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ABSTRACT

The purpose of this two-year study was to document and examine changes in four teachers' beliefs and practices while implementing National Council of Teachers of Mathematics' (NCTM) mathematics standards. Qualitative research methodology was used to develop multiple case studies, which were analyzed individually and across cases. Data came from interviews, observations, journals, attitude and belief surveys, and videotapes. The participants were four elementary-certified teachers in a suburb of a large urban area in a midwestern state who volunteered to teach 6th grade mathematics full-time. The teachers were supported during implementation by colleagues, administrators, professional development resources, and availability of materials. Problems reported included limited knowledge of: (1) NCTM's mathematics standards, (2) current mathematics teaching methodologies, and (3) mathematics content. Documented changes included an increase in student-centered activities, the use of manipulatives and calculators, and good questioning techniques. There were also increases in student participation, teacher and student attitudes toward mathematics, use of alternative assessment, and a change in the beliefs of teachers about mathematics teaching and learning. Contains 34 references. (Author/MKR)

An Exploration of Change in Teachers' Beliefs and Practices During Implementation of Mathematics Standards

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Abstract

The purpose of this two-year study was to document and examine changes in four teachers' beliefs and practices while implementing NCTM's mathematics Standards. Qualitative research methodology was used to develop multiple case studies which were analyzed individually and across cases. Data came from interviews, observations, journals, attitude and belief surveys, and videotapes. The participants were four elementary-certified teachers who volunteered to teach 6th grade mathematics full-time. The teachers were supported during implementation by colleagues, administrators, professional development, and availability of materials. Problems reported included limited knowledge of (a) NCTM's mathematics Standards, (b) current mathematics teaching methodologies, and (c) mathematics content. Documented changes included an increase in (a) student-centered activities, (b) the use of manipulatives and calculators, and (c) good questioning techniques. There were also increases in student participation, teacher and student attitudes toward mathematics, use of alternative assessment, and a change in the beliefs of teachers about mathematics teaching and learning.

An Exploration of Change in Teachers' Beliefs and Practices During Implementation of Mathematics Standards

A growing number of teachers are implementing the National Council of Teachers of Mathematics' (NCTM) *Curriculum and Evaluation Standards for School Mathematics* (1989) and NCTM's *Professional Standards for Teaching Mathematics* (1991). This requires a significant shift in teachers' beliefs and practices about mathematics teaching and learning (Wood, Cobb, and Yackel, 1991). The purpose of this two-year study was to document and examine changes in four teachers' beliefs and practices while a transition from traditional to a closer approximation of NCTM's Standards mathematics program was being implemented. Qualitative research methodology was used to develop multiple case studies which were analyzed individually and across cases.

Data came from interviews, observations, journals, attitude and belief surveys, and videotapes. The participants were four elementary-certified teachers who volunteered to teach 6th grade mathematics full-time. The teachers were supported during implementation by interactions with colleagues, administrators, and researchers, professional development opportunities, professional meetings and conferences, and availability of books, equipment, and materials.

Problems reported by teachers included limited knowledge of (a) NCTM's mathematics Standards, (b) current mathematics teaching methodologies, and (c) mathematics content. Documented changes included an increase in student-centered activities, an increase in the use of manipulatives and calculators, and an increase in good questioning techniques. There were also increases in student

participation; teacher and student attitudes toward mathematics, use of alternative assessment, and a change in the beliefs of teachers about mathematics teaching and learning. Although many beliefs remained constant throughout the study, teacher beliefs did not always match their practices.

Theoretical Framework

Research suggests that children's mathematical experience in school results in learning rules and procedures without developing essential conceptual understanding (Confrey, 1985; Clements & Battista, 1990; Heibert & Carpenter, 1992; Skemp, 1976; Steffe, Cobb, & von Glasersfeld, 1988). Low mathematics performance of students, in national and international studies, is usually associated with poor teaching (Ball, 1988; dos Santos, 1993). In particular, in the United States and Canada there is a strong call for school mathematics reform and for developing mathematical literacy and mathematical power in all students (National Council of Teachers of Mathematics, 1989, 1991; National Research Council (NRC), 1989). Reform advocates stress that students should be actively engaged in doing mathematics; in solving routine and non-routine problems; in exploring, testing, and making conjectures about mathematical ideas; and in being responsible for their own learning. Moreover, teachers themselves need experience in doing mathematics - in exploring, guessing, testing, arguing, and proving - to develop confidence with which to respond constructively to unexpected inquiries that emerge as students follow their own approach to mathematical problem solving.

If reform in learning mathematics is to be successful, attention must be given to existing practices of mathematics teachers. As the view of learning

mathematics changes, so must the practice of teaching mathematics (NCTM, 1989 a, b; NRC, 1989). Thus it is necessary to understand the process involved as teachers make changes in their previous ways of teaching mathematics to accommodate the transformation advocated.

The manner in which practicing teachers learn and change is crucial. The reform requires a substantial change in what is termed "tradition of school mathematics" to a practice that emphasizes inquiry mathematics (Cobb, Wood, Yackel, & McNeal, in press). The few research studies that exist on the learning of practicing teachers suggest that change is difficult to achieve and sustain (Richardson, 1990).

Although a constructivist's view of learning mathematic has been commonly accepted by researchers and mathematics educators alike (NCTM, 1989a; NCR, 1989), learning mathematics in school still continues to be dominated by the traditional transmission view of knowledge. Because so many current teachers of school mathematics are themselves products of the "transmission of knowledge" perspective, there is a need to effect what Richardson (1990) has called "significant and worthwhile change" in mathematics teaching practice. Facilitating meaningful change in instruction will entail helping teachers rethink and learn new mathematics content and stances towards teaching and learning (Cobb & Steffe, 1983; Cobb, Wood, & Yackel, 1990; Noddings, 1986; Putnam, Heaton, Prawat, Remillard, 1992). Any attempt to improve the quality of mathematics teaching must begin with an understanding of the conceptions held by teachers and how these are related to their instructional practice. Failure to recognize the role that teachers' beliefs might play in shaping their behavior is

likely to result in misguided efforts to improve the quality of mathematics instruction in schools (Thompson, 1984; von Glasersfeld, 1986).

