Learning to Teach Mathematics Differently: Reflection Matters[1]

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The nature of mathematics teaching, influenced by constructivist and social theories, is better understood as the result of investigations of accomplished teachers, but questions still remain as to how teachers' learn this complex form of teaching. This research reports an investigation of the interplay between beginning elementary teachers' reflective thinking and changes made in their mathematics teaching. The findings reveal teachers who change in teaching progressively increase in depth of reflection on their teaching and in appropriately interpreting their students' intentions and mathematical thinking. Reflections of teachers with little change in mathematics teaching consist of descriptions, evaluations, and rationalizations of events; moreover, they are unable to view circumstances from the students' perspective.

It is widely accepted that changes in perspectives on students' learning and the development of knowledge in mathematics reflect trends in cognition and the nature of knowledge influenced by post-modern philosophies. Together these trends have significantly changed the view of mathematics teaching to a more complex pedagogy that represents a major shift from the long-standing emphasis on single computational procedures (MSEB, 1989). Although, the nature of teaching, influenced by constructivist and social theories, is better understood as the result of investigations of accomplished teachers (e.g., Jaworski, 1994; Schoenfeld, 1998; Wood, Nelson & Warfield, in press), questions still remain about how teachers' learn this complex form of teaching.

A significant body of research exists which indicates teachers have learned as evidenced by changes in their practice, beliefs and knowledge. But the question still remains, how do we know if teachers *are* learning? To answer this question it is necessary to investigate the *process of reflection* which is thought to be central in teachers' learning (Schön, 1987). The purpose of this research is to examine how teachers used both their reflective thinking as a process in pedagogical reasoning and their classroom practice to transform their mathematics teaching in ways advocated (e.g., National Council of Teachers of Mathematics [NCTM], 1989, 2000).

OVERVIEW

Several studies have shown that teachers develop the pedagogy necessary to create reform-oriented mathematics classes as they reflect on events that occur in their classrooms (Fennema, et al., 1994; Cobb, Wood, & Yackel, 1990; Simon & Schifter, 1991). Fundamental to the thinking about teacher learning is the

contention that "attempts to influence teachers knowledge and beliefs will not be at their most effective unless they draw on teachers' first-hand experiences of interacting with their students during mathematics instruction" (Cobb, Wood, & Yackel, 1990, pp. 141-142). Although these studies identify changes in teaching and teachers' beliefs, other studies have shown that while some teachers develop complex forms of teaching, others make little change (e.g., Vacc & Bright, 1998). Furthermore, among teachers who make changes, some teachers continue to develop in their teaching while others do not (Franke, et al., 1998). This raises questions about the commonly accepted notion that elementary classrooms are a source of opportunities for teachers' learning.

Along with classrooms as sites for teachers' learning, reflection is thought to be an essential process in teachers' learning and central in their capacity for pedagogical reasoning (Shulman, 1987). Subsequently, reflective thinking is viewed as central to much of the thinking in mathematics education about teacher learning. Studies, such as that of Mewborn (1999), have investigated what teachers' found problematic in classroom situations as a means to examine their reflective thinking. In her study, Mewborn found that teachers' reflective thought followed Dewey's (1933) five phases; moreover, to be a reflective thinker required teachers to hold relativistic beliefs. Although this research contributes to an understanding *about* the reflective thinking of teachers, it is still not well understood how teachers use reflective thinking to make sense of their work and how reflection influences the changes they make in their teaching.

Thus, the purpose of this research is to investigate how teachers use reflective thinking in their pedagogical reasoning and how their thinking relates to changes in teaching. It is contended that substantial change in teaching occurs as teachers reflect on their lessons, examining how classroom events that occurred compare with their intentions, and making alterations based on their reflections. In this study, the process of reflection was examined by investigating what teachers' notice when observing their classrooms, the interpretation they make of events, and the changes they propose in their practice. These findings about the process of reflection were then compared with analysis of the teachers' videotaped classrooms with regard to their development of socially interactive learning environments and the mathematics that occurred during the lessons.

THEORETICAL ORIENTATION

Cognitive and social context theoretical perspectives guide the research on the processes of teachers' learning. Both of these perspectives hold the view that the human mind is generative, creative, proactive, and reflective and that humans interpret and give meaning to events and things in their lives. Social environment provides opportunities for learning and differences in social context are thought to affect the nature of what is learned. Therefore, the social context teachers create for student learning affects their own opportunities for learning within the classroom. Thus, from a social interactive perspective the teachers' creation of classroom social structures important to students' participation in the discourse of inquiry is of central interest.

