ORCHESTRATING MATHEMATICAL DISCUSSIONS IN THE MIDDLE SCHOOL MATHEMATICS CLASSROOM

by

ROBYN LYNN BRYANT OVRICK

(Under the Direction of Denise S. Mewborn)

ABSTRACT

This qualitative research study was designed to answer the question “How do middle school mathematics teachers orchestrate a classroom environment that fosters mathematical discourse among students from low socio-economic backgrounds and with limited experiences?” I chose two participants from different school systems with a student body largely from low socio-economic status because I wanted to learn how one helps such a group of students engage in mathematical discourse. Gayle taught in a Title I school where 88% of the students were considered economically disadvantaged. Jessica taught in a school where 43% of the students were economically disadvantaged.

A triangulation of methods was used to gather data for my research, including interviews, observations, and archival data. I observed Gayle and Jessica every day of the first week of school, and then four and three more times, respectively, over the next 12 weeks. Each lesson was audio-taped and transcribed. Transcriptions were coded according to themes from the literature – classroom management, math talk moves (Chapin, et. al., 2003), and Hufferd-Ackles
et al. levels of questions (2004), and relationships. All questions were also coded in light of the revised Bloom’s Taxonomy of educational objectives (Krathwohl, 2002).

From the data, I formulated three conclusions regarding the orchestration of mathematical discussions in the middle school classroom. There is no one way to initiate mathematical dialogue, but the implementation of math talk moves (Chapin, et. al., 2003) transcends the personalities of the teachers, the environment of the schools, or the level of student poverty. The second conclusion regards the connection between small and large group discussions. Students are more likely to talk about the mathematics in the small group without a lot of prompting when they know that they must present to the whole class about their findings. The final conclusion is that the teacher’s relationship with high poverty students is essential. When the teacher knows her students, she is more able to vary her levels of questioning appropriately, whether to sustain student engagement or to push the student to the next level.

INDEX WORDS: mathematics, discourse, math talk, middle school, poverty, relationships, questioning
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DEDICATION

I lovingly dedicate this work to my niece and nephew, Macey (7) and Bryson (6), who have prayed daily, “God, please help Robyn write her paper so she can come visit us more often.” I’m coming to visit!
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CHAPTER 1
BACKGROUND

In 1989 the National Council of Teachers of Mathematics [NCTM] published the *Curriculum and Evaluation Standards for School Mathematics*. Mathematics as communication was a standard included in all grade bands. “Emphasizing communication [oral and written] in a mathematics class helps shift the classroom from an environment in which students are totally dependent on the teacher to one in which students assume more responsibility for validating their own thinking” (NCTM, 1989, p. 79). By the time of the publication of *Principles and Standards for School Mathematics* (NCTM, 2000), communication had been moved to a process standard – a process through which students should learn the mathematics.

In my work as a mathematics specialist for a Regional Educational Service Agency [RESA], I have observed that many middle school mathematics classrooms still model the traditional format of the teacher giving notes on the board (or Smart Board) while students copy the notes and examples. This is then followed by students practicing more of the same types of problems while the teacher walks around the room and helps those having difficulty with the new concept being taught. I do not believe that all classroom teachers start out choosing to teach in this format. Instead, I believe that many have an idea of what they would like for their classrooms to look like; they just do not know how to make it happen.

I chose to focus my research on the oral format of mathematical communication because mathematical discussions excite me as a teacher. Unfortunately, I experienced this exchange of ideas as a teacher only a couple of times a year and almost always as a surprise. Suddenly, my
students would break out in a discussion about the topic or activity for the day. I would get so excited that I would try to get a discussion going the next day, but it would not happen.

After attending graduate school, I made a more directed effort to orchestrate mathematical dialogue in my classroom by choosing activities that I thought would open the door to discussions. However, I experienced great frustrations because my students would complain about the task, talk off-task, or refuse to work with others. I began searching for a classroom that I could observe where discourse was happening regularly. By talking to other teachers in my schools, I discovered that teachers trying to implement mathematical discussions in their classrooms were experiencing the same frustrations.

In my next job as a professional developer, my goal is to help teachers change their practices in a way that impacts student understanding as well as test scores. Because there is sufficient research describing the benefits of mathematical discourse among students (e.g. Chapin, O’Connor, & Anderson, 2003; Elliott & Kenney, 1996; Hiebert et al., 1997), I challenged myself to find out how a teacher can orchestrate mathematical discussions in her classroom. I began by reading teacher resource books on writing and talking in the mathematics classroom. Marilyn Burns, a well-known and respected mathematics educator, addressed mathematical communication in several of her books. In *Writing in Math Class* (1995b), Burns gave numerous writing activities, samples of student work, and suggestions for implementing writing in the classroom. In another book she provided several problem solving situations that encourage mathematical thinking and discussions (Burns, 1995a). In a more current book, Burns and Silbey (2000) answered specific questions from teachers about leading class discussions. She told readers that students must feel safe in the classroom environment to express and explore their mathematical ideas. She also suggested that teachers purposefully teach the rules of
discussion. Burns also provided several prompting questions or statements that encourage students to talk about their mathematical thinking. I continued to read books and articles on mathematical discussions and discovered that there is further research describing the characteristics of a classroom environment that supports mathematical discourse (Burns & Silbey, 2000; Chapin et al., 2003; Elliott & Kenney, 1996; Hufferd-Ackles, Fuson, & Sherin, 2004).

In reviewing the research involving discourse in the classroom, I found that there appears to be a gap in describing how it happens. I still did not know how a teacher takes a group of students that is not interested in mathematics, school, or each other and turns that group into students who talk with each other about the mathematical tasks and their mathematical thinking. It cannot be magic. So my research question was: How do middle school mathematics teachers orchestrate a classroom environment that fosters mathematical discourse among students from low socio-economic backgrounds and with limited experiences?
CHAPTER 2
LITERATURE REVIEW

Mathematical Discourse

Mathematical discussions encourage students to reflect on their own thinking about the mathematics and as a result learn to be clear and convincing (Chapin et al., 2003; Hiebert et al., 1997; Pugalee, 2001). “Students who are involved in discussion in which they justify solutions will gain better mathematical understanding as they work to convince their peers about differing points of view” (NCTM, 2000, p. 60). “Understanding is developed through the construction of relationships, by extending and applying mathematical knowledge, by reflecting about experiences, by articulating what one knows, and by making mathematical knowledge pertinent to oneself”(Sutton & Krueger, 2002, p. 15). Professional Standards for Teaching Mathematics (NCTM, 1991) define the teacher’s role in classroom discourse:

The teacher of mathematics should orchestrate discourse by –

• posing questions and tasks that elicit, engage, and challenge each student’s thinking;
• listening carefully to students’ ideas;
• asking students to clarify and justify their ideas orally and in writing;
• deciding what to pursue in depth from among the ideas that students bring up during a discussion;
• deciding when and how to attach mathematical notation and language to students’ ideas;
• deciding when to provide information, when to clarify an issue, when to model, 
  when to lead, and when to let a student struggle with a difficulty;
• monitoring students’ participation in discussions and deciding when and how to 
  encourage each student to participate. (p. 35)

Classrooms that Promote Understanding

Hiebert et al. (1997) stated that “we understand something if we see how it is related or 
connected to other things we know” (p. 4). They identified reflection and communication as the 
two most important components in making connections. “Reflection occurs when you 
consciously think about your experiences” (Hiebert et al., 1997, p. 5). One reflects by 
consciously looking at things again and thinking about what you are doing and why you are 
doing them. It is a way of internally communicating with oneself. “Communication involves 
talking, listening, writing, demonstrating, watching, and so on. It means participating in social 
interaction; sharing thoughts with others; and listening to others share their ideas” (Hiebert et al., 
1997, p. 5). When communication takes place in the classroom, students are more likely to think 
about their own methods, as well as other methods, by listening to other students share their 
methods. Communication and reflection work together to produce new connections.

Hiebert et al. (1997) defined classroom instruction as “a system…of many individual 
elements that work together to create an environment for learning. None of these dimensions, by 
itself, is responsible for creating a learning environment that facilitates students’ constructions of 
understandings” (p. 7). Although classrooms that promote understanding may appear to be 
different, Hiebert et al. recognized and described five common critical components. These 
components are task (which will be discussed later in this chapter), classroom social culture, 
teacher role, mathematical tools as learning supports, and equity and accessibility.
Teacher role. An important role of the teacher is to select appropriate tasks with goals in mind, as well as the sequence of these tasks (Hiebert, et al., 1997; Pelilino, 2007; Stein, Smith, Henningsen, & Silver, 2000). Hiebert et al. (1997) cautioned teachers to select the sequence of tasks with the goal of overall residue in mind and not to fall into the trap of selecting tasks based on the goal of covering the material. To select appropriate tasks and sequences, the teacher must know each of her students well, as well as the mathematics that should be learned.

Creating a classroom in which all students can reflect on and communicate about the mathematics is another important role of the teacher (Hiebert et al., 1997). Obviously, the appropriate selection of tasks provides students with such an opportunity. An additional way that a teacher works to create this type of environment is through focusing on solution methods rather than answers. “The methods used by different individuals should be open for examination and discussion, and the goal of all participants should be to search for better methods” (p. 39). It is the teacher’s responsibility to make sure that the discussions go in this direction. Focusing on methods also removes the teacher’s need to verify if an answer is correct or incorrect. Students learn to make judgments of correctness based on the logic of the methods and argument, rather than to depend on the teacher. “Everyone will agree on the right answer to a problem, if they understand the problem and think about it long enough” (p. 40).

The teacher must also decide how to handle the tension between allowing the students to problem solve on their own and providing support when students are lost or heading in the wrong direction.

[Teachers] need to respect students as intellectual participants. On the other hand, if left on their own, [some] students can spend a great deal of time floundering and making little
progress. More than that, if teachers do not intervene at all, students are likely to miss a
good deal of mathematics. (Hiebert et al., 1997, p. 30)

It is possible for teachers to help students so much that the difficulty level of the task becomes
watered down and the students simply end up doing the steps told by the teacher, therefore
minimizing their opportunity for learning. However, it is also possible for teachers to intervene
in a way that promotes students’ responsibility for learning and that pushes students’ thinking.
“Information can and should be shared as long as it does not solve the problem; does not take
away the need for students to reflect on the situation; and develop solution methods that they
understand” (Hiebert et al., 1997, p. 36). One way that teachers can help is by suggesting
different strategies, being careful not to attach correctness to any one method (Hiebert et al.,
1997; NCTM, 1991). They can also “suggest recording techniques that would be easier for
everyone to understand. This is part of helping students communicate their methods to others”
(Hiebert et al., 1997, p. 37-38). Many students find it difficult to put their thinking into words
(Hiebert et al., 1997; Pelilino, 2007). The better the teacher knows her students, the better
equipped she is in guiding their communication.

*Classroom social culture.* A community of learners makes up a classroom. “Communities
are defined, in part, by how people relate to and interact with each other” (Hiebert et al., 1997, p.
9). Hiebert et al. identified four features of a classroom social culture that promote mathematical
discussions and personal reflections. One important thing is that all students should feel
comfortable to share their ideas knowing their ideas will be appreciated. It is the responsibility of
the teacher to help students realize they must not only understand their own methods but should
respect and understand the methods used by others. A third core feature is that mistakes are to be
appreciated and looked upon as an opportunity to “examine errors in reasoning” and, therefore,
to learn from them (p. 9). Finally, the correctness of an answer should depend on whether or not the argument or method makes mathematical sense. “Debates about correctness may take time and require further examination and investigation….Experiencing this kind of uncertainty and even learning to enjoy it is an essential part of thoughtful problem solving” (p. 49). Students must become confident in themselves and in others as capable sense-makers.

In order for this type of classroom to take root, certain expectations and norms regarding interactions must be established. Participation should not be optional. “Doing mathematics as part of a group means seeing yourself as a participant of a community. Communities share certain goals and certain ways of working together toward the goals” (Hiebert et al., 1997, p. 43).

There are many benefits to a classroom culture in which students interact with one another regarding the mathematics. “Doing mathematics involves collaboration” (Hiebert et al., 1997, p. 43). When a group is working together, they must communicate. They must decide on methods to use, agree on the terms that they are using, and establish the most efficient way to determine the solution to the problem.

Communication makes information and solution methods available…When students work together to search for better methods, they each share their own methods and listen to those of others….through discussing the methods and comparing the advantages of each, students can lift themselves out of their rut and see the problem in a new way.” (Hiebert et al., 1997, p. 44)

By working together, tasks that may have been out of reach for some students become attainable. “Students can share information and pool expertise, and thereby help each other work through new problems and develop new methods of solution. Students can…construct understanding
working collaboratively that they would not be able to accomplish working alone” (Hiebert et al., 1997, p. 45).

**Equity and accessibility.** “Every student has the right to understand what they do in mathematics. Every student has the right to reflect on, and communicate about, mathematics. Understanding is not just the privilege of the high-achieving group” (Hiebert et al., 1997, p. 11).

It is vital that all students participate in presenting and explaining their thinking to others, as well as listen to the explanations of others. Hiebert et al. reminded their readers that explaining one’s thinking does not always come naturally. It should be the responsibility of the teacher to help all students, including bi-lingual students, learn how to express their ideas and reflect on their thinking.

When sensitive teachers ask probing questions that help a child to express his or her thinking, or when children are given the opportunity to hear other children and to practice the skill of reporting their thinking, they become more willing and even eager to make sure that everyone understands how they have handled the task. (Hiebert et al., 1997, p. 71)

The type of tasks plays an important role in equity. The task must “allow and encourage each student to problematize…invite each student to use knowledge he or she already possesses…and it has to leave something behind of mathematical value” (Hiebert et al., 1997, p. 69). For some children the tasks have been made so easy that they are no longer a problem, or so difficult that it is impossible for students to access. The teacher should not treat each student exactly the same. She may need to provide different support and help for different students. As a result, it is necessary for the teacher to know each student well, “understand the mathematics that should be learned, select tasks that enables each student to engage in problematic mathematics, and
orchestrate the complex world of the classroom so that children reflect about their thinking and participate in mathematical discussions” (p. 72).

Math Talk Community

Hufferd-Ackles et al. (2004) described a math talk community as a “classroom community in which the teacher and students use discourse to support the mathematical learning of all participants” (p. 82). One of the primary goals of this type of classroom is for all participants to understand and extend each others’ thinking. Their article focused on a case study of a third grade teacher of urban Latino students, who began the school year by teaching in a traditional manner, but over the course of the year experienced success at implementing reform, primarily in the area of classroom discourse. This success was important because “[m]any educational reforms bypass classrooms with children from poor or non-English speaking backgrounds partly because such children are assumed not to be linguistically prepared to participate in reform-based practices” (p. 82). The researchers videotaped lessons, took field notes, and conducted interviews. When coding the data, they looked for themes. “Three themes and the relationships among them soon emerged as central, and these became the focus of data analysis: evidence of mathematics community, teacher actions, and student actions” (p. 87). From these themes they identified four components that “captured the growth of the math-talk community over time” (p. 87). The four components were questioning, explaining mathematical thinking, source of mathematical ideas, and responsibility for learning. After compiling data from numerous observations, they characterized levels 0-3 for each component, which included teacher actions and student actions in each category. Hufferd-Ackles et al. described each component in light of the case study mentioned above.
*Questioning.* The questioner in the classroom was the focus of this component. At a Level 0, the teacher was the only questioner. She primarily asked students for answers to questions, rarely following those answers with questions regarding the methods or strategies used to obtain them. As a shift in the math-talk community took place, the focus of questions also shifted. The teacher began to ask more questions concerning the methods and strategies that the students used. Hufferd-Ackles et al. (2004) commented that the teacher shifted rather quickly from a Level 0 to a Level 1, due primarily to the curriculum, *Children’s Math Worlds* [CMW], that she used in the classroom. CMW prompted the teachers frequently to ask questions like why and how.

The teacher had primary control concerning the shift between Level 0 and Level 1 in questioning. However, the shift from Level 1 to Level 2 differed. This shift occurred because the teacher was no longer the only questioner; the students began to ask questions as well. The teacher encouraged this shift by asking the students who were not presenting to think of a question that they could ask the presenters when they were finished. The students asked questions similar to the ones the teacher had been asking in class about methods and strategies. Not only did the students begin to ask questions, but they also began to listen to others’ questions and responses. “One lower-achieving student often demonstrated active listening as he announced, ‘Someone already asked that.’” (Hufferd-Ackles et al., 2004, p. 94). As the classroom shifted to a Level 3 math-talk community the students began to initiate questions. “None of the interactions occurred between only two people” (p. 96). Hufferd-Ackles et al. provided examples of the teacher’s simply letting the students lead the direction of the class by their questions and discussions; yet, she stepped in periodically to help clear up misconceptions or “to manage time by overseeing turn taking” (p. 96).
Explaining mathematical thinking. This component of the math-talk community is focused on the “process of explaining” (Hufferd-Ackles et al., 2004, p. 96). As the students became more comfortable explaining their thinking in the class, the community shifted through the levels. At the Level 0, students simply answered questions with short one or two word answers. At times the teacher even gave responses herself and did not wait on the students to answer. The shift from Level 0 to level 1 was a painful one for the students. “[T]hey were uncomfortable responding to several consecutive questions while standing in front of the room” (p. 99).

“The Level 2 explanation of mathematical thinking began after students became more comfortable with the process of communicating about such thinking” (Hufferd-Ackles et al., 2004, p. 99). Although the teacher still had to ask probing questions at times, the social culture of the classroom also began to change. The students began to support one another as they explained their reasoning; as a result, the students became more confident and less shy. At the third level, students began to defend their answers and methods “more confidently and thoroughly,” even without the prompting of the teacher (p. 101).

Source of mathematical ideas. Level 0 in this component represented a traditional classroom where the teacher told the students how to solve a problem. The case study teacher would have her students copy the word problem, word for word, and then work it out in their notebook by themselves. At times she would work an example out on the board showing them how to solve it and then tell them to solve several just like it. The shift from Level 0 to Level 1 took place when the teacher began to ask the students for ideas on how to solve the problems. “Eliciting students’ ideas allowed her to uncover their previous knowledge and current misconceptions…It also allowed her to modify the course of lessons according to the evolving
ideas of the students” (Hufferd-Ackles et al., 2004, p. 102). The teacher even became comfortable in soliciting additional responses from students after a correct answer had been given.