Changes in school mathematics can occur only if it is also recognized that teachers are key figures in the reform process. Everybody Counts (NRC, 1989b) calls our attention to the fact that curriculum and instruction in our schools and colleges are years behind the times; they reflect neither increased demand for higher thinking skills, nor greatly expanded uses of mathematical sciences, nor what we know about the best ways for students to learn mathematics.

Cooney (1990) provides a perspective in which success of the current reform effort is seen as contingent upon teachers' abilities to shape classroom events and to create learning environments compatible with the present state of knowledge of the learning and teaching of mathematics. Research on teachers' beliefs about the teaching and learning of mathematics shows that epistemological shifts must occur for significant change to transpire (Wood, Cobb, and Yackel, 1991). Benbow (1993) claims that beliefs about the nature of mathematics and attitudes towards mathematics have tremendous effects on mathematical performance. Moreover, subject matter beliefs have been shown to be significant factors in the learning of mathematics (Anderson, Anderson, Martin, and Romagnano, 1993; Hollingsworth, 1989).

The next stage for research as recommended by Cobb, Wood, and Yackel (1991) is to research means of implementation and determine which change agents facilitate or debilitate teachers in transition. Through case studies, it will be shown how individual teachers with different levels of experience are implementing reform. These findings may assist other researchers in determining

what factors are most important in effecting positive change in the teaching and learning of mathematics.

Purpose

The purpose was to describe how teachers and classrooms in one educational setting changed as use of mathematics Standards was increased as a central component in a sixth grade mathematics program. The following questions organized the study a) What motivated teachers to increase use of mathematics Standards in their classrooms?; b) How were teachers supported during implementation of student-centered mathematics instruction?; c) What difficulties did teachers experience during implementation?; and d) What changes occurred in teachers and classrooms as use of mathematics Standards increased? Results regarding teachers' difficulties and accomplishments may be useful to other teachers and researchers and contributes to our understanding of the process of teacher change.

Method

Setting

The community selected for study is a suburb of a large urban environment in a midwestern state. This community has a small-city atmosphere. The middle school selected for study comprises Grades 6 and 7 with 845 students and 67 teachers. The children who attend this school include both socioeconomic extremes, although the number of low SES children are insufficient to qualify for Chapter One funds for government-sponsored mathematics programs. However, eight percent of the students are considered under academic hardship and 65 students qualify for free or reduced lunch through the Disadvantaged Pupil

Personnel Fund (DPPF). The middle school structure at the sixth grade level includes teams of teachers assigned to approximately 125 students.

This school was selected because it has been involved in a comprehensive restructuring program, now in its fourth year. The sixth grade teachers have spent the last three years focusing on developing a strong whole language literature program but to the exclusion of appropriate teaching procedures for promoting mathematics skills and reasoning. Perhaps because of this, teachers in this study relied too heavily on textbooks and paper and pencil tasks while ignoring hands-on exploration of objects that would allow pupils to better conceptualize basic mathematics principles. It was this sixth grade staff who requested university assistance in their mathematics reform effort and subsequently agreed to make this effort a research project.

Process of Change

This study was conducted over a two-year period across three distinct phases of time: Year One--planning year; Summer--intensive professional development; and Year Two--first year of implementation. Year One was spent developing a shared vision of what sixth grade mathematics should comprise. This was done by conducting a self-assessment, visiting exemplary middle schools, attending professional meetings and conferences, participating in in-service workshops, designing a summer institute, reading current literature, and purchasing appropriate books, equipment, and materials.

By January of Year One, the sixth grade teachers, along with their principal, decided to make mathematics a priority in their school. This meant that available funding would be targeted toward mathematics in the coming year. The teachers

were each able to order a classroom set of new textbooks, manipulatives, instructional materials, and supplies. Towards the end of Year One, it was decided that grade six should have full-time mathematics teachers--four teachers volunteered for the job. They knew this commitment would require extra time and effort on their part.

Cooperation between the school and university enabled participants to develop a well-needed summer institute. During the same year, a newly developed Model Mathematics Program (1990) was being mandated for implementation statewide. This Model Program was based upon the NCTM Standards. Each school district in the state was to interpret the model in a way that would match their district environment and needs. The summer institute used the model mathematics program as a basis and used student-centered activities, inquiry-based methodologies, manipulatives, and technology.

After the summer institute, a support system was engendered through the use of graduate students from the university, along with field work pre-service teachers. The graduate students were paired with the four sixth grade teachers who volunteered to teach mathematics full-time. Their job was simply to offer help implementing the new curriculum and assist in any way the teachers needed during Year Two.

Data Gathering

A cyclical process of questioning, observing, and hypothesis generating occurred throughout the three phases of this study (Spindler & Spindler, 1987). There were four major data sources (see Table 1), including interviews (2 per teacher, 30-60 minutes each); observations (20 per teacher, 60-90 minutes each--2

were videotaped); group discussions called Seminars (11 meetings 2-6 hours each); and surveys (2 per teacher and student). There were two types of interview questions used during initial interviews including "grand tour" questions suggested by Spradley (1979) and more specific prompts. For example, questions such as "Tell me your life story as it pertains to mathematics", "Tell me about your mathematics program," or "How have you used mathematics in your classroom?" were used. These "grand tour" questions were followed by specific questions about teachers' challenges, support systems, and reasons for changes in their beliefs and practices.

Insert Table 1 About Here

Classroom were observed to (a) provide a shared experience between the researcher and the teacher to be used as subsequent topics in interviews and project meetings and to (b) enable the development of questions for future interviews that were based specifically on each individual teacher's classroom experience. Large group discussions provided opportunities to document teacher perceptions within the context of a group discussion (Bogdan & Biklen, 1982; Goetz & LeCompte, 1984; Kirk & Miller, 1986) and provided a source of data for triangulation of multiple sources.

Topics for large group discussions were selected by the participating teachers in advance of each meeting. Topics included discussions for professional

development in instructional approaches, evaluation concerns, and reflections on the process of change. After-school meetings assisted the teachers with on-site technical and immediate feedback for their concerns. Other teachers in the school were encouraged to attend. In addition, the middle school teachers' belief and attitude surveys were administered to each participating teacher in June of Year One and again in May of Year Two. .

