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ABSTRACT

Three mathematics teachers and 10 of their ninth grade students were observed and interviewed during a 6-week period. One teacher claimed that her main challenge--implementing a student-centered curriculum--was her doubt that students would make the right connections without her explanations. Another teacher struggled with the dynamics of operating both small-group and whole-class discussions and ultimately decided not to hold whole-class discussions. A third teacher achieved a more equal balance between teacher-directed and student-centered activities. All three teachers demonstrated more difficulty than students changing their expectations about appropriate mathematical activity. (Author)

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HIGH SCHOOL TEACHERS' EXPERIENCES IN A STUDENT-CENTERED MATHEMATICS CURRICULUM

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Three mathematics teachers and ten of their ninth grade students were observed and interviewed during a six-week period. One teacher claimed that her main challenge implementing a student-centered curriculum was her doubt that students would make the right connections without her explanations. Another teacher struggled with the dynamics of operating both small-group and whole-class discussions and ultimately decided not to hold whole-class discussions. A third teacher achieved a more equal balance between teacher-directed and student-centered activities. All three teachers demonstrated more difficulty than students changing their expectations about appropriate mathematical activity.

It is now well documented that many mathematics teachers communicate a narrow view of mathematics—as a set of fixed procedures to be mastered by students (e.g., Thompson, 1992). In contrast, reform movements, including many specific curriculum development projects in the United States, are guided by a growing consensus that school mathematics should be portrayed as an exciting subject to be understood and explored. This paper describes the experiences and conceptions of three high school teachers attempting to implement a student-centered mathematics curriculum that explicitly supports the assumption that mathematics is a vibrant and useful subject. The paper focuses on two main themes: (a) how teachers (and to a lesser extent, students) made the transition from a teacher-centered to a student-centered classroom, and (b) teachers' and students' beliefs about mathematics, particularly the mathematics suggested by a specific set of curriculum materials.

Because we were interested in describing how mathematics teachers' conceptions were related to their classroom decisions and actions, we considered research related to teachers' conceptions of mathematics and mathematics teaching (e.g., Thompson, 1992). Since we wanted to interpret teachers' and (to a lesser extent) students' conceptions, decisions, and actions in a climate of change, we investigated literature (both general and in mathematics) related to the intellectual growth of adolescents and adults (Belenky et al., 1986; Cooney, 1994; Copes, 1982; King & Kitchener, 1994; Perry, 1970). Expecting students to explore and understand mathematical ideas requires them to accept much of the responsibility or authority for determining, for example, appropriate procedures and methods to solve problems. We were interested particularly in learning about participating teachers' and students' beliefs about pedagogical authority (i.e., where the authority of mathematical correctness and understanding lies—with the teacher, the textbook, or the student) and so we focused on what this literature said about authority.

Design

Curriculum Materials, Participants, and Research Sites

Teachers and students in this study used materials generated by the *Core-Plus Mathematics Project (CPMP)*, a curriculum that encourages and supports teachers in organizing the classroom so students can explore mathematical concepts, work cooperatively, learn from each other, and think about and solve interesting problems (Hirsch, Coxford, Fey, & Schoen, in press). Three teachers (one female, two male) were selected from two high schools in neighboring public school districts located in a small northeast urban community. All three had taught for 10 or more years, but none had previously taught using *CPMP* materials. Ninth grade mathematics classes (one taught by each teacher) were observed daily for 5-6 weeks during November and December of 1994. This study took place while classes participated in a unit called *Patterns of Change*, the second unit in the ninth grade *CPMP* sequence. All three teachers were well-established traditional teachers (by their own admission) and recognized at the outset of the study that change would not be easy. Yet all were extremely enthusiastic about using the *CPMP* materials and incorporating the accompanying suggestions.