At a Level 2, the main source of mathematical ideas was no longer solely the teacher. The teacher became more comfortable using incorrect solutions as additional opportunities for learning and would lead class discussions and “allow the students to uncover the error” (p. 105). The shift to Level 3 depended on two things. The students had to be more comfortable in sharing their ideas and more confident in the fact that their ideas were important and worth sharing. And the teacher had to come to this point of belief as well.

*Responsibility for learning.* The shift from one level to the next in this component had the tendency to take place concurrently with the shifts within the other components. At a Level 0, the teacher would repeat the responses other students would give. This action encouraged students to listen to the teacher only. As the teacher began to change her actions, she started asking the students to repeat what another student had said. This shift to Level 1 eventually caused problems for class discussions because the teacher spent so much time having students repeat verbatim what another had said that not much learning was taking place.

The teacher helped shift the level of responsibility from a 1 to a 2 when she began asking students to describe what someone else had just said in their own words. Students were still required to listen to what others were saying, but at this level they had to understand what the other person said. At a Level 2, the teacher also asked students to add to what someone else had said. She asked students to describe the differences between their methods and someone else’s. The shift to Level 3 “occurred as students took the initiative to clarify other students’ work and ideas for themselves and for others during whole-class discussion and small-group interactions”
Hufferd-Ackles et al. (2004, p. 108) reported that the case study class moved rather quickly to a Level 1, primarily because of the curriculum being used by the school. The class spent “approximately 8 weeks at Level 1 before moving to Level 2” (p. 110). According to the authors, this shift is the most difficult because the lesson shifts from teacher-centered to student-centered. The class functioned at a level 2 for approximately 3 months before moving primarily to a Level 3. However, when new concepts were introduced, the class tended to fluctuate between levels. The teacher noted that when the class went back to be more teacher-centered, she was more apt to lose students’ attention.

Math Talk Moves

Chapin et al. (2003) implemented Project Challenge for four years. The goals of the project “were to identify English-language learners (ELL), minority students, and economically disadvantaged elementary and middle school students who had potential talent in mathematics and to provide them with a reform-based mathematics curriculum that focused on mathematical reasoning and communication” (Chapin et al., 2003, p. ix). They first tested over 300 students, hoping to find 100 with mathematical talents to include in the study. “Less than a dozen stood out as obviously talented in mathematics” (p. x). They assumed that there were students that had hidden potential, so they used test scores, past performances, and teacher recommendations to help them select 100 students that were representative of the demographics of students in the district. These students were divided among four teachers who implemented a reform-based curriculum. Investigations in Number, Data, and Space was used in the fourth and fifth grades, while Connected Mathematics [CMP] was used in grades five through seven. During the first
year of the study most students were reluctant to speak out in class; however, as time went by, they became more comfortable talking in class. Even teachers of other subjects commented on how these students had a “striking ability to verbalize their thoughts and explanations” (Chapin et al., 2003, p. xi). The standardized test scores of these students improved tremendously from year to year, moving from the 74th percentile to the 91st percentile. Chapin et al. (2003) attributed these results to the hard work of the teachers and students, the tasks provided by the curriculum, and the “productive use of classroom discourse” (p. xii).

Chapin et al. (2003) described five productive math talk moves that teachers can use in the classroom to help students learn mathematics. Teachers are encouraged to listen to what the students say during mathematical discussions (Hiebert et al., 1997; NCTM, 1991, 2000). Sometimes students are unclear about what they are trying to say. Revoicing is a talk move that teachers can use when a student’s explanation is unclear. The teacher restates what she understood the student to have said. She then validates for the student that what he/she had to say is important by asking the student to verify if her revoicing was correct. Revoicing can also serve the purpose of making “one student’s idea available to others, give them a time to hear it again” (Chapin et al., 2003, p. 13). A second talk move that encourages students to listen to one another is restating someone else’s reasoning. The teacher asks a student to repeat in his or her own words what another student has just said. An additional talk move that requires students to listen to others is “asking students to apply their own reasoning to someone else’s reasoning. Do you agree or disagree and why?” (p. 14). In addition to asking for agreement, the fourth talk move includes the teacher prompting students to add to what another student has just said. Over time, students become more willing to comment on what the group is discussing without prompting from the teacher. Finally, the fifth talk move is silence. Teachers are encouraged to use at least
10 seconds wait time for students to think before calling on a student for response. Once a student has been called on, wait time should again be given.

Chapin et al. (2003) suggested that if a teacher wanted to orchestrate mathematical discussions in her classroom, that she should first try two moves – revoicing and wait time. These are two talk moves that are used by the teacher. They recommended that the teacher be deliberate in practicing these moves; they even advised that the teacher actually time herself. “Twenty seconds is a good place to start. Then make your students see that you are willing to wait” (p. 111). They cautioned that it may take waiting many different times for the students to believe they are actually supposed to think about the problem. After the wait time the teacher is then supposed to call on a student. To avoid embarrassment Chapin et al. (2003) suggested that the teacher encourage the student by stating that the problem is a very complicated one; “it may take a long time to put something into words. That’s OK. In this class we’ll always wait for you to put your thinking into words” (p. 111-112).

Once the teacher has practiced with her two talk moves, Chapin et al. (2003) stated that she should establish the norms of a “talk-centered” community (p. 112). Then she is to introduce the students to the three talk moves requiring them to take part in the discussion. She will request that they restate what someone else has said in their own words. They will be asked to agree or disagree with what someone else has said. They will also be required to provide a reason for their thinking. Once the new moves have been introduced, the teacher is then encouraged to practice the moves in a whole group discussion. One way to set up the discussion is to present a problem that can be solved in more than one way or one that can have multiple solutions. During the discussion the teacher will need to ask for many contributions. She will need to make sure that she keeps the discourse momentum slow and asks for students to restate what others have said.
“It doesn’t happen overnight. So you must persist and be flexible” (p. 120). The discussions should focus on understanding, not on correcting. Chapin et al. (2003) even provided suggestions for what to do when a group of students finish working on a problem before everyone else: Ask the students to try to solve the problem in a different way. If two groups are finished, have them share with one another their methods or strategies. Chapin et al. (2003) recommended that a teacher evaluate her progress as facilitator by keeping track of the moves used during a lesson. Did she try to include everyone in the conversation? Did the discussion remain focused on the mathematics? Were the students respectful of everyone’s contribution? Chapin et al. (2003) concluded by encouraging teachers to try one new thing at a time.

Mathematical Tasks

In this dissertation, I refer to a task as the problem or collection of questions that the students are asked to complete. There are many opinions regarding how a task should look. According to Professional Standards for Teaching Mathematics (NCTM, 1991), it is the teacher’s responsibility to pose worthwhile mathematical tasks. These worthwhile tasks should be based on significant mathematics and the interests of the students (NCTM, 1991; Pelilino, 2007). Tasks should be engaging, call for connections, and promote communication (Hiebert et al., 1997; NCTM, 1991; Sutton & Krueger, 2002). Many of these tasks can be solved in more than one way and possibly have more than one correct solution (NCTM, 1991).

There are three important features of appropriate tasks. Tasks must be interesting to the students so that they will want to solve the problem. Secondly, students must be able to connect their current knowledge and skills to the problem. Through problem solving, new understandings and relationships are developed, and as a result, connections are made more naturally and will more likely remain (Hiebert et al., 1997). Tasks “must engage students in thinking about
important mathematics” so they can “reflect on and communicate about the mathematics” (p. 8). Finally, tasks should also leave behind important residue, such as new understanding of the mathematics as well as learned methods or strategies for solving problems (Hiebert et al., 1997).

**Bloom’s Taxonomy**

Bloom’s Taxonomy was developed as a need among “faculty at various universities” (Krathwohl, 2002, p. 212). The faculty wanted to create a test item bank of various levels of questions that would be accessible to use in creating final examinations for college courses. However, they wanted a common agreement regarding the level of cognitive demand that the question required. A task force was created to analyze these test items and to develop a common analysis tool (Krathwohl, 2002). After seven years of development, the task force presented Taxonomy of Educational Objectives (Forehand, n.d.; Krathwohl, 2002). Bloom was the educator that wanted to attach the term Taxonomy; and although the other team members disagreed, they acquiesced, and the Taxonomy then became referred to as Bloom’s Taxonomy (Forehand, n.d.).

The Taxonomy consisted of a “cumulative hierarchy” of objectives (Krathwohl, 2002, p. 212). This term meant that in order for someone to be able to complete a problem that required understanding, he must first remember things (Forehand, n.d.). The original Taxonomy was one dimensional and the levels were described by using nouns – knowledge, comprehension, application, analysis, synthesis, and evaluation (Krathwohl, 2002). Krathwohl, an original team member, noted that each of the six levels, except for application, was divided into smaller subgroups. As previously mentioned, the original Taxonomy was designed for only a small audience (Forehand, n.d.; Krathwohl, 2002). Because taxonomy was an uncommon term in education during the 1950’s and 1960’s, “potential users did not understand what it meant,
therefore, little attention was given to the original Taxonomy at first” (Krathwohl, 2002, p. 213). However, it has now been translated into 22 different languages (Forehand, n.d.; Krathwohl, 2002).

During the 1990’s one of Bloom’s students saw a need to update the Taxonomy to be more applicable for its use in education (Forehand, n.d.). With Krathwohl’s assistance (Forehand, n.d.) they worked for six years to create a revision of Bloom’s Taxonomy, referred to as the Revised Taxonomy (Forehand, n.d.; Krathwohl, 2002). The Revised Taxonomy is two dimensional. They took the large list of subcategories under the original Knowledge category and created a dimension (the y-axis on the table) to represent the subject matter content – Factual Knowledge, Conceptual Knowledge, Procedural Knowledge, and Metacognitive Knowledge (Forehand, n.d.; Krathwohl, 2002). The second dimension (the x-axis on the table) of the Revised Taxonomy described “what is to be done with or to that content” (Krathwohl, 2002, p. 213). This dimension includes the six levels of the original Taxonomy. The names of each level were changed from nouns to verbs – Remember, Understand, Apply, Analyze, Evaluate, and Create. Although evaluation used to be last in Bloom’s Taxonomy, it was switched with creativity (Forehand, n.d.; Krathwohl, 2002).

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Figure 1. The Cognitive Process Dimension
Now task objectives can be placed into any cell(s) within the 2-dimensional table. The table can be used “to classify objectives, activities, and assessments” (Krathwohl, 2002, p. 218). Doing so “provides a clear, concise, visual representation of a particular course or unit. Once completed, the entries in the Taxonomy Table can be used to examine relative emphasis, curriculum alignment, and missed educational opportunities” (p. 218).

**Connected Mathematics**

Although this dissertation is not a research study of the second edition of the *Connected Mathematics Project* curriculum [CMP II], both participants taught in school systems that had adopted CMP II for middle school mathematics. As a result I provide some information about the curriculum here. CMP II authors looked at research from cognitive sciences, mathematics education, and educational policy and organization and then worked together to develop a middle school curriculum that focused on student conceptual understanding of mathematics (CMP, 2007a). The overall goal for CMP was to help teachers and students “develop mathematical knowledge, understanding, and skill, as well as an awareness and appreciation of the rich connections among mathematical strands between mathematics and other discipline” (CMP, 2006, p. 4). Although the authors had a commitment to skill, their primary belief was that “all students should be able to reason and communicate proficiently in mathematics” (CMP, 2006, p.4). The development process took years of pilot lessons, student and teacher input, reviews, and revisions.

The result was a curriculum in which mathematical ideas are embedded in interesting problems and build logically on one another. Unlike many traditional textbooks where the units are based on isolated topics, CMP problems are connected to previously learned mathematical topics. “Rather than seeing mathematics as a series of unrelated experiences, students learn to
recognize how ideas are connected and develop a disposition to look for connections in the mathematics they study” (CMP, 2006, p. 4). The program is designed so that students must work together to investigate situations and then summarize those findings with others in the class. The problems encourage classroom discourse, a variety of solutions and/or solution strategies, and higher-order thinking (CMP, 2007b). Ten years of data show that “CMP students do as well as, or better than, non-CMP students on tests of basic skills…and outperform non-CMP students on tests of problem solving ability, conceptual understanding, and proportional reasoning” (CMP, 2006, p. 6).

Classroom Behavior Management

Classroom management, while not overtly mathematical in nature, is critical to having a successful classroom in which dialogue can occur. Numerous researchers have recorded suggestions for classroom teachers regarding behavior management (Alderman, n.d.; Barbetta, Norona, & Bicard, 2005; Brady, Forton, Porter, & Wood, 2003; Canter & Canter, 2001; Marzano, 2003; Pitonyak, 2004; Wood, 1998). However, Bucher and Manning (2001) have summarized the work of five theorists “who laid the groundwork for contemporary classroom management” (p. 84).

Bucher and Manning (2001) first described B.F. Skinner’s introduction of behavior modification “as a way to shape behavior” (p. 84). Next, they looked at Redl and Wattenberg’s group dynamics theories, followed by William Glasser’s choice theory. Finally, they concluded with Thomas Gordon’s theory of “Discipline as Self-Control” (p. 84).

Behavior Modification

As a psychologist, Skinner did not specifically address the ideas of classroom behavior management. Through his research on operant conditioning, however, he concluded that
immediate and proper feedback “strengthens the likelihood that appropriate behavior will be repeated” (Bucher & Manning, 2001, p. 85). This theory has been adapted by some behavior specialists who encourage rewarding students for positive behaviors. Students will repeat behaviors that reap rewards and stop behaviors that do not. Yet in order to be effective the “reinforcement should be appropriate and immediate” (p. 85).

As a result of Skinner’s influence, teachers are encouraged to ignore inappropriate behaviors of a child and instead praise students around him for appropriate behaviors. When the child realizes that he will not receive any attention for his inappropriate behavior, he will likely stop. When the desired behavior happens, the teacher is encouraged to praise him immediately for his considerate behavior (Bucher & Manning, 2001). Another recommendation for teachers is to use only positive comments, even when correcting a child. Behavior contracts are also suggested for students who regularly behave inappropriately. The student can earn points through appropriate behavior and redeem the points for something desirable (Bucher & Manning, 2001).

*Group Dynamics*

The theories of Redl and Wattenberg “encompass group dynamics, self-control, the pleasure-pain principle, and understanding reality” (Bucher & Manning, 2001, p. 85). Their theories have relevance to middle schools today because group dynamics focus on the idea of peer pressure. Students will repeat the behaviors of others in the classroom whether they are appropriate or not. Redl and Wattenberg also suggested that “much misbehavior results from a temporary lapse of an individual’s control system, rather than from a desire to be disagreeable” (Bucher & Manning, 2001, p. 86). As a result a teacher can help a student regain that control, usually through simple measures like eye contact or close proximity.
Redl and Wattenberg also supported the use of positive reinforcement; however, unlike Skinner, they coupled that with negative reinforcement as well. “An unpleasant experience will lead to avoidance of the unwanted behavior” (Bucher & Manning, 2001, p. 86). In addition, Redl and Wattenberg’s theories suggested that teachers “encourage students to appraise or understand reality” (Bucher & Manning, 2001, p. 86). Students should understand the connection between their actions and the consequences, not just the consequences that they experience personally, but consequences on the whole class.

Choice Theory

Choice theory was coined by William Glasser and has been relevant to the classroom teacher (Bucher & Manning, 2001). He believed “that students think rationally, yet still rely on teachers to make and enforce rules” (Bucher & Manning, 2001, p. 87). In contrast to Skinner and Redl and Wattenberg, Glasser opposed the use of rewards and punishments. Although he believed that one can control his own behavior, Glasser stated that there are “four basic psychological needs [that] drive students: the need to belong, the need for power, the need for freedom, and the need for fun” (Bucher & Manning, 2001, p. 87). If any of these needs are not met, then it is probable that the child will misbehave.

It is the teacher’s responsibility to create an environment in which everyone belongs and enjoys. They must “teach and manage in a way that adds quality to students’ lives” (Bucher & Manning, 2001, p. 87). The teacher must know her students and recognize when a psychological need is not being met. A student must be given the opportunity to choose his behavior freely, and he should not choose based on the resulting reward or consequence. However, according to Glasser, if the teacher strives to meet the four basic psychological needs of the student, then it is likely that she will have fewer behavior problems to manage (Bucher & Manning, 2001).
Thomas Gordon stated that teachers must insist that their students exhibit self-discipline. He also claimed that rewards and punishments were ineffective. One has no control over anyone’s behavior except his own. Consequently, Gordon said that a teacher should not become upset by a student’s behavior. She “should send the message that daydreaming is unacceptable, the problem is the student’s and, ultimately, he or she will have to accept the responsibility for changing the behavior” (Bucher & Manning, 2001, p. 88). However, teachers should listen to their students to determine what may be the cause for inappropriate behavior. Once the teacher has identified the cause of the behavior, she can help the student accept responsibility for his problem and then choose a solution (Bucher & Manning, 2001). As the teacher learns more about her students, she can “tailor curricular and instructional decision towards individual students without sacrificing academic rigor, achievement, productivity, or creativity” (p. 88).

Gordon believed that students should be taught self-discipline. He pointed out that discipline could be used as a noun or as a verb. As a noun, discipline had a more positive connotation than as a verb. The noun discipline “suggests order, organization, knowledge of and compliance with rule and procedures, and consideration of others’ rights; as a verb it suggests control and punishment” (Bucher & Manning, 2001, p. 89). He argued that the verb form of discipline leads to aggression and that we should use non-controlling methods to change a child’s behavior. The teacher should use “I-messages” when pointing out inappropriate behavior. “I am frustrated when students are picked on in my class.” “I am annoyed when students are tapping their pencils on the desks.” These messages convey to the student how the teacher feels about the student’s behavior rather than focusing “the message only at the student” (Bucher & Manning, 2001, p. 88).
Effective Classroom Management Components

Bucher and Manning (2001) suggested that most teachers try a combination of suggestions from each of these theorists. Unless a school adopts a particular classroom management model for everyone, each teacher can choose what will work with her students and her personality. Canter and Canter (2001) agreed with Glasser and Gordon when they stated that “good curriculum and motivating instructional techniques will help students stay on task” (p. 6). There are four primary components to effective classroom management: the mental set of the teacher; rules and procedures; disciplinary interventions when problems occur; and relationships between teacher and students (Alderman, n.d.; Marzano, 2003; Pitonyak, 2004).

The mental set of the teacher refers to the teacher’s “with-it-ness” and emotional objectivity (Marzano, 2003). A teacher is “with it” and emotionally objective when she can quickly identify a problem and act on it immediately without becoming upset because a classroom rule has been violated (Marzano, 2003; Pitonyak, 2003). Barbetta et al. (2005) noted that many mistakes teachers make when dealing with behavior can be avoided by determining the cause of the behavior. If the purpose is to gain attention, then remove the attention. However, if the cause is to cover up a deficit in learning, address the learning gap with additional assistance or by changing the instruction.