This study was divided into three distinct blocks of time. The divisions were: Year One--the planning year, Summer--intensive professional development, and Year Two--the first year of implementation. This was done to facilitate analysis and secure appropriate data. These divisions were not predetermined and were heavily influenced by the data-gathering process and on-going analysis. Data collection methods were utilized as appropriate throughout the two years and were adjusted as data analysis informed the study. For example, the idea of establishing a summer institute emerged from Year One planning sessions with the participating teachers.

Other adjustments resulted from on-going analysis. During Year One, interview questions were determined before the study began. Other adjustments were made in response to specific situations. For example, one of the four participating teachers was unable to attend the summer institute because she gave birth to her first son that same summer. During the first year of implementation, Year Two of the project, two of the teachers were unable to participate in the Seminar meetings. One of those teachers was involved in the implementation of an inquiry-approach, interconnections, and interdisciplinary team of sixth grade. Because of the time-consuming nature of that program, our work with Linda took

a back seat and we watched as if from a window. The other teacher, Carrie, was so concerned about implementing all she had learned from the first year of planning, the summer institute, the professional conferences, and purchasing so many new materials, she felt too overwhelmed to continue attending meetings. However, both teachers were included in videotaping, audio interviews, and observations.

Year Two was the first year of implementation. Data were gathered in many ways. Weekly visitations included observations, field notes, tape-recorded interviews, videotapes, teacher journals, and researcher journals. Data were gathered from teachers, students, and administrators. The student data collected included achievement test data from grades five and six and mathematics attitude and confidence questionnaires that were administered at the beginning and end of Year Two. Data collected from administrators included interviews and unsolicited comments and letters.

There were also benchmark activities collected such as tests, grades, lessons, and conversations with the students. Artifacts were collected from the teachers and the students. These included lesson plans from Year One and Year Two, assessment strategies, and student projects also from both years. There were monthly meetings held after school with teachers, the mathematics coordinator, and university personnel. Multiple sources of data were necessary to provide for the richest description possible of the teachers' environments, behaviors, interactions, and meanings, as they related to mathematics. The sources were tapped into a constant-comparative process of collection, analysis, and focusing.

To best inform the research questions, data-gathering techniques were used that would best describe the changes that were occurring in beliefs and practices. Consequently, in-depth interviews were used in an attempt to discern patterns in the way teachers talked about the process of change. Observations however, remained important opportunities to document teacher and student behaviors within the classroom setting, to document potential discrepancies between interview data and observations and to triangulate interview and Seminar data. An attempt was made through a member check to make sure that data collected were a true reflection of what the teachers meant to say. This would further serve as a validity check (Kirk & Miller, 1986). Finally, there were peer debriefing sessions among the research team using reflexive journals to document anecdotal comments, summative vignettes observed to further clarify observations, and team video viewing to build consensus among the researchers as to what changes were occurring.

Teaching and Learning Environments

The initial condition of the sixth grade mathematics program was undeniably the traditional, transmission-of-knowledge type program. This may indeed have been a consequence of their focus on their restructuring program in other disciplines. Each of the fourteen sixth grade teachers taught mathematics to their own homeroom class, because none of them wanted to teach mathematics as a specialty. The fourteen teachers were divided into four teams. Three teams had four teachers each, the last had two. Each team was permitted to develop their own class schedule for the year. The individual teams did not need to have similar schedules among the teams. All teachers chose to teach their mathematics

class as the first period of each day. One team allowed only thirty-eight minutes for mathematics in their entire day.

The methodology of the teachers observed was traditional teaching of mathematics. Each classroom was arranged with desks or tables in rows. A typical day included reviewing homework from the previous lesson followed by a ten-minute introduction to the new lesson which was usually teaching another procedure, then students were assigned to work practicing that procedure from problems arranged on a worksheet or from textbook pages. The textbooks they used were seven years old, and most of the pages were of problems for practicing skills. The homework assignment was to finish the exercise from the textbook or additional problems from the worksheet.

Students were not allowed to talk or work together. The atmosphere in each mathematics class varied from room to room. In some classes, there was a relaxed atmosphere where students felt they could ask their teacher for help on their problems. In two of the classes observed, there appeared to be a routine strongly grounded in regimen. Students were made to follow strict procedures for how they behaved and moved around the classroom. It was noted that whenever students completed a worksheet, they would hand in that worksheet, sign a form, move directly to another area of the classroom, and pick up another worksheet. After class, the teacher informed me that there were 130 such worksheets. The students had the year to complete them. He noted a bulletin board that publicly displayed the progress each student was making on these extra worksheets. The teacher was proud of his disciplined class.

Role and Composition of the Research Team

This research project was partially funded through the Dwight D. Eisenhower Mathematics and Science Program sponsored by the Ohio Board of Regents. Study participants consisted of researchers, respondents, and informants. The researchers used the traditional collaborative approach to this ethnography as an attempt to gain more sources of data (Becker et al., 1961; Bogdan & Biklen, 1982; Goetz & LeCompte, 1984; Kirk & Miller, 1986). Members of the research team varied in the degree to which they were identified with the interests of specific participants and informants in the school. The intent was to ensure that interests of all parties were addressed and that the account incorporated perspectives of diverse groups (Hochschild, 1989; Oakley 1984; Rollins, 1985).

The research team consisted of a project director, two research associates, and four research assistants. The role of the project director was to conduct planning sessions, Seminar meetings, and debriefing sessions; design and conduct the summer institute; and organize inservice workshops. The role of the research associates was to conduct weekly observations, take field notes, make weekly journal entries, present activities in assigned classrooms and at monthly workshops, and to participate in regular debriefing sessions. The research assistants conducted audio interviews, observations, and videotaped lessons by participating teachers.

Data Analysis

Although the research questions provided a focus for the study, specific categories used in analysis were not predetermined. Categories emerged through

the process of ongoing analysis (Bogdan & Biklen, 1982; Goetz & LeCompte, 1984) and likewise shaped the design of the study. As transcriptions of interviews and field notes were gathered, a list of potential coding categories emerged. Categories were also obtained from viewing the videotapes of lessons and of the Seminar meeting discussions.