From a cognitive perspective the construct *reflection* drawn from the work of Dewey (1933) is used to describe the process by which teachers give meaning to their own and students actions and is used to examine teachers' learning. Reflection, in this study, is defined as the distancing of one's self from the object of reflection. Borrowing from Dewey's (1933) notion of that reflective thinking; consists of "a state of doubt, hesitation of perplexity in which thinking originates," and "an act of searching, hunting or inquiring to find material that will resolve the doubt" and "dispose of the perplexity" (p.14). The early work of Shulman (1987) on pedagogical reasoning and the recent research of Mewborn (1999) on the characteristics of reflection are used to further delineate the process of teacher reflection. Using both cognitive and social interactive perspectives allow for an explanation of teachers' learning that considers the interplay between teachers' reflection as a central process in pedagogical reasoning and their the development of classroom learning environments.

The characteristics of teaching follow conceptualizations of Jaworski (1994) that describes a teaching triad that consists of three dimensions, management of learning, sensitivity to students, and mathematical challenge. In addition, the interactive dimensions of participation and questioning from Wood (Wood & Turner-Vorbeck, in press) further characterize teaching.

DATA SOURCE, METHODOLOGY AND ANALYSIS

Approach to Teacher Development

The study reported in this paper is part of a larger 2-year research and development project in which the research goal was to investigate how elementary teachers' develop their classroom teaching in accordance with reform schemes.[2] The development aspect of the project consisted of creating an approach to inservice teacher education for elementary teachers that utilized three central themes that incorporated tenets of constructivism, social constructivism and sociology. Taken together, these themes reflected a stance toward working with teachers that placed importance on individual development of teaching in conjunction with the formation of public or common knowledge of teaching through the generation of a community of professional practitioners. In order to promote teachers' learning and yet attempt to develop an approach to development that would be less labor intensive for teacher educators, certain aspects of technology were used as support (cf. Wood, 1999 for further detail about the approach).

For the purpose of promoting teacher personal reflection, a component was created in the professional development approach that required teachers' to reflect on their teaching activity in conjunction with their students' mathematical thinking during mathematics lessons. Teachers made video recordings of their lessons and then later used these videotapes to examine the events that occurred during their lessons. However, in order to engage in investigation of their instruction, teachers

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[2] The project is "Recreating Teaching Mathematics in the Elementary School" funded by the National Science Foundation.

needed support in developing their skills in making observations and reflecting on videotaped classroom events. As a means of support, a 3-step procedure was created, following Jaworski (1988), for responding to the tapes by writing in "reflective journals." These steps were to: write their expectations for the lesson prior to teaching; make detailed records of the discourse during class discussion; and, compare and contrast the records of the events described with their expectations. Following this, they were to write a "plan of action" to carry out in the classroom based on the results of their reflections.

Teachers and Data Source

Seven beginning (2 years of previous teaching experience) elementary teachers participated in the 2-year research and development project that involved an intensive investigation of their learning to teach. The seven teachers taught in the same school district in first through fifth grades (6-11 year-olds).

The reflective journals and the class videotapes served as the primary data sources for the research on individual teacher reflection and learning to teach. Each teacher made written comments following the format described above for the purpose of recording their reflections before, during, and after watching their classroom videotapes. Secondary data sources were each teacher's written journal responses to specific questions asked by researchers during the group working sessions and e-mail exchanges between the teachers and research team.

The primary source of data for analysis of classroom teaching consisted of videotape recordings of mathematics lessons recorded by each teacher twice per month. Each lesson videotaped was viewed and logged by the research staff as a detailed record to be used in the analysis.[3]

Methodology and Analysis

The methodology and analysis followed a qualitative research paradigm and procedures similar to those of Glaser and Strauss (1969) and Strauss & Corbin (1990) in which categories were developed from the data, examined for confirming and disconfirming evidence and revised. The specific methodology and analysis for examining reflection and classroom practice are described next.

Processes of Reflection

For the teachers' journal entries a written running record of each entry was compiled by one member of the research team of each teacher's: a) expectations, b) description of events, and c) reflections on the lesson. The three entries were analyzed and refined, analyzed again, and a running record for each teacher written by the same member of the research team. The teachers' responses were categorized as description, reflection or rationalization. The section of the journal that consisted of reflections on the lessons was additionally categorized in terms of depth of reflection. These categories revealed not only the nature of what aspects of students' thinking teachers' reflected on but also the quality of their reflection. The categories for quality of reflection consisted of *thought on action, thought on thought,* to *thought on thoughts of children*. The teacher journal responses to

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[3] Research team members were Luiza de Souza, Caroline Van Tuinen, Michael Palm, Janet Warfield, and myself.

researcher-asked questions and the content of the e-mail messages provided supporting evidence for the running records. Each member of the research team individually analyzed each teacher's written journal entries and then met to discuss their analyses with the other members of the research group. Differences in interpretations were discussed and resolved by looking within the data for confirming or disconfirming evidence.

