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ABSTRACT

This study investigated the effect on teachers of observing or implementing an alternative form of instruction in a primary-grade arithmetic class. Under consideration were the relationships between the beliefs teachers held about mathematics and about teaching mathematics, and their recognition and internalization of the principles of the alternative instruction. Responses to interviews with those teachers who implemented the instruction were then compared with those who observed the lesson, to provide insight into how the intensity of involvement influenced perception. Several patterns emerged and included: (1) differences between teachers in their analysis of the salient features of the instruction; (2) differences between teachers in their beliefs about mathematics and how to teach it; and (3) the relationship between where teachers stood in their analysis of the instruction, their beliefs about what is important in mathematics, and how these things should be taught. To elaborate on the patterns and to support interpretations, each pattern is described briefly and details from teachers' reflections are provided. An outline of the interview questions is appended. (LL)

Teachers' Beliefs and Their Responses to Reform-Minded Instruction in Elementary Mathematics

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ABSTRACT

We investigated the effect on teachers of observing or implementing an alternative form of instruction in primary-grade arithmetic. More specifically we considered the relationships between the beliefs teachers held about mathematics and about teaching mathematics, and their (1) recognition and (2) internalization of the principles of the alternative instruction. We found that teachers' beliefs about what mathematics is of most value and how it should be taught were closely related, and, in turn, that these beliefs were related to how they responded to the alternative instruction. We offer some conjectures as to the conditions that influence the ways in which teachers respond to changes in instruction consistent with the reform efforts in mathematics.

INTRODUCTION

The mathematics education community has been developing a shared vision of alternative approaches for teaching mathematics. Among other things, this vision moves away from a view of the teacher as holder and imparter of knowledge, and towards a view of teacher as guide and facilitator in the process of students' construction of knowledge. Unfortunately, this vision has not always involved the classroom teacher. A major problem facing the mathematics education community is how to engage teachers in discussions of changing classroom instruction and to share with classroom teachers the nature of current perspectives. Reforms of the past several decades have often relied on merely telling teachers to make significant changes and have expected that to be sufficient (Cohen and Barnes, 1993). This ignores the fact that these teachers must make sense of the proposed changes in the context of their own prior knowledge and beliefs about teaching, learning and the nature of the content being taught. The process of change in attitudes, beliefs and practices has been shown to be a complex one (eg. Wood, Cobb, & Yackel, 1991; Simon & Schifter, 1991), and thus it is imperative that we seek alternative ways of involving teachers in educational reform.

There are many possible ways of bringing teachers into the reform process. One is to promote discussions with teachers about their beliefs about mathematics, how students learn mathematics, and how these beliefs are related to practices in classrooms. Teachers who are involved in interventions that focus on promoting discussion of this kind do show changes in their thinking and their practice (Simon & Schifter, 1991; Wilson & Ball, 1991). Another way to facilitate changes in practice is to familiarize teachers with information about children's thinking and behavior in a specific area of mathematics. Such information, at least when it is sufficiently detailed, can be used by teachers to make decisions about instruction that move them away from traditional teaching approaches (Fennema, Franke, Carpenter & Carey, 1993; Knapp & Peterson, 1991). A third form of intervention is to work with teachers intensively, either in an apprentice fashion or more collaboratively. Reports of these experiences show significant changes in teachers' thinking and practice, and also reveal the remarkable complexity of the change process (Heaton & Lampert, 1993; Ball & Rundquist, 1993).

In this paper, we describe another way in which teachers can be involved in the mathematics reform process. We studied the responses of teachers who observed an alternative reform-minded instructional approach and teachers who were asked to actually implement such an approach. It is possible that teachers may find themselves in situations where they observe others teach in alternative ways and are asked to respond to these observations. It is reasonable to believe that if teachers are provided with alternative models of teaching, they may see new possibilities in their own practice. This is the basic argument that encourages schools to have teachers visit other classrooms and observe how their colleagues are teaching particular topics. Indeed, this may become one of the most common ways of exposing teachers to alternative practices. Teachers may also be asked to try out experimental units using a different form of instruction in hopes that they may incorporate some of the alternative approach in their own practice. Our aim was to understand more about how teachers respond to these situations. How

do teachers respond to observing others teach in different ways? Do responses change if they are asked to implement alternative approaches? What might explain differences between teachers in these responses?