Wood (1998) described social norms as “an interlocking system of obligations and expectations, established by both the teacher and the students and underlying the manner in which members of the classroom interact, and forms the smooth functioning of the class” (p. 175). He also suggested that there are implicit aspects of these norms that are less obvious but are a part of the everyday expectations. The explicit aspects are more obvious and are usually called rules or procedures. Although some people use rule and procedure interchangeably,
Marzano (2003) defined a rule as “general expectations or standards, [whereas] a procedure communicates expectations for specific behaviors” (p. 89).

Brady et al. (2003) stated that teachers and students should work together to create classroom rules. These rules should be framed in the positive and condensed into 3-5 overall classroom rules. Marzano (2003) added that procedures should then be taught explicitly and practiced for specific routines, e.g. beginning, work period, and ending of the class, classroom discussions, transitions, use of materials, and turning in work. I have chosen not to make a distinction between rules, norms, and procedures so the terms are used interchangeably in this dissertation in accordance with the language used by each participant.

The third component discussed by Marzano (2003) is that of disciplinary interventions. A list of interventions that he summarized includes nonverbal disapproval, token economies, isolation time-out, overcorrection, differential reinforcement, group contingency techniques, interdependent group contingency, dependent group contingency, and stimulus cueing. This collection is similar to the recommendations mentioned by Bucher and Manning (2001) when they summarized the four theorist groups. It is important to look at the behaviors rather than the student, as the problem. If a teacher is having repeated problems with the same behavior, then she is advised to back up and review the rules and procedures (Pitonyak, 2003).

Canter and Canter (2001) suggested that a teacher can motivate students to behave by offering praise to those that are behaving appropriately. “Focus[ing] on the negative…creates a negative environment in the classroom. It sends the message to students that the teacher is looking for misbehavior, is expecting misbehavior, and is ready and waiting to pounce on students who don’t follow directions” (Canter & Canter, 2001, p. 116). Offering praise to individual students who are following directions, by explicitly stating what they are doing
correctly, gives other students additional time to hear and follow the instructions (Canter & Canter, 2001). This suggestion coincides with what Pelilino (2007) had to say about positive strategies when she noted that “emotionally damaged students cannot effectively deal with criticism and channel it to improvement” (Pelilino, 2007, p. 4).

**At-Risk Students and Children of Poverty**

Pelilino (2007) defined the term at-risk children as “children who are likely to fail in school or in life because of their life’s social circumstances…Poverty is considered a major at-risk factor” (p. 1). Ruby Payne (1996) described some of the characteristics of poverty. She admitted that most of her data came from life experiences. Her husband grew up in situational poverty because his father died when he was six. Yet he lived in a community filled with generational poverty. She grew up in a middle class environment, and for six years as adults, she and her husband lived in an affluent neighborhood. It was there that she saw the big picture, the lines drawn between the classes.

Businesses and schools “operate from middle-class norms and use the hidden rules of middle class” (Payne, 1996, p. 11) Therefore, children from poverty must be taught those norms and hidden rules. Payne described two types of discourse patterns. Formal-register gets straight to the point; however, casual-register *chases a rabbit* to get to the point (Payne, 1996). People from poverty tend to use casual-register discourse methods. Payne cautioned that sometimes when a teacher gets straight to the point, a person from poverty might see that as being rude. A child of poverty may have difficulty writing and speaking in class because he must go round and round to get to the point. Casual-register discourse tends to be “more entertaining, more participatory and exhibits a richness of character, humor and feeling” (p. 49). In contrast, formal-register discourse has “sequence, order, cause and effect, and a conclusion: all skills necessary
for problem-solving” (p. 49). She recommended that teachers request that students first write in casual-register and then help them translate into formal-register. She also suggested that teachers use graphic organizers to show patterns of discourse as well as directly teaching formal-register patterns. She also proposed using a behavior plan that requires students to “learn how to express their displeasure in formal register and therefore not be reprimanded” (p. 49).

There are hidden rules that exist among the classes. Teachers tend to bring to the classroom hidden rules from the middle class, while children of poverty bring with them different hidden rules. “An understanding of the culture and values of poverty will lessen the anger and frustration that educators may periodically feel when dealing with these students and parents” (Payne, 1996, p. 62). A few that are related to this dissertation will be summarized.

People are considered possessions to people from poverty, while things are possessions to people from middle class. To people from poverty, a personality is to be used for entertainment and a sense of humor is highly valued. However, to people from middle class, a personality “is for acquisition and stability. Achievement is highly valued” (p. 59). Education is valued, yet it is abstract and not a reality for people from poverty, while education is vital for making money for people from the middle class. People from poverty believe in fate and that they cannot change chance. People from the middle class believe that they can change the future by making wise choices. The driving force for people from middle class is achievement and work, while the driving force for people from poverty is survival, entertainment, and relationships. “Two things that help one move out of poverty are education and relationships” (p. 11)

Relationships

A positive student-teacher relationship is the fourth component of effective classroom management. In addition to classroom management, “meaningful student-teacher relationships
have a positive impact on students’ learning and their participation in science and mathematics classes” (Brand, Glasson, & Green, 2006, p. 231). “If a teacher has a good relationship with students, then students accept her rules, procedures, and disciplinary actions” (Marzano, 2003, p. 91). Marzano (2003) summarized the Classroom Strategy Study conducted by Jere Brophy, where he studied 98 teachers and the way they handled certain situations. He concluded that effective classroom managers do not treat all students the same, rather, they “tend to employ different types of strategies with different types of students” (Marzano, 2003, p. 93), which requires a teacher to have a relationship with each student in order to determine what strategy will work best with each student.

Parsley and Corcoran (2003) concluded that a positive student-teacher relationship is one of the most important factors in reaching the at-risk student. They summarized four actions that are essential for a positive relationship to be developed. The students must feel that the teacher trusts them. One way that she can show this is through assigning responsibilities. Additional actions include getting to know the students and letting them know that she cares about them as individuals. The teacher must also “communicate to students that he or she is willing to help them learn by creating a supportive learning environment in which students are not afraid to take risks...and in which students feel that they belong” (p. 86).

Positive student-teacher relationship is not just important for students from poverty. Midgley, Feldlaufer, and Eccles (1989) studied 1,301 students for two years. The students were from 12 school districts that were located in middle-income communities in Michigan. Almost 90% of the population was white. The researchers interviewed these students during their final year of elementary school and then again during their first year of junior high school. The questions were designed to uncover the students’ perceptions regarding quality of student-
teacher relationships as well as their perceptions of the usefulness of mathematics. They considered “student perceptions of teacher support to be a strong indicator of the subjective quality of the student-teacher relationship” (p. 982). They concluded from their study that student motivation and their perception of the value of mathematics increased as students moved from less supportive teachers to more supportive teachers. The converse also happened. Students who moved from supportive teachers to less supportive teachers expressed a decline in their perception of the usefulness of mathematics. The impact of teacher support proved to have a greater impact on low-achieving students. Midgley et al. (1989) concluded that “more attention should be paid to providing an environment in which teacher support of [all] students can flourish” (p. 989).
I decided to engage in qualitative inquiry to answer my research question because of the nature of my question. Denzin and Lincoln (2005) described qualitative research as a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them. (p. 3)

Glesne (1999) summarized some of the differences between qualitative and quantitative research with respect to four aspects of research – the assumptions, the research purposes, the research approach, and the researcher role. In a quantitative study the “variables can be identified and relationships measured,” while in a qualitative study the “variables are complex, interwoven, and difficult to measure” (p. 6). The purpose of a quantitative study is to generalize and predict; however, the purpose of a qualitative study is to understand and interpret. A quantitative study begins with a hypothesis, is experimental and deductive, “reduces data to numerical indices,” and “uses abstract language in the write-up” (p. 6). On the other hand, a qualitative study may result in a hypothesis, is naturalistic and inductive, “makes minor use of numerical indices,” and uses descriptive language in the write-up (p. 6). Finally, the researcher’s role in a quantitative study is
one of “detachment [and] objective portrayal;” however, in a qualitative study, the role of researcher is one of “personal involvement [and empathetic] understanding” (p. 6). Given that my research goal was to understand how middle school teachers orchestrate mathematical discourse in their classrooms, qualitative methods were better suited to my study.

Although I believe there are variables that play a role in the mathematical discourse that takes place in a classroom, there are many unseen variables as well, and these variables are not easily quantified. I was seeking to understand and interpret how different teachers orchestrate discussion. Using a triangulation of data collection methods, I conducted participant interviews, classroom observations, and document analysis (Denzin & Lincoln, 2005; Glesne, 1999; Patton, 2002). I observed three participants multiple times and interviewed each teacher once. As data were collected, I coded and analyzed the data to look for common steps or actions that the teachers took in order to create a classroom environment that fosters mathematical discourse. I also gathered the tasks that the students were expected to complete and conducted an analysis of the cognitive demand they required.

**Participant Selection**

In selecting my participants I used a combination of purposeful and convenience sampling. I used the following criteria when choosing my participants:

- Middle school mathematics teacher
- A reputation for using mathematical discourse in her classroom
- Working in a school with at least 50% of the student population identified as economically disadvantaged

I solicited names of potential participants from a professor, two co-workers, and three curriculum directors. Two of the curriculum directors passed my request on to their principals as well. I
received names of only ten teachers who had a reputation for fostering mathematical discourse. Two of the recommended teachers were elementary school teachers, and I decided not to consider them because they have their students all day long and I assume that discourse takes place, in part, because of classroom norms, which elementary teachers establish during times other than math class. As a result, collecting data on the ways that elementary school teachers foster discourse would have required me to be present in their classrooms all day long, which was not practical. Two middle school teachers who were recommended had taken positions as coaches in their systems and did not teach a class on a regular basis. One teacher taught in an affluent middle school, and I was more interested in difficult to manage students that are stereotypically found in schools with a higher percentage of economically disadvantaged students. Another teacher taught in a school that was located over an hour away and thus made it impractical to collect data from that teacher.

I conducted observations of the remaining four middle school teachers within an hour’s driving distance in spring 2007 to determine potential participants. Although some mathematical dialogue was present in all four teachers’ classrooms, one teacher had limited behavior control and only a few students were talking about the math, while the rest of the students were throwing things from center to center or talking off task for the entire period. This teacher seemed very comfortable with that arrangement, but I knew that was not the type of environment in which I wanted to observe. Of the three remaining teachers, I immediately knew that I wanted to study Gayle because her students were demographically similar to the students that I had taught in the past, and I was impressed with the mathematical talk that was going on between group members as well as during classroom presentations. When I observed Stephanie, she was reviewing for the state algebra exam, and her students were very involved in a class discussion that lasted for the
entire period. Jessica was another teacher who had noteworthy mathematical dialogue going on in her classroom. The only negative aspect of including her was that she was not from a school with at least 50% economically disadvantaged students. However, convenience of teacher schedules and availability were the final factors in choosing the three participants – Gayle, Stephanie and Jessica.

Although three teachers were chosen to participate, observations of Stephanie did not contribute anything to my research. Her practice did not match her reputation or what she said in her interview. As a result of a new state curriculum that was implemented during the year of my study, Stephanie was not teaching algebra, which was the subject in which she had such a strong reputation for fostering discourse. Stephanie indicated that she missed teaching algebra (and specifically the type of students who were taking algebra in middle school). This fact, coupled with implementing new state standards and a new textbook, may have had an effect on how Stephanie conducted her classes the year of my study that was inconsistent with what I had observed previously. I interviewed Stephanie, coded and analyzed her interview data, and conducted seven observations of her. However, when I began to code and analyze my observations of her instruction, I found that very little mathematical dialogue was taking place in her class. Thus, I chose not to include any of Stephanie’s data in my results.

Data Collection

During the summer of 2007, I interviewed each teacher once in a one-hour audio-taped session (Appendix A). The purpose of this interview was to learn what goals these teachers held for their students, how they structured their instruction to meet those goals, and what specific methods and procedures they used to foster productive classroom discourse about mathematics.
The beginning of the school year is the most critical time for setting up classroom norms and expectations, so I observed the entire first week of school for each participant. I observed the only class that Gayle taught; however, I chose to observe two of Jessica’s classes to see if the data were different between her two classes. Each lesson was audio-taped so that I would have exact language to refer to when reporting my data. Each teacher wore a microphone attached to a micro cassette recorder. While I observed, I took field notes of things that would not be obvious in the audiotape (e.g., how long the teacher worked with one group, facial expressions, student body language, what was on the board, responses from students, etc.). Because of the difficulty of obtaining parent permission prior to school starting, I did not video tape in classrooms at any time.

For the remainder of the school year, I observed and audio-taped Gayle four more times and Jessica three more times over a course of three months to continue watching the development of classroom discourse. While I was observing, the tape recorder failed to record once for each teacher. The teachers audio-taped all lessons, regardless of my presence. They were asked to let me know which of these lessons might contain rich data for my dissertation so that I could pull those tapes and listen to them. However, even with reminders from me, the teachers did not identify particular sessions of interest, so I collected all audio-taped lessons. Teachers were also asked to keep a weekly reflection log (Appendix B). The goal of this log was for me to have a window into how the classroom community was developing across the school year. I was interested in the teachers’ successes and struggles and in the instructional actions that they took as a result of these successes and struggles. Unfortunately, the teachers did not record the logs on a regular basis.
Data Analysis and Representations

Interview Codes

I began my analysis by looking at the three interviews. First, I transcribed each one myself and then used a process of open coding (Patton, 2002) where I coded each interview line by line. After coding each interview, I organized my thoughts on a large piece of chart paper. The chart paper was divided into 17 sections with an emerging code being a title for each section. Table 1 includes the list of codes that emerged from the interviews.

Table 1

Interview Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>TE</td>
<td>Teacher Expectations</td>
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<tr>
<td>TG</td>
<td>Teacher Goals</td>
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<tr>
<td>TB</td>
<td>Teacher Beliefs</td>
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<td>TM</td>
<td>Teacher Moves</td>
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<td>BK</td>
<td>Background</td>
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<td>P</td>
<td>Personality</td>
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<td>PL</td>
<td>Professional Learning</td>
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<td>CM</td>
<td>Critical Moments</td>
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<tr>
<td>TK</td>
<td>Task</td>
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<td>D</td>
<td>Discourse</td>
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<tr>
<td>TS</td>
<td>Teacher Struggle</td>
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<tr>
<td>CP</td>
<td>Classroom Procedures</td>
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<tr>
<td>BM</td>
<td>Behavior Management</td>
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<td>R</td>
<td>Relationship</td>
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<td>BD</td>
<td>Before Discourse</td>
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<tr>
<td>CP</td>
<td>Change in Practice</td>
</tr>
</tbody>
</table>

I then went back through the coded transcript and summarized my notes and placed them in the appropriate section on the chart paper, careful to include line numbers so that I could quickly find relevant quotes. When I finished this process with the first interview, a friend typed it into a Word document while I began the coding and analysis of the next interview. This process continued until all three interviews had been coded, analyzed, and placed into a Word document.
I summarized each interview and sent the summary to each participant. I asked her if she believed that my summary was accurate, and each agreed with what I had written. I used the results of these interviews, as well as current research, to guide my coding of the observations.

Observation Coding: First Round

I transcribed the tapes of all lessons I observed and hired four other people to transcribe the lessons that I did not observe. Because the participants did not draw attention to any specific lesson that I did not observe, I analyzed the observation transcripts first and read the other transcripts to see if they were consistent with my analysis of the observations. They were, so I did not code those transcripts. Also, I coded the first two observations in both of Jessica’s class periods. They were so similar that I could almost copy and paste from one class to the next. The students’ names were essentially the only thing that was different. Thus, I chose to code only the first period transcripts from Jessica.

When coding the observation transcripts, I intended to code several things. Both participants talked about the questions that they used to encourage discourse. I decided to use the level of questions that Hufferd-Ackles et al. (2004) referred to in their work. Level 0 (TQ0) referred to a short question that functioned primarily to keep the students listening or that demanded a short response. Level 1 (TQ1) referred to questions that focused on student thinking, and less on answers. Level 2 (TQ2) was used when the teacher facilitated “student-to-student talk” (Hufferd-Ackles et al., 2004, p. 89). Level 3 (TQ3) meant that the teacher expected students to ask one another questions about their work, but her questions might still guide the course. I did not find any examples of Level 3 questions in any of the observation transcripts. In addition to teacher questions, I coded specific math talk moves that the teacher used – revoicing, restating, reasoning, prompting, and wait time (Chapin et al, 2003).
Another set of actions that I decided to code was non-mathematical in nature. What actions did the teacher use to guide behavior or classroom management? I knew from interviews that Gayle planned to have the students set classroom norms (SN) (Brady et al., 2003). How did they address behavior of off task students (AB)? All behavior management research mentioned the importance of the relationship between the teacher and students, particularly when teaching students of poverty (Alderman, n.d.; Canter & Canter; 2001; Marzano, 2003; Parsley & Corcoran, 2003; Pelilino, 2007). However, once I began coding my first observation transcript, I soon discovered that relationship was too broad a category. I noted five ways that the teachers worked to develop relationships with the students – by simply talking with them (RT), by praising them (RP), by encouraging them (RE), by asking personal questions (RPQ), and by using terms of endearment (RTE).

During their interviews, the participants were asked what expectations they held for their students. In addition to expecting their students to follow the classroom norms (All N), they also expected all students to participate (All P). Both teachers had their students keep a notebook and expected them to record what they had done (All W). When sharing an answer, both teachers expected their students to explain their work (All E). Thus, I decided to look for evidence of these expectations when coding the observations. Additionally, both teachers wanted their students to feel confident about the math that they are doing; therefore, I decided to look for the actions that the teachers took to promote that confidence (PC).

Additional codes were needed while I was coding the first observation transcript because I noted that the teachers modeled organization (MO) and modeled thinking (MT) for their students frequently. Modeling organization included how to label a piece of paper to facilitate finding it later and how to organize a poster for presentation to the class. Students also asked
questions, so I decided to code them similarly to the teacher questions. If a student was asking a question for a simple answer, then the question was coded as a level 0 (SQ0). If the student was asking why or how something happened, it was a level 1 (SQ1). If the students were asking each other questions after being prompted by the teacher, it was coded as a level 2 (SQ2). But if the students were talking to each other without any prompting by the teacher, I coded that as SQ3, even if it was not a question. For a complete list of observation transcript codes, see Appendix C.