The Project Teachers

To secure confidentiality, the four sixth grade teacher participants (referred to as Project teachers) have been given pseudonyms. They varied in years of experience and specialty areas, but were comparable in areas of certification and mathematics background (see Table 2). Early observations (ring Year One) indicated that these four Project teachers were very traditional mathematics teachers. They arranged their classroom desks in rows, reviewed homework, presented how to solve the new type of problem for the day, then assigned seatwork which was to be done independently. The textbooks they used wc e old and worn. There was no visible use of manipulatives or technology. Nor was there any indication of group work, student-centered activities, or mathematical project assignments.

Insert Table 2 About Here

Constraints of length prohibit a full description of the four teachers in this study. Instead, a brief description is offered of each teacher based on an analysis of the interview data.

Linda: Linda was the type of person who never hesitated to learn new things; performed well mathematically; exuded enthusiasm towards mathematics; and loved children. When Linda started teaching mathematics, she was placed with a group of learning disabled children, and quickly learned how to work with students in small groups and use mathematical models. She saw how disabled students could learn mathematics be seeing it, and tried to implement these new ideas in regular classes, but struggled with large numbers of students. Upon committing herself to becoming a full-time mathematics teacher, Linda became excited about learning how to teach mathematics for understanding and signed up for every workshop or inservice program offered. About her recent mathematics teaching experience, Linda explained,

> Historically , all teachers were centered around one subject except math -- math is the extra and so we all did it and I think it was done very haphazardly. Most people, including myself to a degree, just followed the book step by step. Whatever you got through you did. All sixth grade teams were grouped for math, so then you had those who really succeeded and did well, those who didn't do as well. For so long we've spent the first half of the year going back through adding and subtracting and multiplying and dividing. And it's the same old thing and they (the students) all hated to go to math.

Linda's team was to enter their first year of implementing a student-centered, student-driven curriculum program and she was concerned about how mathematics could be connected to other disciplines. She also wondered how she could tie in all that she had learned during the summer institute.

Carrie. Carrie's greatest love was social studies. She chose to teach mathematics because she hated English and science and knew that social studies would not be a full-load assignment this year. She had very limited self-confidence in mathematics. About her mathematics teaching, Carrie says,

> But it's amazing when you have the answers in the book how it's real easy to teach math. And at that time it was still... here's how you do it, practice, here's a worksheet, practice -- kill and drill, kill and drill, kill and drill. This is the formula, this is the way you do it, okay? Here's a test, and now we'll go on. You know, over and over and over again. Math is the only class I've always been frustrated in that not every single kid gets it because it, of all the other classes, that is a building block class throughout their entire school career. They have to get certain things to go on and be successful the next year. Social studies an I science stuff, if they didn't learn something there, that's not a big problem. You know? But with math it is. And so that responsibility weighs very heavy on me. I'm very frustrated with it sometimes and very overwhelmed that they're just not getting all of it.

Carrie was very worried about not being organized enough to begin the first year of implementation. She felt as though she was so confused at times that she did not know what questions to ask nor what assistance to request. Carrie said that to teach mathematics she needed a road map. She was most comfortable teaching from a textbook or an explicit curriculum guide.

Sherry. Sherry was happy to try anything that would help her students learn mathematics better. She too was a social studies teacher, but did not like the way she taught mathematics. Referring to her early school years, Sherry said, "I

always felt that I just couldn't do math." After observing her class during Year 1, Sherry excitedly reported how she was able to conduct such a pleasant mathematics class. She said:

> I want you to know that I started the year off differently this year. You want to know what I did? Well, I walked into class, got them (the students) quiet and said, "I know you all hate math, but I want you to know that I hate it too. And that's OK. Somehow we will work together and somehow get through this year together." You know, I think it worked. It seemed to put them at ease and now we can just get on with it and not feel so pressured.
>
> In the classroom, I was a very traditional math teacher in terms of demonstrating and having the kids do some sample problems and then do the drill afterwards. Um -- we did the basic story problems, but not a whole lot of extension. In terms of working with hands-on things we probably worked with rulers and did some measuring.

Sherry was thrilled with the prospect of learning how to teach mathematics for understanding. She was uncomfortable with the way she taught mathematics and was relieved to find that help was on its way.

Sally. Sally always loved mathematics. For the past two years, she taught two groups of the higher-achieving students for mathematics. Her classes were completely self-paced where the students worked on individual packets while she spent most of her time sitting at her desk tutoring individual students. When she did go to the board, she reported feeling as though she only had about 10% of the students' attention. Sally noted that when she did the individual tutoring she knew she had 100% of that student's attention and thought that was good.

> Because I started off teaching developmentally handicapped and with kids like that -- they were fourth and fifth graders, you had to use concrete examples. And then went into sixth grade and teach more self-contained -- taught a lot of different subjects. Math was always kind of my favorite because -- I don't know -- there just wasn't a lot of memory work. It was almost like you learn it and you practice it in different ways and it was kind of something that sticks with you -- not some history date.

Because Sally enjoyed mathematics, she was interested in becoming a part of the study, but was very skeptical as to whether what was being proposed would be any better than what she was already doing. Sally considered manipulatives as toys and activities that used manipulatives were games and not real mathematics.

Results

The results of the cross-case analysis will be organized by: (a) types of support during implementation; (b) difficulties encountered during implementation; and (c) changes in the beliefs and practices of the Project teachers.

Types of Support During Implementation

Interaction with Administrators.

Moral and monetary support from the school administrators were important to the success of this project. After interacting with the teachers and observing their committed attitude towards the development of a rich new mathematics program, the group decided to make mathematics a top priority for resources for the coming school year—the first year of implementation. Linda, Sherry, and Sally were all pleased with the generous support provided by the administration.

Carrie, on the other hand, thought that the support was limited to outside assistance. That meant that she was not getting the type of support she felt she needed in her classroom, but would not expound on what it was she felt she was missing.

Professional Development Opportunities:

The culmination of the Year of Planning was a summer institute designed by and for the Project teachers with the assistance of university faculty. This institute would serve as a simulation of what they defined sixth grade mathematics to be. In this case, it was decided that the curriculum would be one based upon the national Standards, the methodology would become student-centered and inquiry-based, and that manipulatives and calculators would be used whenever appropriate. The Project teachers would be the students and they would work through all the activities, identify the applicable learning theory, then reflect upon them from both student and teacher perspectives. This would later prove to be an important professional development strategy because the student-centered activities that actually were taught in the classrooms were exactly those with which the teachers interacted.