In this paper we discuss the reflections of teachers who were involved in different ways with an alternative form of instruction consistent with reform efforts in mathematics. The teachers participated in a project that focused on the effects of implementing this mathematics instruction on children's learning of place value concepts and multidigit addition and subtraction (Hiebert & Wearne, 1992, 1993). Teachers participated in one of two ways: some were hired to implement the instruction, and the others allowed the instruction to take place in their classrooms while they observed. We were interested in the perceptions of both groups of teachers to this alternative form of instruction. Comparing the responses of the teachers who implemented the instruction with those who observed may provide some insights into how the intensity of involvement influenced their perceptions.

We were interested further in the factors that might account for differences between teachers within these two groups. Previous theoretical and empirical work (Dossey, 1992; Thompson, 1992) provide convincing arguments that teachers' beliefs strongly influence their mathematical practice and constrain the nature of the changes they make. In particular, beliefs about two aspects of mathematics instruction seem to be especially relevant: (1) what mathematics is of most value, of most importance for students, and (2) how should this mathematics be taught. We hypothesized that these beliefs might help to explain teachers' perceptions of and reactions to a form of instruction that was considerably different than their own.

METHOD

Participants & Setting

The participants consisted of every teacher that had either observed the alternative instruction in their classroom or implemented such instruction at some point during the three years of the project. The observers included 4 first-grade teachers, 2 second-grade teachers and 3 third-grade teachers. Three teachers were hired to implement the alternative instruction. One of these teachers had taken time off to be at home, one was on leave doing graduate work in education, and one had just taken early retirement. The twelve teachers ranged in experience from 1 year to 24 years, four had 5 or less years of experience, two of these had not taught at all before the year they became involved with the project.

The alternative instruction was implemented during 3 weeks in first grade and about 12 weeks in second and third grade. The classroom teachers who observed the alternative instruction were attentive to varying degrees. They were told that the instruction would cover the same material they would have covered but would use a different approach that may help students understand the content more thoroughly. They were not obligated to monitor classroom activities but were told they were welcome to observe and offer comments. Most of the teachers positioned themselves in the back of the room and divided their time between observing and doing clerical work or grading papers.

Three experienced teachers were hired to implement the lessons. The lessons were developed by one of the authors and contained problems for the students to work and questions for the teachers to pursue. The researchers and teachers met daily during the units to discuss the day's lesson and to make adjustments based on the outcomes from the previous lessons. During these sessions, the discussions periodically turned to deeper philosophical issues that motivated the approach of the alternative instruction.

Alternative Instruction

The alternative instruction was implemented in some of the classrooms in a large rural-

suburban elementary school. During the first year of the project, alternative instruction was provided in grade 1, during the second year in grade 2, and during the third year in grade 3. Instruction was implemented only during the times when the classroom teacher would have covered place value and multidigit addition and subtraction. The instruction differed from conventional textbook-based approaches by focusing on student use of physical representations, greater use of story problem situations, and an emphasis on students developing, sharing and discussing their own solution strategies.

A sample lesson might begin by the teacher presenting numerical information on a chart, such as the average height and weight of different kinds of bears. The teacher might begin the lesson by discussing the entries in the chart, and then asking the students to determine how much more one bear weighs than another. Students were encouraged to solve the problem using their own set of materials or with paper-and-pencil or both. During the instruction students had their own sets of physical materials, Unifix cubes and base-10 blocks in first grade, base-10 blocks in second and third grades, and were encouraged to use the materials whenever they wanted or needed them. The students would then share and explain their solution strategies, again using the materials and/or paper-and-pencil. Time was devoted to questions and discussions about different strategies. The teacher might then pose another question involving the same context, but increasing the complexity of the task, such as "if there were three average sized bears on a bridge that could only hold 2500 lbs, what three bears could be on the bridge?" The lesson continued in this way, often with additional questions posed involving the same context. More complete descriptions of the instruction can be found in (Hiebert & Wearne, 1992, 1993).