To ensure fidelity in my coding, I shared my coding scheme and first four coded observations with a co-worker. We read through each observation and talked about areas where she questioned my coding. We came to an agreement, and I felt good about my consistency. I followed this method again when I began coding the observations of the second teacher. My co-worker also helped me organize my codes into a spreadsheet so that I would have a snapshot of what actions the teacher used in each observation. She called out the code and line number(s) while I placed the line numbers into the appropriate cell. For an example see Appendix D. Next, I counted the number of times each code appeared on each spreadsheet.

Observation Coding: Second Round

After all observations had been coded and codes transferred to a spreadsheet, it became obvious that the questions were a significant part of the mathematical discussions that took place in both teachers’ classrooms. I decided to use Bloom’s Revised Taxonomy of educational objectives (Krathwohl, 2002) to code each question with regard to the level of cognitive demand it required. For simplicity, these levels were coded by numbers – Remembering (B1), Understanding (B2), Applying (B3), Analyzing (B4), Evaluating (B5), and Creating (B6). When I began my second round of coding I realized that some questions did not fit into Bloom’s levels because they were yes/no questions, or they were not mathematical in nature. The teachers also
asked questions more than once. If the question was repeated while she was moving from group to group, or if the question was repeated when it was first phrased, I coded it as repeat (R). In addition to looking at the questions, I recorded the task involved in the lesson and also determined the level of Math Talk Community for each observation (Appendix E) (Hufferd-Ackles et al., 2004).

When the question codes were complete, I recorded them on my spreadsheets as well. All yes/no questions were colored; the repeated questions were slashed through; and the questions coded by Bloom’s levels had a 1-4 written beside them. There were no level 5 or 6 questions during the observations. Because classes varied in length, I did not feel comfortable comparing the number of questions from one class period to the next. Rather, I decided to calculate percentages. Once the repeated questions were removed, I calculated the percentage of yes/no and each type of Bloom’s questions. At this point, I also used Bloom’s levels to code each task question. Wolcott (2001) stated that one should not focus solely on the differences between quantitative and qualitative approaches. He cautioned that “most qualitative researchers would benefit by paying closer attention to counting and measuring whatever warrants being counted and measured; most quantifiers could ‘lighten up’ to reveal highly personal aspects about themselves that strongly influence their professional practice” (Walcott, 2001, p. 85). In accordance with Wolcott’s caution of not ignoring the numbers, I created a summary spreadsheet for each participant. The summary sheet included the following for each coded observation:

- question levels and percents
- number of each math talk move
- number of times thinking was modeled
- number of times organization was modeled
• level of each task question

I used these summary sheets as I looked for trends and commonalities among the teachers.

Limitations

There are limitations with all research projects (Patton, 2002). One might consider the number of participants chosen and the methods through which they were chosen to be limitations of this study. I realize that when the sample size is small, one must be cautious in making generalizations (Patton, 2002); however, when choosing my participants, I felt that spending more observation time in their classes was more important than observing a greater number of teacher a fewer number of times. Patton (2002) also cautioned that convenience sampling should be used as the “last factor” (p. 242) in choosing participants, as was the case with my research. As I stated, however, a true picture, not convenience was my objective. Although I was able to construct a picture of the discourse that took place in Gayle’s and Jessica’s classrooms, I consider their classroom sizes a limitation to this study. Gayle’s class contained 13 students and Jessica’s classes averaged 16 students in each. It has been my experience that these are not typical middle school classroom sizes. As a result, one may argue that smaller classroom size made it easier for Gayle and Jessica to orchestrate mathematical discussions.

Audio-taping rather than video-taping the classes proved to be a limitation as well. Although I was able to hear clearly what the teacher said because she wore a microphone, I was unable at times to determine the exact words that students were using. With a video tape, I could have used context clues, such as body language or even tried to read lips. When transcribing from an audio-tape, I experienced difficulty remembering who was speaking at the time. Mentally I had to place student names with voices as opposed to using a seating chart and taking...
notes from a video-tape. I have already discussed that video-taping was not an option during the first few weeks of school.
CHAPTER 4
FINDINGS AND RESULTS

Gayle

Gayle’s Background

Gayle had been a middle school mathematics teacher for 27 years, teaching either 7th or 8th grade mathematics for 24 years and serving as a district level mathematics coach for the previous three years. The year of my study was Gayle’s third year serving as a mathematics coach for her school system, and in this role one of her responsibilities was to teach a group of students for the entire year. However, she was also required to attend to other duties that sometimes caused her not to be available to teach. Because of the nature of her coaching job, Gayle did not really have her own class; rather, she worked with a first-year teacher who willingly allowed Gayle to teach her 8th graders whenever she was available. The classroom teacher was always in the room when Gayle was teaching and assisted the students when they were working in small groups. I did not record any of the teacher’s conversations because she was not a focus of this research.

The school system in which Gayle taught was in its third year of using the Connected Mathematics Project II materials [CMP II], but CMP II was phased in so this was the first year of using CMP II in the 8th grade. Thus, Gayle had 2 years of experience using CMP II but had not yet taught the 8th grade curriculum from this text. Similarly, the state in which Gayle taught was phasing in new curriculum standards, and the year of my study was the first year of implementation for the new 8th grade standards.
Gayle stated that she did not always encourage mathematical discussions in her class. She attributed this change in her teaching to the year her principal “decided to use school reform” (Interview, 7-31-07, Lines 57-58).

And it was researched-based; it was problem based; it was America’s Choice – Georgia’s Choice. And we did, the kids talked a lot, we called it “accountable talk.” And so they did have to talk a lot about the math. And that’s how I got to that point. (Interview, 7-31-07, Line 58-61)

As a part of the school reform process, Gayle volunteered to host a model classroom. An on-site coach was in her classroom every day modeling lessons, while other teachers also observed. “Then I followed through, and I delivered the same strategies that she used. So having that coach right there on the sides was incredible because she was there every single day. And she modeled [the questioning techniques], so that was good” (Interview, 7-31-07, Line 70-72).

Gayle taught in an urban school system north of Atlanta, Georgia. The school in which Gayle was teaching was designated as a Title I school, and 88% of the students were classified as economically disadvantaged, 17% of the students had disabilities, and 11% were English Language Learners. None of the four middle schools in her school system made Adequate Yearly Progress in 2006-2007, and Gayle’s school was in its fourth year as a “needs improvement” school and was about to undergo restructuring (Georgia Department of Education [GaDOE], 2008). Although Gayle had worked regularly in this school in her role as a coach the two previous years, this was the first year that her instructional assignment was in this school.

The class that Gayle taught was an 8th grade class made up of one white, eight black, and four Hispanic students. Gayle was African American. Four students did not meet standards on
the 2007 state’s criterion referenced test, and none of the students exceeded standards on the test (e-mail, 11-13-07).

At the time of the study I had known Gayle for one year, having met her through my position as a professional development specialist. We developed a mutual respect and admiration for each other during the year that she took a class in which I taught. In that role, I had conducted observations in her class the previous year. We had a good rapport and often communicated by e-mail before I began my research.

Relationships

When observing Gayle in class, the one theme that became most evident was that developing relationships with her students is important to her. What was even more intriguing was the suggested results of these relationships. The students appeared comfortable with her asking questions about their answers, even if an answer was incorrect. They also easily asked for her assistance when needed. Yet to me the most surprising observation was the overall positive behavior and attitude of the students. I have conducted numerous observations in this school as part of my job, and behavior has been a major obstacle to learning in every class I have visited.

Pelicino (2007) defined at-risk students as “children who are likely to fail in school or in life because of their life’s social circumstances” (p. 1). She also reported that poverty is a “major at-risk factor” (Pelicino, 2007, p.1). Gayle had worked with students who were economically disadvantaged for over 20 years, and this year’s class was no exception. She assumed that her students’ prior experiences in mathematics were in very traditional classrooms where the teachers showed them how to do a couple of problems and then give the students lots of practice in their books (Interview, 7-31-07, Line 31). Her experience had been that dialogue between disadvantaged students and their teachers did not take place “because of the levels that they’ve
normally been placed in, in previous years” (Interview, 7-31-07, Lines 15-16). According to Parsley and Corcoran (2003), at-risk students are typically placed in a lower level of mathematics and reading courses, from which they never escape. In order to change the student expectations of classroom norms, Gayle believed that she must first develop relationships with her students.

[I] usually try to establish relationships. Because a lot of times, kids from diverse backgrounds don’t have a relationship with their teachers, so relationships is where I normally start – trying to establish relationships with them… [I do this by] dialoguing with them. Hum, simple things like, greeting them and taking an interest in what they’re doing or saying, during those first couple of days of school. (Interview, 7-31-07, Lines 19-21, 23-24)

Niebuhr and Niebuhr (1999) studied motivating factors of 241 high school freshmen. They separated the student data by race and determined that for black students, there is a positive correlation between student academic achievement and positive teacher-student relationships.

Gayle began working on these relationships from the beginning. The classroom teacher took the lead on the first day of school and Gayle simply assisted. The students were first asked to answers personal questions about themselves on a note card. While they were working on this request, Gayle asked if she could share her responses to the questions. At this point she shared personal information with the class. She told them that she had always lived in the city where she was teaching; her favorite candy was M & Ms; she liked to make things; and her favorite number was three because she had three children (Observation, 8-13-07, Lines 25-26, 36-37).

Another activity during this first observation required that one student try to guide the other two students in the group to draw a specific picture. The rules were that this student was
not allowed to use words at all. There was one group that only had two students, a boy and girl. The boy, Cole, showed a look of disgust when being assigned by the teacher to sit with a girl when he entered the classroom. He sat with his head on his desk during the entire introduction (Field notes, 8-13-07). Gayle chose to participate as a member in this group. He volunteered to be the ‘director’ of the activity and excitedly guided Gayle and his other partner to draw the correct design. When the activity was finished, both students were smiling and thanked Gayle for helping them (Observation, 8-13-07). Gayle expressed a desire to get to know all students when she wrote in a journal entry, “I want to learn more about Bethany and Cooper” (Reflections, 8-16-07, Line 13).

Another strategy that I observed Gayle use was to approach students with a term of endearment when trying to reinforce a norm. For example, on the first day of class, another activity involved four playing cards and a target number. The students were asked to work together in their group, using all four cards and any operation to create the target number. Gayle mentioned in her interview that it was important for students to keep accurate records and an organized notebook (Interview, 7-31-07, Lines 154-159). Although she had not shared this expectation with the class yet, she addressed it in the following excerpt.

G – OK, now let me see what you got. Where’s your paper, sweetie?

Jacob– We’re gonna write it here.

G – Why don’t we all record? Because once we start doing our investigation, everybody will have to record

Jacob – Oh.

G – their work. Cause we’re gonna have a notebook later on in class, and you’ll have to record your work. (Observation, 8-13-07, Lines 107-113)
Notice that the students responded positively to her suggestion, and, as noted in my field notes, they each got out paper and wrote down their group equation (Field notes, 8-13-07). A second example involved Cole, mentioned from above. Gayle had just asked students from another group what to call quantities that change. While she was responding to their incorrect answer, she noticed that Cole was sitting at his desk doing nothing.

G – No, reciprocal is when you take a fraction inverted. Cole, are you done, sweetheart?
Cole – I’m thinking.
G – OK, you got 2 minutes to think a little bit more, before I come over there.
Macey - Variable?
G – Right, you said it. Variable, so now write that down with a variable. (Observation, 8-27-2007, 318-322)

Gayle finished with this group and then went to Cole and his partner. By that time he had begun working again and even had an equation written on his paper about which she was able to question him (Observation, 8-27-07, Lines 327-333). Marzano (2003) would have referred to this excerpt as an example of Gayle’s “with-it-ness” because she addressed his behavior without becoming upset and created a level of trust (Parsley & Corcoran, 2003) by accepting Cole’s response of “I’m thinking” and giving him permission to think for 2 more minutes.

Brophy (1998) described strategies that highly effective teachers use when working with students who have very low expectations of success and tend to give up when they encounter difficulty. These strategies include expecting students to work; providing assistance when needed; reassuring students that “they would not be given work that they could not do” (Brophy, 1998, p. 4); monitoring their progress; praising their progress and success; and “providing them with opportunities to display their accomplishments publicly” (p. 4). Gayle echoed Brophy and
other researchers (Canter & Canter, 2001; Pelilino, 2007) when she said that students from “diverse backgrounds adore praise [and] if you praise them, you have them. ‘Ya’ll are great. You are wonderful.’ They love it.” (Interview, 7-31-07, Lines 93-94)

Examples of Gayle praising the entire class occurred on the second and third days of school when Gayle guided the students in creating their own classroom norms. She asked them to answer three questions independently:

- When solving problems, what do I want others to know about me as a learner?
- How can others support you as you learn mathematics?
- When you are solving a problem, what is it that you don’t want to hear?

(Observation, 8-14-07)

Once students completed their responses, she had them share their responses with others in their group. As a group they were to come up with the top two things that can support them as learners of mathematics and the top two things that they did not want to hear when solving a problem. They put the responses on sentence strips and then as a group presented their ideas to the class. Throughout the entire presentation, Gayle showered them with praise. “Wow, give them a hand. Those were good. They went first; they had to go by themselves. Good job” (Observation, 8-14-07, Lines 188-189). “Very nice. I really liked that one” (Observation, 8-14-07, Line 201). “Very nice. Now one of them that I really like is the one, don’t judge me if I don’t understand. I really like that one. That’s a really, really good one” (Observation, 8-14-07, Lines 240-241). “Wow, ya’ll have blown me away. I’m so amazed. This one and that one are both pretty, pretty powerful” (Observation, 8-14-07, Lines 256-257). The following day, Gayle returned a typed list of the classroom norms. “I went ahead and typed them up. They’re really, really good. I bragged
about them. Everybody’s looked at them. Everybody thinks ya’ll are awesome” (Observation, 8-15-07, Lines 6-7).

As Brophy (1998) suggested, Gayle also monitored each group’s progress and repeatedly praised them for the parts that they had completed. This procedure was evident in every observation that I conducted. In the following excerpt, the students were organizing data from the investigation that they conducted the previous day. Gayle was monitoring each group and making sure that everyone had sketched the steps of the cafeteria. She approached one group where a girl had nothing on her desk.

G- Where’s your paper, sweetie?

Cindy - He’s copying it.

G – Oh, he’s copying down the data.

G - Very nice. You did, you sure did. This right here and you actually did this one – make a sketch. I see your sketch right here. All you have to do now is fill in your numbers for the steps. (Observation, 8-16-07, Lines 282-287)

Actually, this group had completed more than the group she had just left. She was excited to see that they were already on the second bullet of the assignment – draw the set of stairs. She praised them for their progress and then encouraged them to make their sketch complete by labeling the steps.

In the following example where Gayle visited a group of three girls, she executed four strategies that Brophy (1998) suggested. She monitored and praised their progress, provided necessary assistance, and gave them an opportunity to publicly share with the class their successes.
G - Girls, did we, did we come up with what we thought the scale factor would be? Cause
if we know what our scale factor will be, we can

Jen - That’s what we’re trying to do now.

G – Oh OK, that’s what you’re trying to do. OK, did you use the calculator?

Jen - It says 0.6.

G - Ooh, I like what you just said. What did you just say?

Jen - .6?

G - Yep and tell them how you got point 6.

Jen - (She says something that I can’t understand).

Marsha - She forgot what she did, but she made the 3 a decimal 3, I mean 3.0, and she
divided by 5.

G – She divided 5 into it. Very nice. So your scale factor is .6, so we’d have to multiply
all of these by .6 to come up with this number over here is what ya’ll are telling me?

Jen - Uh hum.

G – Try it on your calculator. Multiply .6 by 5 and see if you get 3. (Waits a few seconds
while they check.) Very nice. So now do we know the equation? Y =

Jen - Y=.6

G – Point 6 times

Marsha - times x.

G – And instead of writing that x as a times sign, we can just write .6x, right?

Marsha - Yep.
Gayle continued to check on this group several times throughout the remainder of the period, helping them get everything onto the chart paper in an organized manner. She also asked them questions prior to their presentation so they would feel capable of answering the questions in front of the class.

Finally, Gayle quickly learned and called all students by their names. As she learned student personalities, she easily treated the students as individuals. I was observing on a Friday, and Cole came dragging in and laid his head on his desk. Gayle came over to me and told me that she was going to let him pout for a few minutes and then he would be OK (Observation, 10-13-2007). She later explained in a phone conversation that Cole played junior varsity football on Thursday nights. When they lost, he either came in complaining about something hurting or did not come at all. And when they won, he was always present, happy, and healthy on Friday (Conversation, 10-14-2007).

Around day three, Gayle told me that she thought Tony was a child of one of her former students. She told me that she would give him lots of attention so he would not fall through the cracks, as his mother did (Field Notes, 8-15-2007). During my fifth observation she said his name 25 times in one class period. The first time was to encourage him to copy his warm up a little quicker. Once, she called on him because he had a question about the warm up that the class had just gone over. While she had students explaining again what they had just done, she again had to tell him to focus on what was being said. While the students were working in groups, Gayle noticed Tony not on task and sifting through his notebook.
G – Tony, you got to get organized sweetie. Is this your math notebook or is this your whole notebook for 8th grade?

Tony – My whole notebook for 8th grade.

G - So we don’t know what we did with our paper yesterday? (Looking through the notebook) That’s social studies. That’s part of what we did yesterday. That was the warm up. Now remember you got to label these things, Tony. You got to label your warm up. That was warm up number 2? So Tony, you’re gonna have to start on part b right here. All right? Part b, so write down the page number and part b and date it, so you’ll know where to put it when you get your notebook. OK, I want you to go ahead and get started though. I’m gonna check back with you in about 5 minutes. All right? (He found his work from yesterday in his book when he opened it up to start on part b.) (Observation, 8-17-2007, Lines 245-255)

About ten minutes later, Gayle returned to discover Tony sitting quietly, but not working with his group or writing anything down.

G – OK, so now that you found it, Tony. I’m happy you found it. I’ve checked back in and you’ve got it. I want you to start on b1. Now what was your question? You need help? Now what is our process for getting help? Tell me what you do?

Tony – Raise your hand.

G – No you don’t raise your hand. What do you do?

Tony – Ask my group.

G – Right, so you need to ask each one of your group members to try to help you get started with b1 before you ask me. And if they can’t help you, then you ask me.

Tony – I already did.
G – Oh, you’ve already asked them?

Marsha - You did not.