Opportunities to talk with teachers outside of their school building provided teachers with ideas for improving implementation and with confirmation of their emerging program. At a regional mathematics conference held in September of Year Two and attended by all Project teachers, a frequent comment was that there was insufficient time to attend all of the sessions in which they were interested as well as how exciting it was to meet so many other educators who were doing the same types of things. Carrie said being there made her feel a little more at ease

because she found that the messages she was receiving from the sessions she attended were similar to the direction she was taking in her classroom. She exclaimed, "We're doing it right! Now, I know we're in the right direction. Everybody says so!"

While the teachers agreed that conferences were very important to their professional growth, it was the summer institute that seemed to be the place where the most learning was internalized. Linda explained that,

> I've become a stronger math teacher through this extra course work that we've done. I'm more excited about math and the need to teach it from our experiences...from the summer class that we did... as it relates to students -- the activities that we did and actually experienced are the ones that I think most of us are doing in the classroom -- cause I know what it was like and can do that.

Carrie said,

> Because then you really get in there every day all day and you are really working with manipulatives and you are really, ...in there, doing it and not just scattered.

Interactions with Colleagues.

The importance of interacting with colleagues at their school was consistently recognized by the Project teachers. The teachers gathered specific ideas for mathematics lessons by talking with other teachers, by observing displays of children's work, and by visiting other teachers' classrooms. Sally, for example, found through her conversations with other mathematics teachers, that the students in the other classes had more opportunities for learning because they

were arranged in group settings. She was also more easily swayed to use calculators after she saw a colleague achieve success with them.

The Project teachers agreed that interactions with colleagues supported their professional growth. Sally, for example, discussed how Seminar discussions helped her learn more about the activities in other classrooms in other schools. Similarly, Sherry described the Seminar discussions as "very supportive" and expressed a desire for the meetings to continue on a regular basis beyond the scope of the project.

Interactions with Researchers.

As previously discussed, the researchers' roles were interactive with the entire staff and particularly with the Project Teachers. Interviews and Seminar meetings were cited by Sherry as helping because

> ...without those kinds of programs, and without the support we've had from the university, I don't think any of us could be at the point we are.

Carrie learned that her students were able to learn sophisticated mathematical concepts through an inquiry approach. This was amazing to her since some of the topics presented included the same concepts with which she struggled in high school and college.

Not only were the interactions with researchers important, but the continuous presence of members of the research team seemed to ensure that teachers considered changing on a much more frequent basis. Several teachers said that because they knew that someone would be in their classroom, that they felt compelled to continue to experiment and practice things they had learned in

previous professional development activities. Thus, the 'hanging around' theory seemed to play an important role as a catalyst for change.

Obtaining Materials.

Teachers in this study were also supported by various opportunities to purchase books, manipulatives, and calculators. Most of the funding came from building funds which were targeted for mathematics this year--a decision made by the entire school staff. Grant monies, use of public libraries, and teacher-shared manipulatives provided additional mathematics materials. Of the availability of funding for materials and such, Linda said,

> ... if we didn't have all the materials that we were able to purchase this summer, it wouldn't be as successful as it is because that's what's making the program do a few things.

Sally was particularly impressed with the faculty as a whole giving up their wants and needs during a school year for the good of an improved mathematics program in sixth grade.

Difficulties Encountered During Implementation

Difficulties in Instructional Planning.

Sherry said,

> Hindering, as always, is when you're trying to put in place new things, it's trial and error. Just about everything I have done this year -- the way I have presented it -- the materials I've worked with -- have been totally new. And so when you go through those lessons, you're immediately thinking this worked well and I need to do this again or this was a disaster and we have to come up with something else.

Limited Knowledge About Content, Curriculum, and Methods

As the Project teachers shifted from following lessons laid out in their mathematics textbooks to creating student-centered activities with inquiry-based mathematics strategies, some began to doubt their knowledge about mathematics and the new methodologies advocated by the NCTM Standards. Sherry began the year not only doubting her own ability to use inquiry-based mathematics but also concerned about the larger question, "Will they learn basic computation skills if I don't use all the drill and practice activities?" Sally felt that the use of student-centered activities would be more enjoyable for her sixth-grade students but wondered about the skills she should teach. She was particularly concerned about the children in her room who were having difficulty with the basics and was uncertain that they would progress without the specific skill work provided by their textbooks.

I haven't been able to spend a lot of time on going ahead, I think, with problem solving, because they have -- they're weak in some of the basics. Carrie added,

-I have trouble understanding concepts.--

The teachers' lack of knowledge about current methodologies made choosing materials difficult for some. Activity selection was particularly difficult for Carrie, who was overwhelmed by all the new ideas regarding content, curriculum, and methodologies she had learned. She was not familiar with student-centered activities and felt awkward not being at the front of the room all the time.

Organizational Concerns.

The Project teachers found that instructional planning for inquiry-based mathematics was quite different from planning for procedure-driven mathematics. Sherry had used the same mathematics plans for many years while using the mathematics textbook as the curriculum. Now it was her responsibility to select the appropriate sequence of materials, to decide how the materials would be used, and to define both her role and the role of her students. Although she found some assistance in the teaching guides that often accompanied the new materials, the teaching points were usually limited, leaving her to make many decisions about the organization of each lesson. She was excited about using her own ideas to teach; however, she was also anxious that her plans would provide optimum educational experiences for her students.

The teachers were consistently concerned about how to use manipulatives and technology with the new curriculum to foster enthusiasm for mathematics with their students but at the same time support their students' growth in mathematics learning. At a Seminar session, Sherry wondered how she would facilitate a lesson without providing too much information. She found it difficult to decide which student questions to answer, what types of responses to provide, and how she would assess student progress.

> Carrie demonstrated her anxiety towards not being organized by saying I want help, but I don't know what help I need. I don't know even what to ask you to do. ... I have no idea. Organize me. You know, do something...

Concerns About Use of Mathematics Textbooks.

Linda rarely used textbooks at all because their new program included a student-driven curriculum, so they used textbooks as an added resource rather than curriculum. Both Carrie and Sally used their textbooks far more extensively than Sherry. They each began teaching from the beginning of the text and proceeded pretty much page by page. Carrie said she needed a road map from which to teach and Sally thought that she would miss something important if she did not proceed page by page.