Data Collection

Interviews with each teacher took place during the Fall and Winter of 1992-1993

following the conclusion of the three-year project. The first author, who had not worked with any of the teachers previously, served as the interviewer. The interviews were semi-structured and focused on obtaining the participants' views of what mathematics is of most value, how mathematics should be taught, their impressions of the project, and their reflections on how the project did or did not impact them. Although general questions and probes were determined a priori and are listed in Table 1, each interview was considered a conversation, and therefore question order was not always preserved and relevant tangents were pursued. Throughout the interviews it was stressed that their impressions of the project were desired. Most of the participants seemed to feel comfortable with this as was evidenced by their demeanor and willingness to talk during the interview about positive and negative aspects of the instruction.[1]

Data Analysis

The first author transcribed all the interview tapes. Each of the three authors read and analyzed the transcripts separately, looking for themes and patterns emerging both within teachers and over the entire set of teachers. Regular meetings were held to discuss our interpretations of the interviews. These meetings were audiotaped. The first author then reviewed these discussions, and returned to the interviews to review the evidence in the original contexts, and to look for any additional confirming or disconfirming evidence. The analysis was then written up and discussed several more times as drafts of the paper were

[1] Two of the teachers experienced some hesitancy in expressing their views. Ms. Harper appeared reluctant from the outset, so she was reminded her that the interview need not be recorded, or not occur at all. She agreed to do the interview, but remained hesitant to discuss certain issues at any length. After concluding the interview and turning the tape recorder off, Ms. Harper offered a few comments that, although she did not seem to mind the interviewer hearing, she did not want anyone else to hear. Her fear seemed to be that her words would be conveyed to someone at her school, despite repeated assurances that no one besides the three authors would be privy to the transcript.

revised.

RESULTS

Several patterns emerged during the review of transcripts. One involved differences between teachers in their analysis of the salient features of the instruction and the merits of these features. A second pattern involved differences between teachers in their beliefs about mathematics and how to teach it. A third pattern involved the relationship between where teachers stood in their analysis of the instruction and their beliefs about what is important in mathematics and how these things should be taught. The three patterns form our primary observations. We first describe each pattern briefly and then present details from teachers' responses to elaborate on the patterns and support our interpretations. We do not have sufficient evidence from this data set to remove all uncertainties about our observations. Rather, we offer these observations as working hypotheses about how and why teachers may respond to observing or implementing reform-minded approaches to teaching mathematics.

Teachers' evaluation of alternative instruction

Part of the interviews with the teachers focused on what they recognized as the important features of the alternative instruction and whether they believed these features represented good practice. We were interested in whether the teachers identified the same features we believed were most significant and how they evaluated their merits. The teachers fell into roughly three groups with respect to the match between their views and ours. On the one end, there were those who seemed to focus on one particular aspect of the alternative instruction or picked up on features we believed were tangential rather than recognizing the goals of the instruction as a whole. For most of these teachers the experience did not seem to affect their stated practice. In the middle were teachers who seemed to recognize the features of

the instruction we believed were crucial, but saw them in a fairly localized way. Some of these teachers internalized the nature of the instruction, and planned to implement it, in ways that we had not intended. Finally there were those who not only recognized the features of the instruction that we believed were important, but seemed to understand the more general goals of the instruction and thereby drew more general implications. Effects on practice for this group seemed much more promising.

Teachers' beliefs about mathematics and teaching

We were particularly interested in two dimensions of teachers beliefs: (a) what kind of mathematics is important for students to learn, and (b) how this mathematics should be taught. Beliefs about these issues were expressed predominantly in response to questions about their practice (questions 3, 4, & 5 in Table 1). Although each of these dimensions should be viewed as a continuum, we identified three points on each continuum as a way to consider differences between teachers.

The mathematics students' should learn is characterized on one end by a focus on learning the skills and particular algorithms associated with mathematics. As one moves towards the middle, the focus on skills and algorithms is expanded to include the importance of understanding their nature and function. At the other extreme, the importance of skills and particular algorithms is greatly diminished and replaced by a focus on processes and big ideas.

Teachers' beliefs about how to teach mathematics were revealed most clearly in their comments on the responsibilities of the teacher and the students in learning mathematics. The responsibilities of teacher and student are characterized on one end by the notion that the teacher bears most of the responsibility for determining both what is to be learned, and how it is to be learned. Towards the center of this dimension, the teacher does not play such a direct role, but rather attempts to guide the student along one of a few acceptable paths to success

which have been predetermined by the teacher. At the other extreme the teacher is responsible for creating an environment in which students have much of the responsibility for finding their own path to success.