Tony – I did.

G – OK, ask them nicely. Come on Tony, ask them. Ask one of your partners.

Tony – (He asks them something that I can’t understand).

G – Very nice. (Observation, 8-17-2007, Lines 323-342)

Probably the most profound scenario occurred while Gayle was making her rounds and noticed that Tony was on the floor. She told him to get up and he responded with, “You are disappointed with me” (Observation, 9-12-2007, Line 391). She replied, “Thank you, you took the words right out of my mouth. Get up, now” (Observation, 9-12-2007, Line 392). Gayle moved on to the next group and Tony got up. Episodes like this with Tony continued throughout this observation and others. However, Gayle always treated him with respect and spoke to him with a smile. Sometimes she even chuckled at his antics. Tony responded well to her attention and by the next time I observed, he was offering to help another group answer a question while they were presenting (Observation, 8-27-2007).

Classroom Discourse

Several things became obvious through the analysis of Gayle’s observations. Although she did not have an established relationship with the students, she did not work on those relationships in isolation. Instead, Gayle immediately introduced the students to higher level tasks during the first week of school. In addition to challenging tasks, she also asked numerous questions that ranged from remembering to analyzing on the Bloom’s revised taxonomy (Krathwohl, 2002). As the observations progressed, Gayle’s use of yes/no questions decreased, while her use of higher level questions tended to increase. Gayle also used at least two talk
moves numerous times in a class period (Chapin et al., 2003). In conjunction with these actions, the math talk level of the classroom quickly moved from a Level 0 to a level 2 over the course of six weeks (Hufferd-Ackles et al., 2004). (Appendix E).

Prior to the observations, Gayle shared in an e-mail some of her thoughts and beliefs regarding discourse in the mathematics classroom. In agreement with the research (Chapin et al., 2003; Hiebert et al., 1997; NCTM, 1991, 2000), Gayle believed that having students talk about the mathematics was important. “It helps to reinforce what they already know. It also allows students to hear the thinking of other students; sometimes their understanding is influenced by their peers rather than by me” (E-mail, 3-13-08, Lines 2-3). She also used mathematical discussions as a formative assessment. “Having them talk about math also tells me what they know and understand” (E-mail, 3-13-08, Lines 3-4).

*Reluctance.* Gayle also said that she made a deliberate attempt to orchestrate mathematical discussions in her classroom. Gayle admitted that student reluctance was probably her biggest struggle in orchestrating mathematical discussions. She said in her interview that she wanted her students to have confidence. She wanted them to believe that they can do the mathematics; they can talk about it; they can problem solve; and they can master the content (Interview, 7-31-07, Lines 17-18, 34, 36-37). When teaching at-risk students, “[t]eachers must hold high expectations for students and communicate to all students a belief that they can succeed” (Parsley & Corcoran, 2003, p. 87). In each observation there were at least 20 instances in which she tried to promote their confidence in one or more of those areas. Frequently, Gayle would remind the students about a standard that they had in 6th or 7th grade mathematics. “…part of your 7th grade standard last year, you had terminating and repeating decimals” (Observation, 8-17-07, Lines 119-120). “It’s linear. Good. So you are remembering from last year. I’m happy”
(Observation, 8-16-07, Line 148).” What do you call this top number from your 6th grade standards?” (Observation, 8-17-07, Lines 171-172). Often, she would remind them of something that they had done during a previous lesson, or of an example that had been completed earlier that day.

OK, so all we need to do now is find the slope. So how you gonna find the slope? Anybody know how to find the slope? So look at that table that’s back there. What did Dalton tell ya’ll about this last week? (Observation, 8-27-07, Lines 615-617)

Although Gayle provided such prompts or reminders often, she never did so in a condescending way or in a way that accused the students of not trying or not thinking. Rather, she seemed to be telling students that they had seen this material before and that she therefore had confidence in their ability to use it to solve 8th grade mathematics problems. Ruby Payne (1996) called this the adult voice. Most people have three voices inside their head – the child voice, the adult voice, and the parent voice. However, many children of poverty tend to lack the adult voice, because they have had to “function as their own parents...In many instances they also act as parent to the adult in the household” (p. 106). Payne said that teachers tend to use their parent voice when speaking to students. “To a student who is already functioning as a parent, this is unbearable” (Payne, 1996, p. 106). Using an adult voice is one more example of Gayle’s attempt to build relationships with her students.

In accord with the earlier discussion in the relationship section, Gayle said that she praised and encouraged students to help them overcome their reluctance to do and talk about the mathematics.

[I] just keep encouraging those kids that “You can talk about it.” And when you find that one child that decides to open up and talk about it, then you’ve got your captivating
person right there. The bragging and the praising will encourage the rest of them.

(Interview, 7-31-07, Lines 89-92).

She has never had a class in which she did not have at least one or two students step out and take the chance to talk in class (Interview, 7-31-07, Lines 98-99). However, she admitted that there are some students that are harder to reach than others.

In addition to certain talking protocols, another strategy Gayle used to reach the reluctant student was to go to them in private. She tried to find something powerful in what the student had written or said to a classmate and then privately build on it (Interview, 7-31-07, Lines 130-135). Gayle shared an example about a reluctant student named Heather.

Heather, in the class that you observed, she’s a prime example of that. She was so reluctant because she knew that sometimes all the kids in her group, they knew answers or they had an idea of what the answer was. And Heather kind of knew, but she was real unsure of what she did know, so many times I would go to Heather one and one.

“Heather, look at what you just did. Tell me about that. Well, let me see if I can help you.” Just ask her some questions and get her going. (Interview, 7-31-07, Lines 136-141)

I remembered Heather from Gayle’s class that I observed the previous spring as part of a course that Gayle was taking through RESA. By that time of year, Heather appeared to feel comfortable sharing with her group and volunteered to present in front of the classroom. Another example of this strategy occurred during observation 5. The students were working on a warm up exercise where they were changing fractions to decimals by dividing the numerator by the denominator. Gayle noticed that Bethany, a Hispanic girl that rarely talked in class, had changed a couple of the fractions without having done the division. She asked Bethany if she would share with the class what she had done when they went over the warm up. I was surprised when Bethany easily
said OK (Observation, 8-17-07, Lines 37-39). After the class had gone over a couple of the fractions, Gayle said, “6/8. OK, now I’m gonna stop with the fractions and let Bethany talk about her fractions” (Observation, 8-17-07, Lines 94-95). Although she talked so quietly I could hardly hear her, Bethany told the class how she reduced 6/8 to 3/4 and then remembered from their benchmark fractions in 6th grade that 3/4 was .75 (Observation, 8-17-07, Line 96). Gayle praised her in front of the class and then let another student share what he did with the last fraction.

**Orchestration.** When a person orchestrates a symphony, there are so many things going on at one time that it is difficult for the observer to notice them all. Although this description fits how I felt while analyzing data from my observations, I will attempt to describe Gayle’s actions while orchestrating mathematical discussions in her classroom. Hiebert et al. (1997) described the greatest problem for teachers: “How to assist students in experiencing and acquiring mathematically powerful ideas but refrain from assisting so much that students abandon their own sense-making skills in favor of following the teacher’s directions” (p. 29). Although the level of math talk continued to increase over time, the amount of help Gayle provided, the level of questions Gayle asked, the number of math talk moves Gayle initiated, and the amount of modeling Gayle provided all appeared to vary as the difficulty level of the task changed.

In addition to the classroom teacher’s taking the lead during the first class, there were several other times when Gayle was not in charge of the classroom. Once classroom norms were established on day two, Gayle left and students were given a pre-assessment (Observation, 8-14-07). When students were finished measuring the steps in the cafeteria on day three, students finished the pre-assessment from the previous day, while those who were finished worked on a separate task assigned by Gayle (Observation, 8-15-07). Gayle had to leave early on day four
because of her coaching assignment for the school system (Observation, 8-16-07). As a result, I will discuss primarily the discourse that took place in observations 5-8.

Observations 5 and 6 were characterized as a math level 1+ (Hufferd-Ackles et al., 2004). Gayle was still the only questioner but focused most of her questions on student thinking, such as “Dalton, how are we getting this sign right here?” (Observation, 8-17-07, Line 467). Student ideas and multiple strategies were elicited, although Gayle sometimes filled in explanations herself. For example, Tony asked Gayle how to change fractions to decimals. She solicited help from the class. After being told by the students that you must divide the fraction, Gayle asked Tony how to set up the division problem for 1/4. He told her that “you put 1 on the outside and the 4 on the inside” (Observation, 8-17-07, Line 157). Gayle responded with, “Tell me why you did that” (Observation, 8-17-07, Line 158). When Tony did not respond, she continued, “Did you look at the size of them and maybe think that 4 was bigger and you could divide 1 into 4 and you thought you couldn’t divide 4 into the 1?” (Observation, 8-17-07, Lines 158-160). Students were asked to repeat what other students said and to help other students. I characterized the classroom community as operating at level 1+ rather than level 1 because students began asking questions to other students without any prompting from Gayle. An example of unsolicited questioning occurred while a group was giving a presentation. One student in the group answered a question that Gayle asked regarding the equation. “We made our table by using the graph, then we had to find the scale factor. And the scale factor is point 6. So” (Observation, 8-17-2007, Lines 829-830). Before she could continue, another student interrupted with a question, “How did you get .6?” (Observation, 8-17-2007, Line 831). Also students’ ideas sometimes guided the direction of the lesson, as described earlier when Bethany was asked to explain how she changed the fraction to a decimal without doing division (Observation, 8-17-07, Lines 37-39, 94-96).
In observation 7 the classroom community showed a few more characteristics of level 2, so I classified this day as a math level 2-, while in observation 8 the classroom community functioned at a math level 2 (Hufferd-Ackles et al., 2004). Students began providing more thorough descriptions as illustrated in the following excerpt.

G – Alexis, can you explain it to us?
Alexis – I subtracted 5 from each side. And then when I subtracted 5 from the first side, it left me with 24. Then I divided 4m by 4 and it left me with m and divided 24 by 4 and it left me with 6.

G – Wow! That was very well said, and I didn’t have to ask you any questions, you told me all the whys, all the becauses. (Observation, 9-26-07, Lines 15-20)

Gayle not only encouraged students to share their thinking with their partners; she also encouraged them to respond to their partner’s thinking. “Tell them what you added and see if they have any suggestions because you are on the right track” (Observation, 9-26-07, Lines 317-318).

Although I rated the level of difficulty of each task using Bloom’s Revised Taxonomy, the difficulty level and amount of help required to solve it successfully is dependent on the cognitive and emotional status of the child who is working the task. In discussing equity in the classroom, Hiebert et al. (1997) talked about equity in the classroom and noted that “the teacher [should] not treat each student in exactly the same way. [She] may need to provide different conditions and supports for students with different needs” (p. 73). Depending on the difficulty level of the task and the student with whom she was working, Gayle provided different supports. In the next excerpt, the students were given the following table to complete. Notice that an example was already completed for them.
Table 2

Warm Up Activity

<table>
<thead>
<tr>
<th></th>
<th>4</th>
<th>6</th>
<th>3</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise</td>
<td>4</td>
<td>6</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Run</td>
<td>5</td>
<td>9</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Ratio (Fraction)</td>
<td>4/5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ratio (Decimal)</td>
<td>.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

G – Do you know how they got this right here?

Sue - Yes.

G – How?

Sue - (She mumbled and was difficult to hear.) You get 8, and then they got 5. Then they divided to get. Well, I know they divided it. I know that.

G – Uh hum, you’re right. So you divide this one into this one. So when you do your little division symbol, the 5 will go where?

Sue - It will go, like inside.

G – It will go outside.

Sue - Yeah, outside, and the 4 would go over there, inside.

G – Right, so go ahead. That’s how they got that one, so now you know how to do these.

(Observation, 8-17-2007, Lines 45-54)

Gayle noticed that Sue had copied the table but was doing nothing else. Gayle approached her and started with a simple yes/no question. It has been my experience that a student will claim to understand something just so that the teacher will leave him alone. However, Gayle did not stop there; she then followed up with an understanding question (Krathwohl, 2002) by asking Sue,
how? Although she had difficulty describing what was done with the 4/5 to get .8, Sue knew with certainty that a division problem must be done. Instead of writing out the division problem for Sue on her paper, Gayle pointed out what was to be divided and asked where the numbers should be placed. At this point, when Sue put the 5 in the wrong place, Gayle simply corrected her. She accepted the correction and continued setting up the problem. Gayle confirmed for Sue that she was right and then assured her that she would be able to complete the rest of the problems and left her to work independently. Hiebert et al. (1997) summarized Dewey by stating that “teachers should provide information if it is needed for students to continue their problem-solving efforts and they cannot readily find it themselves, and if it is presented as something to consider and not as a prescription to follow” (p. 36). Hiebert et al. also suggested that the teacher should not have the final authority on correctness. Brophy (1998) suggested that “highly effective teachers…implemented similar strategies to help failure syndrome students – such as including encouragement …[and] providing reassurance” (p. 4). Some might assess the interchange between Gayle and Sue above and argue that Gayle told Sue too much and should not have told her that she was incorrect in how she set up her division problem. I, however, characterize the situation as being consistent with the recommendations above from the literature because Gayle discovered where Sue was stuck, helped her over the hump, and then left her with encouragement and reassurance that she could continue without further help.

Pelilino (2007) said that the brain “does not store memories, but recreates them every time we recall” (p. 9). Because children of poverty have fewer experiences, “the more closely new information conforms to what the learner perceives as interesting, useful, and emotionally stimulating, the more likely it is to be integrated” (Pelilino, 2007, p. 9). In this next example, Gayle summarized the story in her own words (Payne, 1996). Instead of asking the students to
read the task from the book, she related it to the students’ experiences and created student interest in the problem. She first asked if anyone had a birthday coming up and then what was the best gift to receive. Many responded with, “money” (Observation, 8-27-07, Line 145). Next, she described the problem and then asked how many of them had younger brothers or sisters. Almost all of them raised their hand.

They’re really nosey, right? Well, little sister wants to know, how much money Grandpa gave [her] and how much money [she was] gonna put aside? And she won’t tell her that. She’s only gonna give her two clues about her money. And the two clues are in your book. So I want you to open your book up now to problem 4.4. (Observation, 8-27-07, Lines 162-165)

She had everyone’s attention at this point. Everyone turned in their books to look at the two clues. She gave them 15 minutes to work by themselves and then she wanted them to share with their partners what they had discovered. For some students, Gayle provided less assistance than she provided for Sue earlier. While the students were working on the task, she walked around to watch their progress.

G – So what does this 15 tell me?
Dalton – (He had a table on his paper) How much she saved.
G – In how many weeks?
Dalton - (I can’t hear his response.)

G – Well, she saved that much right there, after 5 weeks. Right? And that much after 8 weeks. So from 5 weeks to 8 weeks is how many weeks?
Dalton - 3?

G – Uh hum. So in 3 weeks, she saved $15?
Dalton - So she saved $5 each week.

G – Uh hum.

G - Tell me where you got your $15. Where’d you get your $15?

…

Dalton - From this week she had $175, and on the 8th week, she had $190. From 5 weeks to 8 weeks, that’s 3 weeks. That’s $15, from 175 to 190. So that’s $5 a week.

G – OK, good deal. (Observation, 8-27-07, Lines 177-188, 193-195)

In this example Dalton had already drawn a table on his paper but appeared stuck. Gayle asked him simple remembering questions (Krathwohl, 2002) while pointing to the information that he had already placed in his table. It may appear to the reader that she told him that the difference in the amount of money was $15, but he already had that on his table; she was actually asking him if that was true (Field Notes, 8-27-07).

During the same observation, when students completed the birthday money question, they were to continue working on the next problem dealing with Celsius and Fahrenheit. With some coaxing, Cole had completed the first problem. When asked to continue on to part b, Cole replied, “What? I don’t know how to do no b” (Observation, 8-27-07, Line 358). This is the same day that Gayle gave him two more minutes to think. Interestingly, she walked off without replying. Several minutes later, Cole raised his hand. She walked over to him to see what he wanted.

Cole – You got to start me off here or something.

G – OK, all right. So in this one, how are these things right here, just like what you had over there? Do you see any similarities between this problem and the problem you just did?
Cole – Asking for the same thing. (Observation, 8-27-07, Lines 451-455)

She began by asking him an analysis question (Krathwohl, 2002) – to compare the two problems for similarities. After she asked him a couple more remembering questions about the problem, she then suggested that he either make a table or a graph of the information. Gayle then left Cole and his partner to work on the remainder of the problem alone.

In addition to asking questions of varying cognitive difficulty, Gayle also used various math talk moves described by Chapin et al. (2003). Although she used four of the five moves frequently, the one she used most often was revoicing, which has two purposes. The first purpose is to verify that you have correctly heard what a student has just said. The second purpose is to “make one student’s idea available to others; give them time to hear it again” (p. 13). An example of revoicing occurred during a lesson that I did not observe. This excerpt comes from the transcript of the audio-tape. The students had simplified radicals of perfect squares previously. This day, Gayle introduced them to radicals that were not perfect squares and walked them through how to simplify a radical by going over an example using a series of remembering questions.

G - So what strategies did we use, because we have to go back to our essential question.

What strategies did we use to simplify this?

Tina – First we listed all the factors of 72, then found one that was a perfect square.

G – Oh! I’m loving it! She’s saying it! Say it again. We found all the what? What are all these things over here called?

Tina – Perfect squares that were factors of 72. (Transcript, 10-10-07, Lines 543-548)

This is one time when she used revoicing so all the students would have a second chance to hear the information.
I could not find evidence of a precise pattern that Gayle followed when asking questions or assigning tasks. The examples above provide evidence that Gayle knew her students, knew what they could accomplish on their own, and knew when they needed assistance. Regardless of their past experiences, she provided mathematically rigorous activities for her students and asked questions of varying cognitive difficulty. Pelilino (2007) insisted that “the curriculum should be challenging to prevent decreased opportunity for higher education, which translates into less opportunity in life for [children of poverty]” (p. 3). Gayle consistently posed challenging tasks for her students, but when the task was too difficult, she made it more accessible to her students by scaffolding the task, doing part of it together, taking out extra information, or posing the task by telling a story that mirrored the task (E-mail, 4-29-2008).

Jessica’s Background

Jessica had 14 years of teaching experience. As an undergraduate music major, she began her career by teaching one year of music. She then taught a year of middle school math. “I just fell into it by default” (Interview, 8-06-07, Line 20). She taught one more year as an elementary school teacher before staying at home to raise her children. Upon returning to teaching, she taught middle school mathematics as well as earned her master’s degree in mathematics education. She had been in her current position for 11 years.

