher implements mathematics education reform and to explore challenges of transforming traditional teaching practice toward student-centered instruction. The teacher, Ms. Y, was selected for close examination of her teaching practice because she demonstrated gradual but dramatic changes during the project period.

Initial Classroom Participation Characteristics

To be clear, the preliminary observation of Ms. Y's instruction illustrated that her general teaching approaches would be consistent with the current reform ideas, evidenced by general social norms as follows. The teacher and the students established permissive and open atmosphere so that students' engagement and even their mistakes were welcomed. The teacher introduced mathematical contents in relation to real-life situations, and emphasized the process of problem solving. She also supported students' contributions by providing praise and encouragement. Students presented their ideas to the whole class and usually listened carefully to their friends' explanations.

However, Ms. Y was very concerned about going through all the activities and problems in the textbook. At first, she faithfully followed the sequence of activities in the textbook, not necessarily recognizing the interrelations among them. Ms. Y attempted to induce students' participation by asking questions such as "What shall we do to solve this problem?", "Who will explain?", and "Do you all agree?" However, in most cases, students' answers were limited to short or rather fixed responses. In this way, students were engaged in classroom activities but had little opportunity to develop their own thinking.

Change: Eliciting Students' Ideas

A noticeable change in Ms. Y's teaching practice occurred after she had an opportunity to see other teachers' instruction in the inquiry group meeting. In particular, Ms. Y was influenced by another teacher who was teaching the same grade. Ms. Y could see more directly how a teacher's different approach even with the same mathematical contents and materials would result in different learning environment on the part of students' mathematical development. In an interview, Ms. Y expressed her excitement about the variety and the depth of students' mathematical ideas, and was eager to change her teaching methods:

I was very impressed by the fact that students could approach a given problem in many ways, something interesting and creative, depending on how a teacher consistently

pursued to do so. As comparing my teaching practice with others, I realized how much my teaching approach and personality traits influence students' learning and engagement as well as classroom atmosphere. ... I also would like to establish a classroom culture in which my students think and discuss actively for themselves.

Instead of relying heavily on the textbook, Ms. Y started to develop a worksheet intended for students to explore important mathematical ideas for themselves. Students were expected to solve a given problem in various methods and to explain their ideas irrespective of the correctness of the answers. Ms. Y also formulated the structure of her lesson as follows: Brief review of the previous lesson or related mathematical topics, her introduction of mathematical contents, students' activities with a worksheet, and whole-class discussion building on students' ideas. In this way, Ms. Y allowed students more time to develop their own sense-making and to explain their thinking to the class.

The following episode shows how Ms. Y orchestrated classroom discourse in a way to elicit students' various ideas. Students in pairs were involved in an activity of choosing 3 number cards, making the biggest and the smallest number, and then figuring out the difference between the two numbers. In the whole class discussion, Ms. Y encouraged students to analyze the results of subtraction.

- Teacher: What do you see? Look at your worksheet and discover something interesting.
- Sohee: Whenever you take three numbers there are two regroupings.
- Teacher: Right! There are always two regroupings. Is there anything else? Why don't you look at the numbers?
- Sohee: As I made the biggest and the smallest number, the number in the middle was always the same.
- Teacher: Yes, it is the same. That's right. Anything else?
- Sohee: When I see hundreds place and ones place, for example, if I had 641 and 146, the 6 and the 1 are the same except their places.
- Teacher: Yes, only the places are switched and the middle number is the same. What happens to the middle number after you subtract?
- Giwon: It always turns out 9 no matter how I subtract.
- Teacher: That's right! The middle number is always 9. Is it really true? Do you have 9 all the time? (Students check their worksheet and agree.) Why do you have 9 in the middle? Because of what?
- Students: Regrouping.

According to the teacher's lesson plan, Ms. Y expected students to discover the fact that the tens place in difference between the biggest and the smallest number is always 9. Students were able to discover the fact and, more importantly, to figure out why. Thanks to the teacher's consistent attempt to soliciting students' ideas, they had

an opportunity to analyze mathematical ideas, merely beyond practicing a standard algorithm of subtraction with regrouping.

Change: Focusing on Mathematically Significant Ideas

Another important change in Ms. Y's teaching practice is related to sociomathematical norms. As noted above, Ms. Y indeed asked for different solution methods to a given problem or activity. She then frequently facilitated students to compare and contrast similarities and differences among the various methods. Meanwhile she differentiated mathematical differences from physical or visual differences.