Data Collection

Teacher and student data were collected between September 1994 and June 1995 using interviews, observations, and students' and teachers' written work and plans. Two one-hour interviews conducted during September and October of 1994 investigated each teacher's conceptions of mathematical functions and of mathematics and mathematics teaching more generally. During a five- to six-week period in which classes were observed daily, each teacher was interviewed four or five times. These hour-long interviews allowed teachers to comment on recent classroom events. One group of students (3-4 students) was identified by each teacher as a target group. Students in target groups were observed and interviewed periodically during class sessions. After students had completed the observed unit, hour-long interviews with 10 target group students encouraged them to comment on their experiences in the observed classes. An hour-long interview at the end of the observation period (December 1994) assessed each teacher's immediate reflections on his or her experiences teaching the unit. To allow teachers to reflect on the entire year's experience, as well as enable them to comment on their resolutions for the next year, teachers were also interviewed at the end of the academic year (June 1995) in a group setting. Fieldnotes were taken during classroom observations and all observations were video recorded, with a cordless microphone carried by the teacher. Teacher and student interviews were audio recorded and transcribed for ongoing analysis. Photocopies were made of the written artifacts (e.g., student work).

Findings

Student-Centered vs. Teacher-Centered Activities

For all three teachers, a dichotomy existed between "a cooperative learning atmosphere" and "a teacher-centered" or "traditional" one. This dichotomy manifested itself in various ways as teachers contrasted their prior experience to what they were trying to do in the *CPMP* class. Ms. Gifford, like the other teachers, communicated an understanding of the intent of *CPMP* curriculum materials. In an early interview she explained: "In theory the teacher goes from being ruler or dictator who is disseminating all the information, to a facilitator. . . . As kids are doing work, you're there to assist." She further described the students' role in this model classroom: "[the mathematics is] something they can get out of their seats and put their hands on and have some ownership of the data that's being used. Rather than my giving them whatever equation, they come [up with the] relationship." However, Ms. Gifford felt like she did "too much front of the room instruction" in her *CPMP* class. Citing as her biggest challenge the fear that her students would not be able to make appropriate connections on their own, she frequently interrupted or even eliminated small group work. She lamented often feeling that she had to "jump in there and save them" and that she had difficulty "letting students go." Of the three classes we observed, Ms. Gifford's was indeed the most teacher-centered. Additionally, her students were the least inclined to describe their *CPMP* class as being radically different from other mathematics classes they had experienced. However, Ms. Gifford (as well as the other teachers) expects that her transition from "dictator" to "facilitator" will become easier in subsequent years, as she gains experience with the *CPMP* program.

Mr. Allen also communicated concern about student abilities, but in his class we observed a substantially different routine. During almost any given class period, after a brief introductory whole-class discussion, students worked in groups of three or four for the entire time. Mr. Allen circulated among the groups, answering questions and helping individuals and groups to stay "on task," but he rarely called the whole class together for sharing, questioning, or summarizing. One reason for his decision to permit extensive group work was that Mr. Allen wanted his students to learn to rely upon other group members (and themselves) instead of solely on him. However, he admitted that his decision to not interrupt group work was due mainly to his previous unsuccessful attempts to gather students together for whole-class discussions. Although he believed whole-class discussions were important, he felt uncomfortable with the "in and out" movement between group work and teacher-centered instruction and thus chose to explain and share important connections and generalizations with small groups of students. In an effort to further compensate for what he perceived to be inadequate teacher direction, Mr. Allen often supplemented curriculum materials with teacher-constructed review sheets.

Mr. Johnson was more inclined than Mr. Allen to interrupt small-group discussions to discuss important conclusions but he was not nearly as directive as Ms.

Gifford. Mr. Johnson attributed his ability to easily and comfortably lead transitions between student-centered and teacher-directed activities to his experience teaching computer science courses, in which he organized class as a sort of "lab." The following example is somewhat typical. Before the class period, Mr. Johnson made overheads of one group's work. During the class discussion, the students from this group stood in front of the class and pointed out connections between a graph, equation, and table they had generated. Mr. Johnson helped them do this by standing in the back of the room and asking questions, making comments, and providing encouragement, but he was careful to let students explain most of the important connections and conclusions.

Although Mr. Johnson considered himself to be very capable of leading effective whole-class discussions and he believed that such interactions were sometimes necessary (even teacher lectures), he was convinced that to meet the needs of all his students, he needed to let them do most things in groups. During interviews he frequently commented that many students thought that teacher lectures were "boring and confusing" but that group explorations were "refreshing." For example, during one interview he claimed that he lost "half his students when he talk[ed]." On another occasion, he explained that in past years 90% of his students were so "turned off" by his lectures that he could "do anything and they would just sit there." In such situations, Mr. Johnson would plead, "My God, you guys are dead!" and students would respond, "but it's boring." He agreed, describing traditional, teacher-directed classrooms as being very boring and ineffective.