But I did [the masters] in math, for uh, well for certification purposes certainly, but I needed the background. Although teaching middle school, I didn’t find it a problem. I was always good at math, but of course I learned math the old way, so I could teach it the old way without any problem. But I’ve adapted to the new way. (Interview, 8-06-07, Lines 23-26)
In contrast to Gayle’s situation, Jessica’s school had used CMP II for 6 years, so she was very familiar with the curriculum. As with Gayle, however, this was the first year of implementing new statewide curriculum standards in 8th grade mathematics, so some adjustments had to be made to CMP to match the new curriculum.

Jessica described her first experience with using CMP. During textbook adoption, the middle school and high school teachers in her county all agreed on a particular textbook. The assistant superintendent told them that they had not chosen a textbook series that was on the exemplary list and that he would make an executive decision. As a result, the middle school purchased CMP; however, the materials did not arrive until three weeks into the new school year and the teachers received no prior training. Although the teachers attended CMP training in Michigan the following year, they were very frustrated their first year of using the material. During the first year of implementation, an on-site coach from Florida assisted the teachers. Jessica said that having this person available at all times to model instruction and questioning techniques helped tremendously. “She got us through that first year, but it was very painful” (Interview, 8-06-07, Line 248).

The school in which Jessica was teaching was the only middle school in a small school system located east of Atlanta. The demographics of Jessica’s school system were somewhat different than Gayle’s with 43% of the students classified as economically disadvantaged, 12% of students having disabilities, and no English Language Learners (GaDOE, 2008).

The two classes that I observed consisted of 17 white students, 12 black students, two Hispanic students, and one mixed race student; Jessica was white. Four of her students exceeded, 27 met, and one did not meet the standards on the 2007 criterion referenced test administered by the state (E-mail, 11-16-07).
I did not know Jessica prior to this study. She was one of the teachers recommended to me the spring prior to my data collection.

**Persistent Questioning**

When asked what specific methods and procedures she used to foster productive classroom discourse, Jessica answered simply with, “Questions” (Interview, 8-06-07, Line 148). She admitted, “I think I may have gotten the reputation that I don’t ever answer a kid’s question, which is not really true. But I do tend to answer a lot of questions with questions” (Interview, 8-06-07, Lines 148-150). She said that she asked questions mainly for one of two reasons: “either to clarify for myself what it is they’re asking or to make them come to some conclusion on their own, which is what I really want” (Interview, 8-06-07, Lines 150-151).

Jessica hit the ground running with questions on the first day of the school year. After calling roll, she immediately began a class discussion by referring to a circle map that she had previously drawn on the board. Although the map told several things about her; she pointed out that she loved math. She then asked how many students loved math. One student raised his hand. She continued by asking how many thought that math was hard. Nine raised their hand and she called on one of them to clarify.

J - OK, Meredith, why is math hard?

Meredith – Because you got to learn all those formulas and stuff and when you…. (can’t hear) and all that stuff.

J – Where are you getting all of these formulas? (A couple of students laugh) What formulas are we talking about?

Meredith – Geometry and stuff. Like we did last year.

J – What did you do last year that was hard?
Meredith – (She thinks and then another student says fractions). Naw fractions weren’t hard.

J – OK, what about formulas were hard?

Meredith – Well, well not area, like after you do area. You have to think about all these pi’s, and 3.14 and what you got to multiply it by.

J – How many 3.14s are there?

Meredith – One, one I guess. But it goes on and on and on.

J – Pi goes on and on and on? Well, that’s why we make it 3.14 to make it simple, right.

Meredith – I know.

J – But we make it simple. So why is it hard?

Meredith – Never mind. (Observation, 8-6-2007, Lines 169-185)

Jessica confessed in her interview that she had been known to make a child cry because she would not back away from a question (Interview, 8-06-07, Line 453). She claimed that she persisted because she wanted so badly to know what they were thinking. In this episode, I felt sorry for the student and understood why she gave up. However, it did not seem to discourage the class because immediately after Meredith said “Never mind,” another student added to the conversation by saying, “I still think it’s hard” (Observation, 8-6-2007, Line 186). Jessica continued her line of questioning with this new student and others by asking them what they did to try to understand the math.

On the first day, Jessica also began eliciting from her students what they remembered from 7th grade mathematics about linear relationships. The students were told to create a circle map and place linear relationships in the center. Before she asked them to fill in the outside circle, she asked them to raise their hands if they had no idea what she was talking about.
J - OK. So that means we’ve got to do something to get you started, right? There’s like 6 or 8 of you that don’t know what I’m talking about. What’s the root word in the word linear?

Ss – Line

J – Lines, good. Now you got a better idea of what I’m talking about?

Ss – No.

J - A better idea?

Ss – It has something to do with lines. Straight lines.

J – OK. What does the word relationship mean?

Ss – (some students say something about comparing things)

J – Comparing things. Good. What else? Any other ideas? What does the word relationship mean?

Fara – Compares.

J – One idea is that it compares. What else?

Ss – Works together.

J – Works together. Any more ideas? Does that help you? We’re talking about lines. We’re talking about things that work together. Did that help? OK, if that helps you, then outside this circle, you’re going to think of things that help you describe linear relationships. However, it is that you understand it, OK? Whatever it is you think I’m talking about, I want you to put out here around the circle. (Observation, 8-6-2007, Lines 310-329)

Although I felt a little uncomfortable with all the questioning she did in the beginning of class, the students had already adapted and appeared comfortable with answering her questions. In this...
excerpt, Jessica did not give them an assignment without first helping them make a connection to something they already knew (Bruning, Schraw, Norby, & Ronning, 2004). “I know that it’s my job to figure out…what their prior knowledge is, so I can take it somewhere” (Interview, 7-23-2007, Lines 359-361). She helped them make this connection by asking remembering questions (Krathwohl, 2002), in addition to using the math talk moves of revoicing and prompting students to add more to what was just said (Chapin et al., 2003).

The following is an additional example of how Jessica guided a student by asking questions. The students were working on a problem in their groups. They had been told a story and given a table and were to determine if the data were linear or not. They were supposed to look at the table and make a conjecture and then test their conjecture by graphing it. Michael raised his hand, and when Jessica arrived, he asked her a question about the numbers.

J – (She covers the table in the book with his agenda). OK, tell me how to make a graph.

Michael - I don’t know. I don’t know how to make a graph.

J – Yes you can. Think you know how to do it. If you know how to do it, you, do it, and while you’re doing it, talk to me about it. Tell me what you’re doing.

Michael - Making a line.

J – A line where.

Michael - On the x. Making a y and x axis.

J – Making a y and x axis. That’s good. What are you gonna do now that you’ve got the lines?

Michael - Find out which, where I will put the amount of money, I mean days.

J – Good. Which do you think goes where?

Michael - The amount of money on y.
J – Why did you pick that?

Michael - Because the days, the money, the amount of money that he spends depends on the days.

J – OK, I agree. So now that you’ve decided which is dependent and independent, label them. (Observation, 8-9-2007, Lines 162-178)

As Jessica left, Michael had begun to draw his graph. In this example she helped a student who had given up and declared that he did not know how to make a graph and encouraged him through her questions. The examples just given as well as many others from additional observations confirm Jessica’s statement in her interview that she asked a lot of questions.

Sometimes Jessica’s questioning confused her students, and one example of this misunderstanding occurred during the same observation described above. Jessica had stopped to look at what a group of boys were doing; they had already written an equation and were excited to show it to her. She looked at it and asked them what their equation meant. She followed that question up by asking if the equation made sense. After several more questions, she looked at them and raised her eyebrows and said, “So ya’ll are full of good ideas. You just got to put them all together in one place” (Observation, 8-9-2007, Line 284). She continued to ask them questions for about five more minutes. Their conversation ended as follows:

J - Well, should that work for your equation then?

Bryson - Yes. You said that it was wrong though.

J – Did I really?

Bryson - Yes.
J – I just like to ask a lot of questions. I don’t want you to think you’re wrong. I’m just wanting you to confirm whether you believe it or not. (Observation, 8-9-2007, Lines 301-306)

Frequently throughout my observations Jessica’s students accused her of telling them that their answer was wrong, when in fact she had not. I asked Jessica in her interview if she handled wrong and right answers in the same way.

I try to. I try not to just give it away when I hear it first. I don’t know. You’ll have to be one of those that tell me whether I give it away with my face or not. Because I, I’m trying to be conscious of that. I try not to give it away. (Interview, 7-23-2007, Lines 553-557)

Jessica also used persistent questioning as a means of keeping students on task and ready to respond to a question that may be directed their way. Let me first give some background information regarding the main student involved in the following passage. During my observation two weeks prior to this one, Jessica gave back tests that they began the previous day. She encouraged them to complete the test although many students felt that they had already completed it. Nathan was one of those students. Nathan turned the test in and declared that he did not know any of the stuff. Jessica told him that he did not know any of the stuff because he did not pay attention in class. Several times that same period she called on him, pointing out that he was again not paying attention. In the following episode Jessica had asked the class how to come up with the slope of the equation.

Sheryl – Find out how much it goes up by.

J – And how are you going to find how much it goes up by?

Sheryl – Find the difference between 26 and 34.

J – We can do that, what is the difference in 26 and 34?
Ss - 8

J – I heard two 8’s back here, too. Anybody else have a different answer, or agree or what?

Scott - Agree.

J - Anybody else? Let me see some hands of those who agree that the going up part might be 8. Dustin, you’re not sure?

Dustin – I’m thinking.

J – You’re thinking. I like thinking. Nathan, you’re not sure? (3 seconds) Are you not sure?

Nathan – Uh

J - Are you thinking?

Nathan – Yeah

J – OK, what are you thinking? Tell me something out loud that you are thinking. (3 seconds)

Nathan – Oh, I’m sure

J - How do you know now? (students laugh)

Nathan – Uh. (4 seconds) Cause it goes up.

J – How does it go up? Tell me some more about that.

Nathan – It goes up at a constant rate.

J - How do you know?

Nathan – Cause it’s a straight line

J - How do you know it’s 8?

Nathan - 8? (6 seconds) I don’t know.
J - Then why do you agree?

Nathan - I don’t agree.

J – You don’t agree, OK, then what should it be? You’re not getting out of it (teacher chuckles) did you notice that? I want to know what you are thinking.

Nathan – I’m not thinking nothing.

J - OK, then it’s time to turn it back on so you can think some more. (Observation, 9-27-2007, Lines 163-182)

Nathan tried everything from agreeing to disagreeing with what had been said. Unfortunately for him, yet not unusual, Jessica expected an explanation of his decision. If Nathan had just been paying attention, he could have easily answered her question regarding the difference between 26 and 34. Additional examples of Jessica’s questions will appear in further sections.

*Mathematical Discussions*

Jessica used a variety of strategies to encourage mathematical discussions, in addition to questions of varying difficulty. When analyzing the math talk level (Hufferd-Ackles et al., 2004) of Jessica’s observations, it became obvious that her classes progressed to a level two rather quickly but then became stable. Jessica immediately elicited comments from students and provided rigorous mathematical tasks the first week of school. She also employed many math talk moves within each lesson (Chapin et al., 2003).

One thing that Jessica believed strongly in was classroom discourse. “But I think they do, I think they have to talk” (Interview, 8-06-07, Line 157). She confessed that she did not always feel this way. “I stood in the front and did 5 and let them do 20” (Interview, 8-06-07, Line 180). However, when she went to CMP training in Michigan six years ago, her beliefs about discourse began to change. “It really made a lot of sense to me then, after hearing other experienced
teachers talk about how to teach in a discourse, in an inquiry way, how to get kids thinking about math” (Interview, 8-06-07, Lines 172-174). Of course, she wanted the discussion to be a little controlled, but the noise did not bother her as long as the students were talking about the topic (Interview, 8-06-07, Lines 158-159). Jessica also mentioned that the choice of task influences the mathematical discussions that may or may not take place. She believed that CMP II had helped her in orchestrating classroom discussions, because “it’s not [designed] around exercises. It’s around real problem solving, with real questions that have to be asked, answered and thought about” (Interview, 8-06-07, Lines 277-279).

Jessica said that with the shift to a more discourse-oriented classroom she initially struggled with feeling that she was not needed anymore because the students need to talk about the mathematics and work together to solve the problem situation that they have been given. Instead of standing in front of the room and teaching, she was supposed to facilitate. “I don’t want to feel like I’m just here watching them work, because I feel like I’m not doing anything. Why do they pay me to watch them work?” (Interview, 8-06-07, Lines 198-200). Over time, Jessica became more comfortable with her role and said that she enjoyed getting into the middle of the groups and listening to what the students were saying and thinking (Interview, 8-06-07, Lines 204-205).

*Math talk moves.* In the interview with Jessica she described revoicing, a math talk move discussed by Chapin et al. (2003), as one of her discourse strategies.

Most of the time when they ask me a question, and I repeat their question back to them, they’ll say “No that’s not what I meant.” So they have a hard time posing their questions…And by repeating it to them, first of all, they know what I heard, [and then]
start talking about the problem and it usually will lead them somewhere - that they haven’t even considered before. (Interview, 8-06-07, Lines 151-157)

Repeating the students’ questions in her own words seemed to help the students clarify their questions and further their mathematical discussions (Interview, 8-06-07, Line 156).

Interestingly, I could not locate from the observation transcripts an example of where Jessica incorrectly heard a student question. However, I did easily locate an example of how revoicing and the discussion that followed helped a student realize her incorrect thinking and caused her to change her mind. The students had been given a chart that contained three columns – concentrate, water, juice. Jessica asked them how they were supposed to make 1 batch of orange juice.

J - Somebody explain batch 1 to me. (4 seconds) Carol can you do it? Can you explain how you make 1 batch?

Carol – (from the quiet 3♀) – You get 2 cups of concentrate, 2 cups of water, and 5 cups of juice.

J – You get 2 cups of concentrate, you get 2 cups of water and you get 5 cups of juice?

Carol – Yeah.

J – Mix all three of those things together?

Carol – Yeah.

J – OK, Betty, do you agree? (4 seconds) You take the water, the concentrate, and the juice and mix them all up. (4 seconds) (To the 3♂ talking) Stay with me. Do you agree?

Betty – Just the concentrate and the water.

J – Say that again.

Betty – Just the concentrate and the water, because you will make 5 cups of juice.
J – Just the concentrate and water? OK, we got two ideas floating around. Are you listening (to Terry in the group of 3 boys talking)?

Terry - No

J – If you’re not listening, then you don’t know what we’re talking about. And ya’ll are talking about something else. One idea is we’re gonna mix the concentrate, the water, and the juice together. And the other idea is we’re gonna mix the water and the concentrate together. What do you think, Meredith?

Meredith – I think you just mix the water and concentrate together, because it (something else that I can’t hear).

Lisa - So why it got juice on it then?

Meredith – Because so you can see how many cups of juice you’ll make.

Lisa - Oh yeah.

J – What do you think about that Carol?

Carol – I changed my mind to just concentrate and water. (Observation, 8-10-2007, Lines 57-83)

Jessica used four math talk moves in this passage (Chapin et al., 2003). She began by asking a question and then waited 4 seconds (Wait Time) before she called on someone specific to answer. After Carol gave a response, Jessica repeated what Carol had said, making sure that she had heard correctly (Revoicing). Instead of telling Carol that she was wrong, Jessica continued by asking Betty if she agreed (Reasoning). Again, she waited about 4 seconds (Wait Time) before she repeated for Betty what she wanted her to respond to. Next, Jessica restated in her own words (Restating) the ideas presented by the two students regarding how to make one batch of orange juice. Jessica followed this remark by asking Meredith what she thought (Reasoning).
about the conversation. Meredith stated her position and explained why she believed that the batch was made up of water and concentrate only. Jessica remained quiet while another student questioned Meredith’s response and while Meredith answered her question. When this interaction ended, Jessica then took the discussion back to Carol and asked her what she thought (Reasoning). Carol had been listening to this conversation and stated that she had changed her mind. She thought that the juice was made up of concentrate and water.

Jessica also used restating as a way of bringing attention to something that had just been said.

Trip – How are we going to plot this if this has 3 things?

J - What are the 2 most important things in that table?

Trip – The bridge number and painting cost.

J – The bridge number and the painting cost? So bridge number 1 is just automatically going to cost $52,000?

Leslie – It depends on how many feet.

J - You just said a ton of stuff; do you know what you just said?

Leslie – No

J – Say it again. You should know exactly how to graph that now. Do you know what she just said?

Trip – She just said we should graph these two things.

J – That’s not what she said.

Leslie – I said that the painting cost depends on how many feet.

J - What does that mean?
Leslie – It means you have to have a certain amount of length before you can figure out the cost.

J - What are you writing on your graph? (Observation, 9-27-2007, Lines 332-348)

In this situation, the students had been given another table with three columns – bridge number, bridge length, and bridge cost. Trip had asked how to graph with three things, or variables. Leslie spoke up and said that the cost of the bridge depended on how long it was. Yet when Jessica asked Leslie if she remembered what she just said, Leslie said no. (I think Leslie meant that she did not know the *importance* of what she had just said.) Jessica then turned the question to Trip, asking him what Leslie had just said (Restating). He incorrectly interpreted what Leslie said, and Leslie corrected him by once again repeating it. Unfortunately, neither of them understood what this statement meant regarding the graph.

J - Does the painting cost depend on the bridge number?

Leslie – Yes,

J – See, you can’t explain that.

Leslie – I don’t know

J - (to Betty) What do you think?

At this point, Jessica used the final math talk move, prompting (Chapin et al., 2003). She asked Betty to add to the discussion that had already taken place in her group.

Betty – I think you should have two graphs.

J - I’m reducing your pay. All three of you, I’m reducing your pay. You don’t get a raise. If you put the bridge number on the graph, what is it going to tell me?

Betty – It’s going to tell how many bridges there is. (Observation, 927-2007, Lines 354-357)
There were only 3 people in this group. Jessica has asked all of them questions in an attempt to help them answer Trip’s original question about how to make a graph with three components. The class period was almost up, so she concluded their conversation with a few guided questions.

J – Do you think if I have four points on the graph that I will know that one of them is bridge 1 and one of them is bridge 2 and one of them is bridge 3 and one of them is bridge 4. Do you think I might realize that?