The following episode is an example illustrating how the participants established a norm of mathematical difference. Students were studying the relationship between a part and the whole in the unit of fraction. A rectangle consisting of 3 cells in each of two rows was drawn on a worksheet and students were supposed to color 4 out of the 6 cells. Ms. Y asked students to present their methods in front. Jihoon first showed his method in which he colored 4 cells making a figure of 2x2 square.

- Teacher: Is there someone who colored differently?
- Sohee: (volunteers and shows her method in which she colored the 3 cells in the first row and then 1 more cell in the second.)
- Teacher: What do you see? Jihoon and Sohee colored differently. Who is wrong? (Students express their disagreement in a loud voice.) Who can explain?
- Juhyun: The 4 [cells] is the same both in the square figure and in the Giyeok [A Korean alphabet similar to Sohee's figure].
- Seungjun: Their shapes are different but we can say that they are the same, because it [the given rectangle] is divided by the same 4 cells.
- Teacher: That's right! Because the number of colored cells is the same, we can say that there are the same.
- Seonghyun: Although the colored figures are different, the numbers are the same.
- Teacher: Yes, that's right. (She shows her drawing in which the first and the third column were colored.) Look at mine! For fun I colored one cell, skipped the next cell, and then colored next cell again. What do you think of this?
- Students: (agree that the three figures – Jihoon's, Sohee's, and the teacher's – are the same.)

In the episode, the teacher asked students to compare Jihoon's method with Sohee's. On the one hand, their methods were different (i.e., which cells were colored?). On the other hand, their methods were the same (i.e., how many cells were colored?). Building on this idea, students learned that the fraction $\frac{4}{6}$ is the same regardless of the different shapes. In this way, students were able to contrast difference of mathematical ideas or principles applied to solve a problem with difference of physical materials or representation used.

Difficulties in the Change

Despite the promising transition toward successful student-centered teaching practices, Ms. Y experienced some difficulties when students reacted anxiously to the uncertainty associated with the given activity or they did not come up with a specific idea that she thought was important. In those cases, Ms. Y provided a crucial hint that might change the nature of the given task or introduced her own solution strategies, instead of letting students invent them.

Ms. Y was also frequently struggled with how to balance the encouragement of students' conceptual development and the teaching of efficient procedures such as a standard algorithm. After listening to students' various solution methods, she often ended her lessons by summarizing or formulating the most efficient one and implied the students to use it in solving problems for practice. To be clear, students need to compare and contrast different solution methods, for example, in terms of mathematical efficiency. However, this often happened by the teacher's summary at the end of the lesson. In this way, students might think that there was "one" efficient method in solving a problem and their main activity was to find out the method the teacher ultimately waited for.

In addition, Ms. Y was not sure of how to react to students' novel ideas except praise. Although she listened carefully to students' mathematical ideas, Ms. Y had a difficulty in posing questions that further challenge and extend students' thinking after eliciting it. She usually turned out to follow the sequence of the activities prepared in advance rather than students' emergent ideas.

DISCUSSION

Implementing student-centered teaching practices is fundamentally about significant change, and the teacher remains the key to change. The extent to which substantial change occurs depends a great deal on how the teacher comes to make sense of reform and respond to it. As moving on to student-centered instruction, Ms. Y elicited students' participation and ideas in many ways and then attempted to orchestrate the path of discourse towards conceptual understanding, leading students to be continually exposed to mathematically significant distinctions. In line with many commonalities in the challenges of reforming mathematics classroom culture, this study addresses the need for a clear distinction between attending to the social practices of the classroom and attending to students' mathematical development within those social practices.

On the one hand, Ms. Y was successful in focusing on mathematically significant ideas, in particular, with regard to a norm of mathematical difference. On the other hand, she was limited to be sensitive to students' engagement in order to develop increasingly sophisticated ways of mathematical knowing, communicating, and valuing. The difficulties that Ms. Y had in the process of transforming her teaching practice channel our attention toward the degree by which students' ideas become the center of mathematical discussion and activity.

Another issue to be discussed is a role of a collaborative community where groups of teachers are committed to raise questions on their current instruction, search for alternatives, try on new approaches, and weigh their methods against others' pedagogical alternatives for the common purpose of improving their teaching practices. In fact, many recent studies of teachers' attempts toward reformed mathematics teaching suggest the importance of an inquiry community that provides shared goals and collaboration (Fennema & Nelson, 1997). The message is that participants need to establish new norms for discourse concerning their instructional changes, obstacles and dilemmas of change, as well as the more general nature of mathematics teaching and learning.

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