When the school ordered new textbooks, they were only able to afford a classroom set for each Project teacher. Sherry explained

> Our kids do not have textbooks assigned to them. They're on the tables. They have been used very infrequently. They -- we might look at them -- we might use it as a reference. We go to the glossary occasionally. There may have been -- a few occasions where there was a problem solving -- problem situation or something maybe that we would go over together in class. But, no, I do not use them. Well, when they were told at the beginning of the year that they would not be given a math book, some of them cheered. And again, not having a math book for some parents has been the biggest problem we've had to deal with and we did have extras so we'd just send a book home with those parents. They are telling me they have used them. I hope they have in some way.

Difficulties in Evaluation.

When using worksheets, textbooks, and tests, the teachers found it easy to assign grades. But when they used cooperative learning groups, for example, they

were unsure how to evaluate student progress. Issues of assessment were among the greatest of teachers' concerns. Their constant worries included: (a) meeting the new state-mandated course of study; (b) providing for students' success on mandated competency tests; (c) grading student progress; and (d) identifying student needs to navigate instruction.

For the Project teachers, satisfying the new state-mandated course of study and ensuring appropriate student achievement on mandated tests became sources of pressure that increased during implementation of the new mathematics program. These pressures forced several teachers to have a methodological relapse the weeks prior to mandated testing where they felt they had to "teach to the test" so that their students would have a chance at success. These concerns continued until the results of some of the tests came back during the summer after Year Two where all Project teachers agreed that the test scores reflected sufficient gains to decrease pressures they had felt during the previous year. The principal was also pleased once he saw the standardized test scores, he said, "I've never seen so many sixes. We are accustomed to 2s, 3s, and 4s around here." The numbers he refers to are the stanine scores reported on the mathematics achievement test result forms.

Difficulties remained however, regarding how to conduct alternative assessment. Sherry was the only Project teacher who was ready to handle the assessment issue. In fact, she served on the statewide committee to build assessment tasks to support and inform the new curriculum. Carrie and Linda wanted to move to a new grading system which would reflect a positive attitude towards grading. For example, instead of grading A through E, they would grade

A, B, and I. The I would stand for "In-Progress". This way, they would not fail a student, but would ask the student to continue working on the project until it was at least a B level. Sally wondered when she would have time to do all this "alternative stuff."

The Project teachers each were concerned about how to grade students for their contributions to group activities, how much of the grade should be on groups, and how much grading should happen on an individual basis. They each voiced concerns about how easy it was to grade mathematics before the new program, but they were so impressed by the improved atmosphere and attitudes of their students, that they were willing to learn.

Changes in Beliefs and Practices

From the data that emerged from the study, six categories were identified and used to organize the findings. The categories and the findings summarizing the changes noted from Year 1 to Year 2 in the Project Teachers' beliefs and practices may be found in Tables 3 and 4 respectively.

Insert Table 3 About Here

Insert Table 4 About Here

Changes in Beliefs and Practices in Classroom Organization

From the very beginning, Linda believed that a combination of classroom organization strategies worked best for her. She thought that students should experience whole class, individual, and small group instruction. Her practice showed that Linda always arranged her classroom tables for small group work and she ended up believing in using small group activities to the exclusion of the other types.

The other three teachers began from a more traditional perspective, they all had their classroom desks or tables arranged in rows and columns to begin, which fit with their belief in the use of whole class instruction. After the summer institute, where the teachers experienced small group work on a regular basis, both Sherry and Carrie began Year 2 by rearranging their classrooms to accommodate more small group work although they believed in maintaining some whole class and individual work. Sally was a little hesitant at first to make such a dramatic physical change to her classroom, probably because she missed the summer institute and had not achieved the level of confidence the others acquired from practice.

Changes in Beliefs and Practices About Mathematics

All Project teachers believed that mathematics was a subject that if learned would help you to think better. While Carrie and Sherry reported no changes in beliefs about mathematics, Linda and Carrie had several abrupt changes in their thinking. Linda thought that she did not have the type of mind that was needed to do advanced mathematics. She thought that mathematics was one of those subjects that you either could or could not do. By the end of the second year of

discover basic mathematical ideas. There were also well-grounded beliefs among the Project teachers that models and visual aids were necessary for students to learn mathematics. Linda said:

> But the neatest thing this year -- shows me still that through guided discovery the kids can find out those things and it doesn't have to be shown -- here this is the way you find the area of a triangle and that sort of thing.

Carrie reported

> They have learned a lot more than any sixth grade class of mine has ever learned, because we didn't review--I think we never did this with them years before because we thought it was too hard for them -- they didn't know enough. ... to be able to do more than add, subtract, divide, multiply and do some fraction work and geometry -- early geometry. I don't think we thought they could handle it -- that it was too intricate -- too beyond them -- and they are proving that they can handle it.

Sherry said:

> ...what I feel best about is that with the participation of the students, discipline problems have been at a true minimum in the classroom.--They walk in the room asking what do we get to do today --Because they know we're going to do some fun things and I think because of that the kids have learned more.

Sally said:

> We're incorporating things we've learned at the beginning of the year all year so that they aren't forgetting, where we're not just doing a unit, having a test, four weeks later we've forgotten because we're not using it anymore.

Changes in Beliefs and Practices Regarding Teaching Mathematics

Linda's major changes in the teaching of mathematics stem from following the textbook step by step to allowing the students to explore new concepts and new ideas through guided discovery. She also believed that if she required students to communicate their ideas, she could learn far more about what her students knew and were able to do.

Carrie's changes were important, but not as extensive as hoped. During Year 1, Carrie described her teaching as, "...here's how you do it, practice...kill and drill." By the end of Year 2, Carrie's approach still followed the textbook, but she made an effort to include all of the extra activities that she used to skip over. She reported also adding the use of more visuals in her teaching, but only if she had learned it first.

> Sherry hardly ever uses her textbook anymore and stated about her teaching: I think when you're working with manipulatives I have a hundred percent of the kids doing something.--as long as there's something there in front of them that they can put their hands on and try and demonstrate with and try working with, I think that they are getting more math than they ever got before when they were just being talked to. --those have been new topics of math, which have generated more interest on their part.