S – Yes

J - So the first thing you said made a whole lot more sense…So that means you have got to make a decision on what depends on what. Because that’s what x and y are. That’s what should be graphed because one of those is x and one those is y. (Observation, 9-27-2007, Lines 358-367)

Reluctance and relationships. One thing that Jessica worked really hard on was trying to involve the reluctant students in the classroom discussions. She used to be that reluctant student and could relate to their fear of speaking out in class. “If the teacher’s up there, I wanted to sit back here. And I wanted to be invisible. I know what’s going on and I can do what you want me to do, just please don’t ask me a question” (Interview, 8-06-07, Lines 468-470). Yet, when asked how she handled these students, she said, “I ask them anyway. I ask them anyway” (Interview, 8-06-07, Line 472). Jessica explained that she questions them because she believes that it is hard being the quiet kid. “You don’t feel like you’re a part of what’s going on in the class. And I want them to feel like they’re part of what’s going on in the class” (Interview, 8-06-07, Lines 474-476). Therefore she made a conscious effort to ask every student at least one question a week. “If I don’t ask it in front of everybody, I’ll make sure I’ll walk around and talk to them, especially at
first” (Interview, 8-06-07, Lines 479-481). She said that the quiet students are easy to spot, usually even on the first day. They want to sit by themselves and not talk to anyone. “You just gotta make friends with them. And I usually tend to do that kind of quietly, because I know how they feel” (Interview, 8-06-07, Lines 485-486). Most of her students willingly participated in some aspect of the classroom discussions. However, there was one student, Carol, who was particularly quiet. The earlier passage where Carol responded with the incorrect combination of ingredients to make the orange juice was an example of how Jessica called on the quiet student. That excerpt came from the fifth day of school, and that was the first time that I had ever heard Carol’s voice.

Jessica mentioned in her discussion of reluctant students that she had to make friends with them. That was not the first time the topic of relationships came up in her interview. She also said an additional advantage to finding out what the students are thinking is that it “fosters a better relationship with the kids…[and] you’re gonna get a lot better reaction and response from them” (Interview, 8-06-07, Lines 205-208). I was impressed with the way Jessica began her first class by calling every student by name. As she called roll, she said something personal to each person.

Jackson Holt, good morning. Got gum? Would you dispose of that for me please? Tim, did I meet you Friday? I thought I did. OK. Jerry Jones, Good morning. I believe you belong to somebody named Allie, don’t you? I taught Allie. Nate Libbet, good morning. Sharon, is it Sharon Lockett? Did I say that right? Good for me. Hezekiah, good morning. (Observation, 8-6-2007, Lines 25-29)
Dustin was absent on Monday because he had been at a fishing tournament all weekend prior to school starting. This is the conversation that took place when she got to his name on the roll on day two.

(To Dustin) Well, you’re new.

Dustin – Yeah, I’m Dustin.

J – You’re Dustin?

Dustin – Yeah.

J – You’re the star?

Dustin – I guess.

J – Did you hear Dustin’s news? Tell them your news.

Dustin – That I won?

J – That you won.

Hezekiah - Won what?

J – I don’t know, but he won. What’d you win?

Dustin – 5 grand and a scholarship.

…

J – For fishing, right? How do you do a fishing tournament?

Dustin – You gotta beat everybody out.

J – I mean, how do you beat them? (To the group of 5 ♀) Are you listening? No. Listen, you want to know about fishing.

Sharon – No I don’t

J – You do. Hang on. You want to know about fishing. Don’t you eat fish?

Sharon – Sometimes.
J – Fish are good, so let’s figure out. How do you win at fishing?

Dustin – By your weight.

J – Their weight?

Dustin – Yeah. At the end of the tournament.

…

J – You’re still tired?

Dustin – Uh hum.

J – Well too bad, we got school today. (Laughs) But we’re real proud of you Dustin.

Dustin – Thank you. (Observation, 8-7-2007, Lines 34-81)

The conversation continues for 57 lines, so I abbreviated it here. During the conversation she not only developed a rapport with Dustin, she also encouraged other students to take part and to listen. She had several non-mathematical conversations with different students throughout my observations. Another example occurred on the first day of school. Halfway through class all football players were called to the gym for a brief meeting. While most of the boys were gone, the rest of the students shared their ideas of what linear relationships mean. The conversation took place when the boys came back from the gym.

J – Oh, ya’ll missed it.

Shadrach – Oh yes. What did we miss?

J – Ya’ll missed it. It was great.

Shadrach – Do it again.

J – Can’t do it again.

Shadrach – Show me how you did it.

J – Show you how we did it?
Shadrach – Yes.

J – Uh, No. You’re gonna have to figure it out for yourself. Isn’t that right? Gotta figure out for yourself. You missed it.

Shadrach – What’s going on?

J – What’s going on? What’s going on?

Shadrach – If it’s funny, I want to know. (Some laughing)

Michelle – We don’t want you to laugh with us.

J – Well, sure we do. We want to be a little community that helps each other, that makes everything funny or not. But if you’re not here, you don’t get it.

Shadrach – It wasn’t my fault.

J – I understand, but you missed it. We went shopping.

Shadrach – You did?

J – We did.

Shadrach – I’ll root for Georgia Bulldogs.

J – That would be good.

Shadrach – OK, now tell me what you did.

Jessica used this opportunity to create an interest in at least one boy who missed class. It became obvious that when you miss time out of her class, that time can not be recaptured. He did not want to be left out and even tried to coax her into telling him what they did, by saying that he would root for her favorite team. She never did tell the boys in detail what they had missed. It is also interesting to note that the other students were paying attention to the dialogue between Jessica and Shadrach, as evidenced by Michelle’s interjection that they did not want the boys to laugh with them,
Orchestration. As with Gayle, I will try to capture Jessica’s as she attempted to orchestrate mathematical discussions in her classroom. As the level of math talk progressed in Jessica’s classes, the percentage of yes/no questions decreased while the cognitive level of her questions followed an increasing trend. Interestingly, the number of revoicing incidents decreased as her number of restating moves increased. Jessica always provided tasks of higher cognitive demand. On the days that there was more group work and less whole class discussion Jessica tended to offer more encouragement and praise.

Observations 1 and 2 were characterized as a math level 1 (Hufferd-Ackles et al., 2004). Although there were mathematical discussions, Jessica talked more on these days than on others. On day one she spent a lot of time working on the relationship aspect by talking to students regarding their feelings toward math, by talking with the football players about what they missed while they were gone, and by sharing her love of the Georgia Bulldogs. I have already shared examples of the first two situations. When class first began, she introduced the students to all of her bulldog paraphernalia around the room. Her husband even showed up with balloons and a Bulldog license plate for her birthday. After he left, she shared with the class how she wanted them to organize their notebook for math. Jessica had one as an example with a Bulldog on the front. After going through the notebook and its order and contents, she told the class that they could get their “cool Georgia Bulldog notebooks at Wal-Mart” (Observation, 8-6-2007, Line 154). She then joked around with one student who claimed to be a Florida Gator fan.

Daniel – That’s OK, I’m a Gator fan.

J – No you’re not.

Daniel – Yes, I am.

J – You can’t be.
Daniel – I am a Gator fan.

J – It’s not possible.

Daniel – It is.

J – Well, I also have my Gator hater sign for those that haven’t seen it yet. So now you know.

Daniel – That’s OK…(keeps talking, she ignores.) (Observation, 8-6-2007, Lines 155-164)

The remainder of the period, Jessica guided the whole class discussion about what a linear relationship is. On day two, Jessica again spent class time talking about non-mathematical topics. I have already shared an example of how she talked with Dustin about his fishing competition. She also walked around the room and questioned many people as to where their notebooks were and asked why they did not have one with them. Jessica also discussed the importance of understanding something as opposed to simply memorizing. The students were supposed to be solving two math sentences on the board while Jessica passed out their textbooks. They were to determine if the problems were correct, and if they were not, they were to add something so that they would become correct. The purpose of this activity was to discuss the role and importance of parentheses. There was a whole class discussion regarding the two warm up problems, then the groups were assigned a problem to work on for the remaining 25 minutes of class. What I found interesting was that this was the first time she had asked her students to work together on a problem, and they actually did. Jessica referred to why this situation might be in her interview.

Well, I think that in 8th grade I have an advantage since they’ve done this in 6th and 7th grade too. Hum, a new student coming in from another system can be a little bit lost for
awhile until they realize that we’re not just doing a set of problems. We’re really trying to think about what’s going on. (Interview, 7-23-2007, Lines 69-72)

The following is an example of a discussion that took place in a group of three boys while working on the assigned task.

J – If you’re finding the speed. How are you finding their speed?

Bobby - Um, hours times miles.

J – Hours times miles?

Ray - Yeah, but you can’t go 35 on a bike.

Wesley – No it’s not…

J – OK, you thought that 35 was easy. What does the 35 mean?

Wesley – That’s how far they go, not how fast.

J – OK, now, is 35 on your table?

Bobby - No, it’s not on there.

J – So, what’s 35?

Wesley – 35 is the amount of miles that Mario traveled in 7 hours.

Bobby - Oh, I don’t need the speed, I need the distance for miles.

J – And you have the distance. You have the distance. And you have the number of hours, they traveled.

Notice that every boy in this group contributed to the conversation without any prompting from Jessica.

The math talk level of observation 3 moved up slightly from a level 1 to a level 2- (Hufferd-Ackles et al., 2004). The main thing that kept this class observation from being a solid 2 is that Jessica did not do much to facilitate student-to-student talk. She was still the moderator
of the discussion. However, during this observation, the students began to “stake a position and articulate more information in response to the probes” (Hufferd-Ackles et al., 2004, p. 89). The following passage is an example of students taking a position and explaining why. The original passage was five pages long, so I have cut out and summarized parts.

    J - We got to figure out the independent, dependent thing. So those are two big words that we got to know. We gotta know something about independent and dependent. So you need to know what those words mean. Do you?

    Betty – The distance depends on the time.

    J – Distance depends on time? Do you, so you do know about this dependent and independent business?

    Marco – Yes.

    J - OK. Good. And you think distance depends on time. Did I say what you said right?

    OK, we got one vote for distance depends on time.

    Ss – No, time depends on distance.

    J – I just love it when ya’ll don’t agree.

    Tucker - I think distance depends on time.

    J – OK, let’s vote. (Observation, 8-8-2007, Lines 180-192)

Jessica wrote on the board the two ideas that time depends on distance and distance depends on time. She asked the students to vote on which statement they believed to be true.

    Tucker - How far you go depends on the time.

    J – How far you go depends on the time you ride?

    …
J – Well, let’s think about it this way. The amount of time you ride depends on how far you go.
Ss – Yeah.

…

J – You gotta think about it both ways and decide which one makes the best sense to you.
Nate - I think the longer, like, if you say you want to ride your bike and your mom says, no, you have no time. So you don’t get to go at all. But if your mom says you have one hour, say, I don’t know, say you go your certain rate. We’ll still get to ride then. So I think distance depends on time. Cause without time, you can’t get any distance at all.
J – OK, did you three hear what Nate said? Did it make any sense to you, what he said?
OK, one of ya’ll give me your argument for this one. Give me an example of why you think you’re right.

Austin – Like, the um, the more distance you go, the more time increases.

Lynn - I don’t know how to explain it.

J – The more distance you go, the more your time increases?

Austin – Yes.

…

Sheryl - But if you stop riding, your time isn’t gonna stop with you. But if you stop riding, then, like…Cause time depends on distance like he was saying. If you stop riding, the time’s gonna keep going. I don’t know.

J – I know what you’re saying. Let’s say, I’m just gonna draw a little graph. And you tell me what you think is happening in this graph.
Figure 2. Graph drawn by Jessica.

Talking among the students.

J – What do you think that is? (Someone raised his hand) Yes.

Tucker - I think, you mean like someone riding their bike?

J – What I drew was a line going up, and then it goes horizontal, and then it goes up a little more.

Tucker - He went riding and then he stopped and then he went again.

Royce – Stopped for a long time

…

More comments

…

Austin – Oh, I think I changed my mind, now that I thought about it. (Observation, 8-8-2007, Lines 209-289)

This whole class discussion took place on the third day of school. Notice how Jessica asked an evaluating question (Krathwohl, 2002) when she drew a line graph on the board without any labels or numbers and asked the students what it represented. Although there were a lot of different students that joined in the discussion, Jessica always talked between them. No one just
spoke up in response to what someone said, nor were they encouraged to talk with each other about the topic.

By the fourth observation, the level of math talk had moved to a level 2 and remained there throughout my remaining observations. I did not observe the students accept responsibility for the mathematical questioning. Although they had gotten proficient at answering questions and providing rather full explanations, they still depended on Jessica to ask the questions.

As the observations progressed, Jessica revoiced less and asked students more often to restate what another student said. This trend occurred regardless of whether the mathematical discussions were whole group or small group. However, one observation that stood out to me on Jessica’s summary chart was observation 4. On that day Jessica provided an extremely high number of praises and encouragements as well as a high number of modeling moments. Up to this point, I have described lessons in which the majority of mathematical discussion took place as a whole group. My conclusion regarding this unusually high number of incidences is that this was the only observation where students worked in groups on a task from the beginning of class until the end of the period. The other observations consisted of either all whole group discussion or a combination of group discussion and small group work. I suspect that because the students were working in small groups all period, it was possible that Jessica felt the need to provide a little more encouragement and support to the group members.

This observation included the excerpt earlier in which Jessica spent time with a group of boys discussing the equation they had written to describe how much money Jamal has left at the end of each day. The boys questioned Jessica by accusing her of telling them that they were wrong. She encouraged them by saying that she never told them they were wrong; she simply liked to ask questions to make sure that they truly believed what they had written. Another
example of encouragement took place when Jessica visited a table of four girls. One of the girls asked Jessica to look at her graph. “I would love to check your graph. I got one issue with you, and that’s that I don’t know where the numbers go…Fix your boo boo. Cause you can fix this easy. The way your graph looks is right” (Observation, 8-9-2007, Lines 343-351). Jessica also spent a lot of time during this observation helping students get their graphs looking exactly right. She did not care what scale the students chose to use, but she was adamant that the axes be labeled and that the scale increase by the same increment. Many students did not start the graph with (0,0). “I want attention to detail. Detail” (Observation, 8-9-2007, Line 387).

As with Gayle, I could not discern a consistent formula that Jessica followed when guiding mathematical discussions. The examples given provide evidence that Jessica believed that her students could do the mathematics, and that by talking about it they would come to a better understanding of the concepts. She believed that questioning was a powerful tool in helping students clarify their thinking and in helping students learn from others. The examples provided also show a teacher effectively using math talk moves within the classroom to guide students in listening to others (Chapin et al., 2003).

*Comparison of Gayle and Jessica*

Both Gayle and Jessica had the same goal of wanting their students to talk about mathematics. They both mentioned in their interviews that coming up with activities for students to talk about was not an easy endeavor and took a lot of time. Although this was not a research study about the Connected Mathematics Project, both teachers stated in their interviews that the curriculum made it much easier to expect mathematical discussions. The curriculum provided mathematically rigorous tasks that were relevant to everyday life. The tasks were not easy and therefore, it made sense for the students to work together and talk about the problems.
Although the two teachers used many of the same techniques, their personalities and teaching styles were quite different. Gayle was soft spoken and made an effort to stroke each child emotionally so that s/he would try and not give up when a task became difficult. Jessica was more aloof, yet she developed a rapport with her students through joking and group conversations. Gayle reminded me of a Tinkerbelle, flitting from group to group, providing praises and encouragement and asking probing and guiding questions to help the groups move forward. However, if she stayed at any one group too long, they began to depend on her for answers, and many of the other groups would become restless. My observation was that her students ran on batteries rather than electricity, and she was the recharger. Jessica, on the other hand, reminded me more of a badger. Badgers spend most of their time digging underground, and Jessica spent most of her time digging into the brains of her students, trying to get them to go deeper with her in their mathematical thinking.

One of my goals in this study was to be able to articulate specific moves a teacher makes to foster and sustain discourse to aid me in my own teaching and my work with other teachers in professional development. I was able to identify specific things that Gayle did to facilitate mathematical discourse but had a more difficult time distilling Jessica’s practice into particulars.

Gayle made a deliberate attempt to get her students to talk about the mathematics. She had the students develop classroom norms so that they had some ownership in the behavior management system in the classroom. She regularly reminded them of the norms and had them self assess how they functioned within the norms on particular tasks. She worked hard at developing personal relationships with the students by providing encouragement and praise on a frequent basis. Not only did she call students by name, but she also used terms of endearment, such as “sweetie,” “dear,” and “honey.” She made a deliberate attempt to regularly have groups
share with the class what they had learned in their groups following each task. She would give
the groups plenty of notice regarding the part(s) they would be sharing. Knowing that they had to
give a presentation to the entire class seemed to cause students to engage more earnestly in their
small group discussions. They had to work together to prepare a product to share and had to
decide who was going to say what. Gayle began the presentations slowly at first, calling on the
groups that finished early but she quickly began to include everyone in the presentations.

One of the reasons that I was not able to articulate specific moves that Jessica made to
facilitate mathematical discourse might be that she taught in a school with a school-wide
discipline plan and where students were used to working meaningful and cognitively challenging
mathematical tasks. (Recall that this was the sixth year of this school system using CMP.) Thus,
Jessica did not have to spend time developing classroom norms or coaxing the students to talk
about the mathematics. Another possible explanation, but one that I reject, is that mathematical
discourse came more easily to Jessica’s students because of their demographics. Although
Jessica’s students were quite different from Gayle’s students, Jessica’s students were
heterogeneously grouped. She taught in a school where 43% of the students were from
economically disadvantaged homes, and there is a government housing project complex located
within walking distance of the school. Jessica’s school was the only middle school in the county,
so her school served all children in the area; the poorer children did not attend a different middle
school. Thus, I attribute the differences in the ease with which Jessica’s students jumped into
mathematical discourse to the school environment and not to demographics.