A related issue concerns sources of pedagogical authority. The teachers communicated, both by the ways they taught and by the things they said, that they wanted students to take more responsibility for learning. For example, they insisted that students work cooperatively. Teachers wanted students to become less dependent on them (teachers) and more dependent on each other. During our post-unit interview we asked students to describe how, in this mathematics class, they would typically decide when they had done a problem correctly. Students who did ultimately refer to the teacher as a source of "correctness" (only about half did), did so after first explaining the important role of peers and discussion within groups to determine correctness. This result, together with our observation and teachers' claims that students preferred to work cooperatively on interesting problems (rather than in a teacher-centered environment), contrasts with the image described by Borasi (1990) of the "invisible hand" of students' expectations operating in mathematics classrooms. Borasi claims that students' expectations often encourage the adoption of a traditional, teacher-directed classroom model, despite teachers' efforts to do otherwise. Students in our study *enjoyed* the student-centered, problem-driven activities and had little difficulty adapting to them.

What Constitutes Appropriate Mathematics?

Participating teachers were deeply committed to change. As the previous section illustrates, to varying degrees, all three teachers were successful in changing their practices to incorporate student exploration and cooperation. Not surprisingly,

during our end-of-the-year interview, all three teachers were able to identify positive and negative aspects of the *CPMP* and traditional curricula, and all favored the more useful understandings that students acquired in the *CPMP* curriculum. Although they did maintain concerns about public acceptance of the program (e.g., college admission, state testing), in general they were happy with the *CPMP* approach. But despite their claimed and observed shift, these teachers struggled longer than their students in changing their traditional views about what constitutes appropriate mathematics and mathematical activity. Further, the teachers' struggle to change (at least their early struggle) seemed to be masked by reference to the difficulty of getting students to change their expectations. From the outset of our study, teachers maintained that because *CPMP* classes were not like ordinary mathematics classes emphasizing traditional topics such as solving equations, factoring, etc., many students in those classes felt like they might "miss out." Although we observed some dissatisfaction and concern among students at the beginning of our study, during our formal interviews with target students at the end of the *Patterns of Change* unit (December, 1994), few of them commented that they were concerned with the non-traditional focus or content of the class. In fact, students reported *liking* the fact that the mathematics they were studying had meaning and application.

Discussion

Our results about teachers' and students' conceptions of what constitutes appropriate mathematics, as well as student conceptions about where the authority of mathematical correctness lies, point to at least two possible implications for curriculum and teacher development. First, individuals who develop and implement new curricula need to be aware that teachers often perceive student pressure or resistance to be stronger than it really is. Second, teachers who plan to do innovative things should understand that although student resistance is often strong at the outset, it lessens as time goes on.

Students in our study had a less difficult time than teachers adjusting to a student-centered classroom environment, one in which the teacher, to a lesser extent, was the ultimate authority. In one sense, this seems surprising. Adolescents are generally *more* inclined than adults to rely on outside authority for verification of legitimacy or truth. However, it is also the case that adolescents are less reflective than adults (King & Kitchener, 1994). Students did not struggle as much with the adjustment to a student-centered environment because they probably did not think much about it. To them, the authority (teacher) set things up that way so that is the way it was. On the other hand, the teachers were not only attempting to do something with which they were unfamiliar and felt considerable outside pressure to resist, but were actively thinking about the pros and cons of the new setup and whether it actually worked better. It is not surprising then that they struggled longer than students.

All three teachers commented that *CPMP* students were more difficult to bring together for whole-class discussions than students in other, more teacher-centered classes. This difficulty posed such a problem for Mr. Allen that he rarely attempted

to gather students together, except at the beginning of class. Some teachers (particularly very traditional ones) may interpret this student tendency as a lack of respect or as evidence of a teacher's inability to appropriately "manage" the classroom (Mr. Johnson would not agree—he claimed that *CPMP* classes were *easier* for him to manage). But perhaps this tendency is simply an indication that students are accepting responsibility for their own learning. When students are given more of the authority or responsibility for learning, it is more difficult to "interrupt" their activities to do activities that are primarily teacher directed. This new classroom dynamic needs to be recognized and addressed by curriculum developers and others interested in reform.

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