Sally described her changes as follows:

> I'm never at my desk anymore. I used to be at my desk a little bit more-- I taught a completely self-paced class for two years of high math kids, where the kids all did their own thing. We had packets and they worked at their own pace, so I was doing one on one instruction all the time. That way, I

had their attention.--I feel like I have more of the kids' attention than I used to. --Sometimes it's a little boring for me, so I can see what it's like for them when I did all the fun stuff.--Next year there are some things I'm going to not spend as much time on, like addition, subtraction, multiplication, and division.

Changes in Beliefs and Practices Regarding the Use of Technology

Linda reported allowing her students to use calculators for everything except concept development before our project, and now she has learned how concepts can also be taught and has added that to her teaching. About the use of calculators Linda stated:

> I used calculators a lot this year. Those students who don't know their multiplying and dividing facts by now aren't going to learn them in sixth grade and it's silly to make them struggle through those again right now. I see my students doing higher level math this year than they wouldn't have been able to do without the use of the calculator.

Carrie and Sherry both believed that calculators should not be used for doing homework of taking tests. Carrie originally thought that using calculators was cheating and still does not allow her students to use them until they know the facts. Sherry used to use them on Fridays for fun activities, but now has them available at all times on the student tables and allows them to be used for anything.

Sally reports having changed her philosophy a little bit about calculators and that she never had a serious problem with calculators. In practice, she does not

allow them to be used for basic facts and to date refuses to allow them to be used on tests.

Changes in Beliefs and Practices Regarding Use of Time

The beliefs of the Project teachers regarding use of time in the classroom changed wholesale from reviewing homework, demonstrating new material, and starting the new homework, to an increased use of small group instruction, increased use of manipulatives, calculators, and guided practice, and increased use of student explanations. These beliefs transferred into practice in that the students were engaged in small group exploratory activities on a far more frequent basis, and a decrease in the use of the textbook page by page.

Discussion

The results of this study begin to reveal the process of change in teachers and classrooms as they begin to implement the NCTM Curriculum, Evaluation, and Teaching Standards. The teachers in this study were motivated to increase the use of student-centered mathematics instruction in their mathematics programs by a dissatisfaction with what they were teaching, how they were teaching, and their prior mathematics text and materials, and through observations of positive student response to the new ideas. They were supported during implementation by colleagues, administrators, by participating in this study, by attending inservice opportunities, and by purchasing textbooks, manipulatives, calculators, and supplementary materials. Problems reported by teachers included a limited knowledge of mathematics content, methods, and evaluation techniques, limited organizational strategies, and difficulties documenting student progress in ways that would inform both grading decisions and instructional planning. In four

classrooms. Changes documented included a decrease in the teaching of procedures and assigning drill and practice work, and an increase in the use of student-centered activities, manipulatives, and calculators. There were also increases in small group work, student communication of mathematical ideas, and the use of alternative assessment such as observations, student projects, journals, and portfolios.

Summary

The results presented herein, are limited by the fact that the focus was on a small number of participants who all worked at the same site, at the same grade level, and who volunteered to be in this study. The characteristics of the school setting were similarly unique: the principal at the research site was consistently supportive throughout the two years; the entire staff cooperated fully; and the teachers were provided with unusual professional development experiences. Moreover, all video-taped observations were pre-arranged with the teachers at their convenience. Consequently, the video data collected was somewhat controlled by the teachers' perceptions of their situations. Although multiple data sources were used to strengthen the credibility of the data, triangulation was not always possible. The examination of the impact on classrooms and teachers was limited to observable changes in classroom management and teachers' practices. Future research might focus on the relationship between changes in classrooms and teachers and student achievement.

In the future as well, changes might be examined in schools where there is less support by either the administration, parents, or members of the faculty; in schools of a different socio-economic status; or in different grade levels.

Longitudinal studies might documented changes through classroom observations that extend over longer periods of time. In addition, research surrounding teachers' pressures of evaluation, the impact of the NCTM Standards on curriculum and instruction, the influence of changing teacher beliefs on instructional planning, and the impact of the organizational changes such as small group instruction, use of manipulatives and calculators on student attitude and achievement.

The results of this study support Guskey's (1986, 1989) argument that the teachers' most immediate need during implementation of a new approach is for information dealing specifically with classroom practice. Teachers struggled daily due to limited knowledge concerning mathematics, mathematics methods, and alternative assessment tools. Because of theses difficulties, professional development programs might begin with specific, practical ideas that readily may be used in the classroom. In-service sessions could include learning theory as well as demonstrations of how to use student-centered activities, discussions of how to increase the use of manipulatives and calculators, sessions on organizing and prioritizing content to be taught, and specific suggestions about classroom organization, lesson planning, and evaluation. The students' enthusiasm towards the changes in classroom practice energized the Project teachers to overcome the difficulties they had in documenting student achievement. Professional development sessions focusing on assessment alternatives might include topics such as performance objectives, interviewing, project presentations, reflective journal writing, and portfolios. Knowledge of such assessment practices may

assist teachers in making grading decisions but also may play a significant role in changing teachers' beliefs and attitudes about mathematics instruction.

The results of this study suggest that districts interested in making changes should attempt implementation slowly by first identifying a few interested teachers to pilot the innovation, supporting those teachers in significant ways, and providing for long-term commitments to change through professional development. Successes may then be shared to encourage the participation of other teachers. Support for interested teachers might include shifting monies from buying workbooks to buying student-centered activity books, providing financial support for teachers to attend professional conferences, inservice programs, or adjust schedules so that interested teachers might meet during school hours to discuss mutual concerns.