There were many techniques that I learned from both teachers. The first is that we must
provide the most challenging curriculum possible for all of our students, regardless of whether
our classes are heterogeneously or homogeneously grouped and whether our students are
economically disadvantaged or not. We simply may need to provide more support and discourse guidance to some students than to others. For any teacher wanting to orchestrate discourse in the classroom, questioning will play an important role. She must provide easy to access questions as well as thought provoking questions that require students to apply what they know and to make conjectures regarding the mathematics available. Chapin et al. (2003) provided a helpful guide to implementing mathematical discussions in the classroom. Revoicing what a student has said to clarify what you heard or to simply provide a second opportunity for students to hear is important. The next step is to ask students to repeat what they heard another student say. When students realize that someone else may be asked to repeat what he/she has just said, they may become apt to speak more clearly (Chapin et al., 2003). Asking students if they agree or disagree with a position someone has just taken and then asking for an explanation causes students to listen carefully to what others are saying so that they may be capable of making a comment if asked. A similar move is asking a student to add to what someone has just said. And of course, not rushing students’ thoughts by giving them time to think before requiring a response is a powerful tool. Another thing that I learned is that mathematical discussions can take place in various formats – whole class discussion, between a small group and the teacher, and between students. The final thing I have learned from these teachers is that the classroom teacher must make the commitment to herself and her students that she is going to require that they talk about the mathematics and not quit. Persistence is the key to developing a classroom environment in which mathematical discussions take place.
CHAPTER 5

CONCLUSIONS

Summary

This qualitative research study was designed to answer the question “How do middle school mathematics teachers orchestrate a classroom environment that fosters mathematical discourse among students from low socio-economic backgrounds and with limited experiences?” I chose two participants from different school systems to include in my study. I particularly sought teachers who were teaching in a setting with a student body largely from low socio-economic status because I wanted to learn how one helps such a group of students engage in mathematical discourse. Gayle, a 27-year classroom veteran, taught in a Title I school where 88% of the students were considered economically disadvantaged. Her class consisted of one white, four Hispanic, and eight black students. With 14 years of teaching experience, Jessica taught in a school where 43% of the students were economically disadvantaged. She had a total of one mixed race, two Hispanic, 12 black, and 17 white students in the two classrooms that I observed.

A triangulation of methods was used to gather data for my research. I interviewed each teacher during the summer to determine her goals for and expectations of her students, her classroom management techniques, and the strategies she employed to encourage mathematical discussions in her classroom. Because I chose teachers from school systems that began school on different weeks, I was able to observe every day of the first week of school for each teacher. I then observed Gayle four more times and Jessica three more times over the next 12 weeks. Each
lesson was audio-taped and transcribed. I also gathered archival data such as the tasks presented to the students and reflections that the participants emailed throughout the observation period.

When analyzing data, I first transcribed and coded the interviews. Next, I set up an initial coding system for the classroom observations. I looked for the main themes that came from the interviews like developing relationships and promoting confidence. I also looked for themes that came from the literature – classroom management; math talk moves (Chapin, et. al., 2003); and Hufferd-Ackles et al. levels of questions (2004). Once all observations were coded, I went back and coded a second time. This time I looked at each question again, in light of the revised Bloom’s Taxonomy of educational objectives (Krathwohl, 2002).

From the data, I formulated three conclusions regarding the orchestration of mathematical discussions in the middle school classroom. There is no one way to initiate mathematical dialogue, but the implementation of math talk moves (Chapin, et. al., 2003) transcends the personalities of the teachers, the environment of the schools, or the level of student poverty. The second conclusion regards the relationship between small and large group discussions. When students are expected to present to the whole group what their small group accomplished, students are more likely to talk about the mathematics in the small group without a lot of prompting. The final conclusion is that the teacher’s relationship with high poverty students is essential. When the teacher knows her students, she is more able to vary her levels of questioning appropriately, whether to sustain student engagement or to push the student to the next level.

The classroom teacher must first commit to the goal of orchestrating mathematical discussions in her classroom. It is not a simple task; however, heeding the conclusions stated above can assist in the process. In addition, the teacher must be persistent and not give up when the students show resistance to talking about the mathematics.
Major Conclusions

I have concluded that there is no one way to initiate mathematical dialogue in the classroom. However, regardless of teacher personalities, the school environment, or the level of student poverty, Chapin et al.’s (2003) math talk moves were evident an average of at least 14 times per class period in each classroom. Interestingly, neither teacher had ever read Classroom Discussions by Chapin et al. (2003), yet they naturally used the moves discussed in the book. In agreement with Chapin et al. (2003), it was obvious that asking students to restate, agree or disagree with, or add to what another student has said increased student engagement in the mathematical dialogue. These moves can take place whether in small group or whole group discussions.

The second conclusion includes the connection between small and large group discussions. Either format is useful when having students discuss the mathematics. However, the teacher must determine what works best for her students. Most of Jessica’s students responded well to long, informal, whole group discussions and stayed on task. However, Gayle’s students needed to be more actively involved at all times. Whole group discussions in her class consisted of small groups presenting evidence of what they had accomplished together. This format was more structured and assured participation of all students. When students were expected to present to the whole group what their small group accomplished, the students were more likely to talk about the mathematics in the small group without a lot of prompting.

The final conclusion is that the teacher’s relationship with all students is important (Marzano, 2003); however, with high poverty students a relationship is essential (Brand et al., 2003; Midgley et al., 1989; Niebuhr & Niebuhr, 1999; Parsley & Corcoran, 2003; Payne, 1996; Pelilino, 2007). Therefore, although math talk moves (Chapin et al., 2003) are necessary to
implementing mathematical discussions, they are not sufficient in isolation when working with students from poverty. Gayle had her students doing things that I rarely observed in other classes where the majority of the students were from poverty. When the teacher knows her students, she is more capable of appropriately varying her levels of questioning, whether to sustain student engagement or to push the student to the next level. Research reported that at-risk students are not familiar with reform-based curricula and, as a result, do not feel comfortable with the demands (Parsley & Corcoran, 2003; Pelilino, 2007). Students of poverty will trust a teacher who tries to develop a relationship with them and will trust her attempt at increasing their levels of self-efficacy. When the teacher knows her students, she realizes when it is time to scaffold to provide the necessary assistance for the students, or to ask the low level question that the student can easily answer (Brophy, 1998; Pelilino, 2007).

Implications

Research has already shown that mathematical discussions are important in helping students construct their own mathematical understandings (e.g. Chapin et al., 2003; Elliott & Kenney, 1996; Hiebert et al., 1997). Yet, my experience in trying to locate potential participants was evidence that not enough mathematical discussions take place in middle school classrooms. Therefore, we need to find ways to help teachers incorporate discussions in their teaching. As a professional developer, I would recommend that administrators introduce their mathematics teachers to Chapin et al.’s (2003) work in Classroom Discussions. This could be provided by an outside professional developer, or it could be part of a book study conducted by the teachers themselves. Supportive follow-up meetings in which teachers share the results of their efforts to use talk moves from the book might help teachers implement classroom discussions more successfully.
In my own professional development courses, I modeled for teachers pedagogical strategies for them to implement in their classrooms. Teachers worked in groups and presented to the class their strategies and results. They also shared excitement in the process and many said that they would implement discourse and group presentations. However, when I observed these same teachers in their classrooms, I saw no evidence of implementation. Both Gayle and Jessica discussed how valuable it was to have intensive on-site support when they were asked to drastically change their teaching approach. As professional developers we should consider providing on-site support along with the course instruction. It is becoming a trend for schools and systems to hire math coaches. However, it is imperative for these coaches to be well trained in both mathematical content and coaching strategies.

An additional implication is the need to make teachers aware of the importance of relationships, especially when working with students from poverty (Parsley & Corcoran, 2003; Brand et al., 2003; Payne, 1996; Midgley et al., 1989; Niebuhr & Niebuhr, 1999; Pelilino, 2007). This concept is usually presented when teachers attend conferences or workshops on classroom management (Alderman, n.d.; Marzano, 2003); but, not every teacher receives such training, and it is rarely connected to mathematics teaching. I would suggest that administrators investigate the possibility of a school-wide focus on relationships.

This previous discussion leads to the final implication. Consideration should be given to the value of school-wide expectations and a focus. Jessica was able to spend much less time than Gayle setting up classroom norms and group work expectations because Jessica’s students were 8th graders in a school that had common expectations. All teachers used CMP II and expected their students to talk about the mathematics. Therefore, Jessica was able to move her class quickly from a level 0 to a level 2 math-talk learning community (Hufferd-Ackles et al., 2004).
Suggestions for Future Research

There are several research ideas that can come from this study. If a middle school decided to do a book study using *Classroom Discussions* (Chapin et al., 2003), a researcher could follow that study and determine its effectiveness. The researcher might investigate the challenges the teachers face, the areas where they have the most success, how they overcome student resistance, and what forms of school-level support are most useful. The researcher could also study two similar schools implementing a book study using *Classroom Discussions* (Chapin et al., 2003) and compare the implementation in two different settings.

As discussed earlier it was difficult for me to find middle school teachers with a reputation of regularly engaging their students in mathematical discussions. One could investigate how to translate the pedagogical strategies of expert teachers, like Gayle and Jessica, to other teachers. In addition, since both Gayle and Jessica discussed the importance of having on-site support, research could also be conducted regarding the types of and effectiveness of on-site support. Many schools have mathematics coaches, but are they being successful, why or why not?

Hufferd-Ackles et al. (2004) studied the practices of a third grade teacher implementing mathematical discussions. Although the teacher started out as a very traditional teacher, she may have had an advantage in orchestrating mathematical discussions because she also taught the same students when they were in second grade (Hufferd-Ackles et al., 2004). A researcher could study the how mathematical discussions develop as a middle school teacher loops from 6th to 7th to 8th grade with the same group of students. In addition, a researcher could also follow a teacher trying to implement mathematical discussions in her class for the first time. What struggles and successes does she experience? What support, if any, is provided? What is the effectiveness of
that support? In response to support, a researcher could investigate how a mathematics coach can support the orchestration of mathematical discussions in a middle school using a reform based curriculum, like CMP II.

Although I conducted some quantitative analyses of the data, a similar study could be done with a more explicit quantitative approach. For instance, a researcher could take a quantitative look at the percentage of words spoken by the teacher and the percentage of words spoken by the students to see if there is a connection to the math-talk community levels (Hufferd-Ackles et al., 2004) as the classroom community evolves.

Final Thoughts

This study was born out of my frustrations with my own lack of success at orchestrating classroom discourse with students of poverty and my growing awareness that such discourse was essential to the successful implementation of more rigorous curriculum standards and reform-oriented curriculum materials. In my current role as a professional developer responsible for helping teachers face the challenges of implementing new standards and curricula, I felt ill-equipped to help teachers orchestrate mathematical discourse in their classrooms. Thus, at the outset of this study I was hoping to find a list of “how to’s” that I could share with teachers that would help them transform their classrooms into communities where everyone was engaged in mathematical dialogue. What this study has demonstrated is that there are no simple recipes for fostering discourse and that every teacher must use methods that are appropriate to her students, school context, and personality.

This study shows that building relationships with one’s students is the crux of starting classroom discourse, an activity which makes students feel vulnerable. Asking students to share their mathematical thinking with their peers, particularly at the middle school level where social
concerns and peer pressure are prevalent, can be a source of anxiety for students. Thus, it is imperative that they have relationships with their teachers that help them not to fear ridicule. Such a relationship will further their feelings that their ideas are genuinely valued and needed in order to move the discussion forward. The result of these student-teacher relationships has a positive affect on student-student relationships. They become interdependent in positive ways, thus making them more willing to contribute to the classroom discussion.

*Epilogue*

After the data for this research were collected, Gayle was pulled from her coaching duties for several weeks to fill in for the unexpected death of another teacher in her school system. When Gayle was able to return to the classroom described in this dissertation, she discovered that six students had been removed from the class due to disruptive behavior. In my professional role I attended an afternoon meeting at Gayle’s school and witnessed a student from the observed class tell Gayle how much she missed her teaching them. The student said that they never presented anymore and hardly ever got to work together.
REFERENCES


Appendix A

Interview Protocol

Participant: ____________________________ Date: ____________________

*How* do middle school mathematics teachers orchestrate a classroom environment that fosters mathematical discourse among students from low socio-economic backgrounds and with limited experiences?“

1. Describe your teaching experience. (Number of years, grade levels, subject areas.)

2. When students come to your classroom, what do they expect math to be like? What do you want them to think math is like? What do you do to make that happen?

3. What goals do you have for your students? How do you structure your instruction to meet these goals?

4. What specific methods and procedures do you use to foster productive classroom discourse?

5. Have you always taught by using mathematical discourse? How did you get to this point in teaching? What struggles do you still have?

6. I want to define a ‘critical moment’ as a moment when something happens in the classroom, and the teacher’s response is detrimental to the development of a classroom culture that supports mathematical discourse. Can you name some of these critical moments? How do you try to handle them?
7. Have you ever regretted the way you handled a critical moment? Share that experience.  
   What were the results of your response?
8. How do you encourage reluctant students to speak up?
9. How do you handle students who like to dominate conversation?
10. How do you get students to do more than give an answer or describe a procedure?
11. How do you handle student-to-student ridicule?
12. How do you handle classroom behavior?
Appendix B

Reflection Journal Guidelines

Date(s):

1 - What strategies, inside or outside the classroom (if any), did you intentionally use to promote a community that supports mathematical discourse?

2 - What successes and/or struggles did you experience?

3 - What do you think was the cause of such successes and struggles?

4 - What instructional actions did you take as a result of these successes and struggles?

5 - Always feel free to include any additional information that you would like to share.
Appendix C

Observation Coding: First Round

Questions – TQ0, TQ1, TQ2, TQ3 based on Hufferd-Ackles (2004) levels

SQ0, SQ1, SQ2, SQ3

Promotes Confidence

In doing (trying) PCD

In talking PCT

In mastering PCM

In questioning PCQ

All

Participate AP

Do their own work, write in notebook AW

Follow norms, work together, student-student relationship AN

Give more than an explanation, more than a short answer AE

Off-task Behavior

Address behavior AB

Relevance/Real life RL

Relationships – Teacher-Student

Terms of Endearment RTE

Talk with them RT

Praise RP

Encouragement RE
Personal Questions     RPQ

Modeling

    Organization       MO

    Thinking           MT

Setting up Norms     SN

Talk Moves

    Wait time         WT

    Revoicing        RV

    Restating        RS

    Reasoning        RN

    Prompting        PT

Responding to Wrong Answers     WA
## Appendix D

### Example of Observation Summary

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Gayle Observation 4
Appendix E
Levels of the Math-Talk Learning Community: Action Trajectories for Teacher and Student
(Social Classroom Culture)

Level 0:

A. Questioning: Teacher is the only questioner. Short frequent questions function to keep students listening and paying attention to the teacher. Students give short answers and respond to the teacher only. No student-to-student math talk.

B. Explaining mathematical thinking: No or minimal teacher elicitation of student thinking, strategies, or explanations; teacher expects answer-focused responses. Teacher may tell answers. No student thinking or strategy-focused explanation of work. Only answers are given.

C. Source of mathematical ideas: Teacher is physically at the board, usually chalk in hand, telling and showing students how to do the math. Students respond to math presented by the teacher. They do not offer their own math ideas.

D. Responsibility for learning: Teacher repeats student responses (originally directed to her) for the class. Teacher responds to students’ answers by verifying the correct answer or showing the correct method. Students are passive listeners; they attempt to imitate the teacher and do not take responsibility for the learning of their peers or themselves.

Level 1

A. Questioning: Teacher questions begin to focus on student thinking and focus less on answers. Teacher begins to ask follow-up questions about student methods and answers.
Teacher is still the only questioner. As a student answers a question, other students listen passively or wait for their turn.

B. Explaining mathematical thinking: Teacher probes student thinking somewhat. One or two strategies may be elicited. Teacher may fill in explanations herself. Students give information about their math thinking usually as it is probed by the teacher (minimal volunteering of thoughts). They provide brief descriptions of their thinking.

C. Source of mathematical ideas: Teacher is still the main source of ideas, though she elicits some student ideas. Teacher does some probing to access student ideas. Some student ideas are raised in discussions, but are not explored.

D. Responsibility for learning: Teacher begins to set up structures to facilitate students listening to and helping other students. The teacher alone gives feedback. Students become more engaged by repeating what other students say or by helping another student at the teacher’s request. This helping mostly involves students showing how they solved a problem.

Level 2

A. Questioning: Teacher continues to ask probing questions and also ask more open questions. She also facilitates student-to-student talk, e.g., by asking students to be prepared to ask questions about other students’ work. Students ask questions of one another’s work on the board, often at the prompting of the teacher. Students listen to one another so they do not repeat questions.

B. Explaining mathematical thinking: Teacher probes more deeply to learn about student thinking and supports detailed descriptions from students. Teacher open to and elicits multiple
strategies. Students usually give information as it is probed by the teacher with some volunteering of thoughts. They begin to stake a position and articulate more information in response to probes. They explain steps in their thinking by providing fuller descriptions and begin to defend their answers and methods. Other students listen supportively.

C. Source of mathematical ideas: Teacher follows up on explanations and builds on them by asking students to compare and contrast them. Teacher is comfortable using student errors as opportunities for learning. Students exhibit confidence about their ideas and share their own thinking and strategies even if they are different from others. Student ideas sometimes guide the direction of the math lesson.

D. Responsibility for learning: Teacher encourages student responsibility for understanding the mathematical ideas of others. Teacher asks other students questions about student work and whether they agree or disagree and why. Students begin to listen to understand one another. When the teacher requests, they explain other students’ ideas in their own words. Helping involves clarifying other students’ ideas for themselves and others. Students imitate and model teacher’s probing in pair work and in whole-class discussions.

Level 3

A. Questioning: Teacher expects students to ask one another questions about their work. The teacher’s questions still may guide the discourse. Student-to-student talk is student-initiated, not dependent on the teacher. Students ask questions and listen to responses. Many questions are
“Why?” questions that require justification from the person answering. Students repeat their own or other’s questions until satisfied with answers.

B. Explaining mathematical thinking: Teacher follows along closely to student descriptions of their thinking, encouraging students to make their explanations more complete: may ask probing questions to make explanations more complete. Teacher stimulates students to think more deeply about strategies. Students describe more complete strategies; they defend and justify their answers with little prompting from the teacher. Students realize that they will be asked questions from other students when they finish, so they are motivated and careful to be thorough. Other students support with active listening.

C. Source of mathematical ideas: Teacher allows for interruptions from students during her explanations; she lets students explain and “own” new strategies. (Teacher is still engaged and deciding what is important to continue exploring.) Teacher uses student ideas and methods as the basis for lessons or mini-extensions. Students interject their ideas as the teacher or other students are teaching, confident that their ideas are valued. Students spontaneously compare and build on ideas. Student ideas form part of the content of many math lessons.

D. Responsibility for learning: The teacher expects students to be responsible for co-evaluation of everyone’s work and thinking. She supports students as they help one another sort out misconceptions. She helps and/or follows up when needed. Students listen to understand, then initiate clarifying other students’ work and ideas for themselves and for others during whole-class discussions as well as in small group and pair work. Students assist each other in understanding and correcting errors.