Classroom Practice

The classroom videotapes and logs were used to investigate each teacher's practice. The videotape logs for each of the classroom lessons were coded by the research team following an extension of the coding scheme developed and used in previous studies of teaching (Wood & Turner-Vorbeck, in press). The research team individually coded each lesson log for one teacher at a time and then met to discuss their analysis. Differences in interpretation were discussed and resolved by looking within the logs for confirming or disconfirming evidence. Certain videotaped lessons collected at the beginning and end of each year served as baseline data. The baseline videotapes were used to gauge changes in teaching over the duration of the project. Following a discussion of the coding of the baseline tapes, each member wrote a summary for each teacher of the interaction patterns, discourse, teacher questions and mathematical topics discussed.

Integration of Teacher Reflection and Classroom Practice

The remaining coded logs, along with the baseline lessons, were matched with journal entries in order to integrate teacher reflections on their classroom practice with video recordings of the lesson. The analysis of the data consisted of comparing and contrasting journal entries of teacher reflection with the log of the lesson being reflected up on. In addition, subsequent lessons were analyzed in order to match instances of teacher insight from reflection and proposed plans for change with video recorded observations of teaching.

RESULTS AND DISCUSSION

Teacher Reflection

The findings from the analysis of the data on teacher thinking and instances of reflection revealed differences among the teachers in terms of the content and depth of their reflection on children's mathematical thinking in the context of their class. Additionally, teachers differed in the intensity or quality of their reflection. That is, from the beginning one group of teachers on reflection saw aspects of their classroom interaction as problematic and gave thought to how their role as teacher influenced the situation (e.g., *"I need to listen more & not lead children to what I want to hear. I need to just let them explain their thinking."*) Later, these same teachers' reflections became 'thoughts about their thoughts' (e.g., *" . . .solve the problem by subtracting at the very beginning so I knew she knew how to solve the problem."*) And still later, these teachers' thoughts were about what children's thinking or intentions might be in the situation (e.g., *"The other children were busy coloring to find the answer I felt that they thought they were going to find the answer quickly (or faster) than it took them!"*) Over the 2-year period, these

teachers appeared to deepen in their understanding of children's mathematical thinking and their view of the problem, solution, or both.

Another group of teachers' responses consisted of summaries of events (e.g., *"all students were on task"*) or evaluations of students' behavior (e.g., *"the students are all doing a much better job of sharing responsibilities."*) When these teachers' did reflect, these primarily consisted of rationalizations (e.g., *"I feel we never have a good discussion when the camera is rolling"* and *"I feel the problem lies before in earlier grades, parental involvement, and many students just being lazy."* Moreover, they often attributed to children's action reasons that were inherent in the child (e.g., *"I had a hard time with the lower math students. They failed to build on other, earlier problems."*) Thus, they seemed not to think about how their children might be thinking about or making sense of a problem or solution; they were seemingly unable to view the situation from the child's perspective. Additionally, they seldom considered how their role, as teacher, might influence the situation.

Classroom Practice

Analysis of the teachers' classroom practice also revealed differences in the growth of their teaching. The analysis of the first baseline classroom videotape revealed that all of the teachers initially taught mathematics conventionally. That is, the focus was on computational procedures, interaction and discourse that consisted of the typical IER pattern described by Mehan (1979) and others. The teachers who substantively changed in their teaching created classroom environments similar to those advocated by reform in mathematics education (NCTM, 1989; 2000). These classes involved teachers and children in discussion that was characterized as *inquiry and argument* (c.f., Wood & Turner-Vorbeck, in press). The teachers that made little change in their teaching continued their conventional interaction characterized by teachers' 'test questions', students' answers, followed by teacher evaluation.

SUMMARY AND IMPLICATIONS

Taken together, the findings revealed two distinct groups of teachers existed that differed in the nature of their reflection and in their development of the pedagogical skills necessary to create interactive learning environment and the mathematics advocated in the reform agenda. Teachers who made changes in their mathematics classrooms progressively increased in the depth of their reflection. They also differed in their interpretation of their students' intentions and thinking— what Jaworski (1994) refers to as "student sensitivity." Conversely, the reflections of teachers who made little change in their teaching consisted of quite different content. Their responses consisted of descriptions, evaluations, and rationalizations of the events that occurred and they were seemingly unable to view the situation from the child's perspective.

Reflection has long been considered as an essential process in teachers' learning and central in their capacity for pedagogical reasoning, both of which are necessary if teachers are to develop and continue to generate more sophisticated forms of pedagogy. These findings provide further insights into how teachers' do or

do not learn to teach differently and the role of reflection in the process that are important for mathematics teacher education.

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