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Table 1

Phases of Data Collection

	Phase I Year One	Phase II Summer	Phase III Year Two
Interviews	1	0	10
Observations	6	0	20
Seminar Discussions	6	2	8
Surveys	1	2	2

Table 2

Four Teachers' Experience, Qualifications, and Background

	Linda	Carrie	Sherry	Sally
Years Teaching	13	15	21	12
Certification	Elementary 1-8 Reading K-12 Special Ed. K-12	Elementary 1-8 Reading K-12	Elementary 1-8	Elementary 1-8 Special Ed. K-12
Specialty Area	Physical Educ.	Social Studies	Social Studies	Special Education
Mathematics Background				
High School	Algebra I&II Geometry	Algebra Geometry	Algebra Geometry	Algebra Geometry
College	Elementary Content and Methods	Elementary Content and Methods	Elementary Content and Methods	Elementary Content and Methods

Table 3

Changes in Project Teachers' Beliefs from Year 1 to Year 2

Beliefs	Linda		Carrie		Sherry		Sally	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Classroom Organization	Combination of whole class, small group, and individual instruction	Small group instruction.	Whole class instruction.	Combination of whole class, small group, and individual instruction	Whole class instruction.	Combination of whole class, small group, and individual instruction.	Whole class instruction.	Combination of whole class, small group, and individual instruction
Mathematics	Helps you learn to think better. Don't have the kind of mind to do advanced mathematics	Helps you learn to think better. Do have the kind of mind to do advanced mathematics	To be good at math you do not have to have a mathematical mind	To be good at math you do not have to have a mathematical mind	Helps you learn to think better.	Helps you learn to think better.	Mathematics is a bag of tricks.	Mathematics is not just a bag of tricks.
Learning	Students can still learn mathematics when using calculators Average students have some trouble discovering basic ideas	Students can still learn mathematics when using calculators Average students with guidance can discover basic ideas	Models and visual aids are necessary for learning.	Models and visual aids are necessary for learning.	Models and visual aids are necessary for learning. Students do not need to master earlier topics to learn others	Models and visual aids are necessary for learning. Students do not need to master earlier topics to learn others	Arguing over math ideas can assist learning Average students have some trouble discovering basic ideas	Arguing over math ideas can assist learning. Average students with guidance can discover basic ideas

Table 3 continued

Changes in Project Teachers' Beliefs from Year 1 to Year 2

Beliefs	Linda		Carrie		Sherry		Sally	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Teaching	Basic skills and patience are not sufficient for teaching mathematics. Correct answers are not as important as student explanations.	Basic skills and patience are not sufficient for teaching mathematics. Correct answers are not as important as student explanations.	Basic skills and patience are not sufficient for teaching mathematics. Teachers need not to know all the answers to student questions.	Basic skills and patience are not sufficient for teaching mathematics. Teachers need not to know all the answers to student questions.	Teachers should not always answer student questions, but let them puzzle it out. Students should sometimes be confused.	Teachers should not always answer student questions, but let them puzzle it out. Students should sometimes be confused.	Correct answers are not as important as student explanations Teachers should follow their math textbook.	Correct answers are not as important as student explanations. Teachers should not always follow their math textbook.
Use of Technology	Use calculators for everything except concept development.	Use of calculators includes concept development.	Do not allow calculators for homework or tests	Do not allow calculators for homework or tests.	Do not allow calculators for homework.	Do not allow calculators for homework.	Do not allow calculators for concepts, homework, or tests.	Do not allow calculators for homework or tests.
Use of Time	50% small groups 10% calculator activities 20% student explanations	100% small groups 40% calculator activities 40% student explanations	30% using manipulatives 20% using calculators 70% small groups 20% guided practice	50% using manipulatives 50% using calculators 75% small groups 50% guided practice	25% using manipulatives 25% small group 15% calculator activities	75% using manipulatives 90% small group 10% calculator activities	10% using manipulatives 1% using calculators 25% small groups 10% guided practice	20% using manipulatives 15% using calculators 30% small groups 20% guided practice

Table 4

Changes in Project Teachers' Practices from Year 1 to Year 2

Practices	Linda		Carne		Sherry		Sally	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Classroom Organization	Desks arranged in small groups	Desks arranged in small groups	Desks in rows and columns for individual work	Desks arranged in small groups	Tables in rows and columns for individual work	Tables arranged for small groups with manipulatives	Desks in rows and columns for individual work	Desks arranged in small groups
Mathematics	Something you have to do to know.	If you can see it, you can do it.	Lots of rules and procedures to memorize.	Concepts that are hard to understand.	Lots of rules and procedures to memorize.	Mathematics is so much more than figures. It's ideas, it's everywhere around us.	A bag of tricks. It's like a foreign language.	It's fun--not just a lot of memory work.
Learning	Getting actively involved, motivated, interested.	Students need to conceptualize things and work with others and explain things. They can learn higher level meth than first thought--even more with calculators	Practice work hard kill & drill. Follow procedures step by step memorize rules.	Hands on activities that force you to think and ask questions. I need a road map.	Try some problems, memorize them, then feed it back. Watching and memorizing.	Hands-on activities where students can try different things. Learn more because they like it better. Pay more attention when they are doing something.	Must know the basics first. Must work at their own pace. Must be ready for higher concepts--can't just jump in to it.	Students should know the basics by now-time to learn new things--learn by using more hands-on. Learn by doing the fun part themselves rather than watching me do it.

Table 4 Continued

Changes in Project Teachers' Practices from Year 1 to Year 2

Practices	Linda		Carrie		Sherry		Sally	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Teaching	Try to get students involved. Followed the book-step by step. First half year spent on whole number operations.	Try to get students involved. Allow students to explore new concepts new ideas through guided discovery.	Amazing when you have the answers in the back--makes it real easy to teach math. Here's how you do it, practice--kill & drill. Very structured need book.	Follow the textbook, but do all the "extra" activities rather than the old ones. Use visuals if I've learned it first.	Present a demonstration have kids do sample problems, then drill afterwards. Follow the textbook.	Computation is secondary to whatever else you're doing. Present new topics rather than just review. Do not use the book? Let students do the fun part.	Self-paced class--everyone did their own thing. Sit at desk and help individuals. Follow the textbook do sample problems at the board.	Get the students involved working in small groups. Let them do the fun part. Do not sit at desk hardly at all.
Use of Technology	Didn't have it, didn't need it--thought students were better off without it.	Use them all the time, learned how to use for concept development.	Using calculators is like cheating. They must prove they know basics	We use them more now, but not until they know the facts.	We use calculators on Fridays for fun activities.	They are always available on their tables. They can use them at any time.	Kids still need to learn basic facts in 6th grade. Calculators can't teach that	We are using them more, but never on a test.
Use of Time	Guided practice	Student-centered activities-always. Students communicate ideas.	Teacher directed. Follow textbook strictly.	Student-centered activities-sometimes. Still follow textbook most often	Teacher directed. Follow textbook mostly Supplement with fun.	Student-centered activities-most often.	Teacher directed. Follow textbook strictly.	Student-centered activities-more often. Follow textbook often.