Most participants fell in similar places on both dimensions, with the skills end associated with the teacher responsibility end. For example, we found that if a teacher indicated that the most important mathematics for students was efficient computation procedures, then the same teacher indicated it was her responsibility to teach such procedures and to ensure that students learned them. In contrast, if a teacher indicated that students were best served by developing a "feel" for numbers and for the processes of arithmetic, then the same teacher indicated the students needed to construct this for themselves. Because of this correspondence between the two dimensions, it is possible to place teachers along one continuum. This simplifies the discussion of the teachers' beliefs and the search for relationships between their beliefs and their evaluation of the alternative instruction[2]. Figure 1 shows the approximate location of each teacher on this collapsed belief scale. (All teachers' names in this paper are pseudonyms.) The teachers whose names are underlined participated in the project more intensively by implementing the instruction.

INSERT FIGURE 1 HERE

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[2] This correspondence supports the linkage of these two constructs in Thompson's (1991) proposed framework for the development of teachers' conceptions of mathematics. This framework is described as having three levels, each of which is described by teachers' conceptions of: "(1) What mathematics is. (2) What it means to learn mathematics. (3) What one teaches when teaching mathematics. (4) What the roles of the teacher and the students should be. (5) What constitutes evidence of student knowledge and criteria for judging correctness, accuracy, or acceptability of mathematical results and conclusions." (p.9)

Relationship between evaluation of instruction and beliefs

The third pattern we observed concerned the relationship between the previous two. In simplest terms, this relationship was quite straightforward. The more a teacher's orientation resembled the skills/teacher responsibility end, the more they focused on one particular aspect of the experimental instruction or picked up on features we believed were tangential. In contrast, those teachers whose orientations resembled the process/student responsibility end seemed not only to recognize the features of the instruction that we believed were crucial, but also understood the goals of the instruction. As an aside, it should be noted that other biographical variables did not relate to teachers' positions on either continua. Years of experience and current grade level were spread across the continua.

Responses of the Teachers who Observed the Instruction

To elaborate our observations we first discuss the teachers who observed the alternative instruction. This is followed by a more focused discussion of two of the three teachers who implemented the instruction. By focusing on these two teachers we can explore in more detail the nature of these patterns when the intensity of involvement is increased.

One extreme: Missing the point. Four of the nine teachers who observed the alternative instruction seemed, from our perspective, to miss the point of the instruction. They tended to focus on singular features, predominantly the use of manipulatives, as the crux of the alternative instruction. These teachers' view of this feature was often at odds with ours. For example, Ms. Anton considered the instruction as promoting only one way to solve problems, using manipulatives, rather than promoting multiple strategies that often involved manipulatives. Although some of these teachers did recognize to varying degrees, the purpose of using manipulatives as a way to link representations, the implication for them seemed to be that the manipulatives served as an initial aide that a teacher may employ to demonstrate the

meaning of a procedure, and not one that could enable students to create their own meaning.

Other critical features were ignored or interpreted differently than we intended. For example, the creation and explanation of alternative strategies were seen by two of these teachers (Ms. Harper & Ms. Anton) as confusing and detrimental to the students who were listening, and only "possibly" beneficial to the one doing the explaining. This is evident in a spontaneous comment by Ms. Harper about her concerns:

> Another thing [that really] upset me a few times was that they um (pause) When they got a little farther up, particularly working with money, they would have them put the problem on the board and the child explained. This would be subtraction usually and regrouping of subtraction. And the child would explain it incorrectly. And that bothered me that the other children were seeing it explained incorrectly. ... The child doing it possibly learned. But the other children in the room didn't. And there was also too much of that, time after time, without the children at the desks having something to do.

The other two teachers in this category barely acknowledged the fact that the instruction emphasized student discussion of strategies.

What is hinted at in the discussions of the alternative instruction with these teachers became evident in the discussions about their own practice--these teachers viewed the teacher as bearing much of the responsibility for teaching their students particular skills and algorithms (the left end of our continuum). The most extreme in this respect was Ms. Harper who discussed her role as the demonstrator of all things, down to "teaching them strategies of how to count". Ms. Harper's opinions on what is important for her students to learn became evident when she described what she was able to accomplish with her "high" group of students but not with her lower group: "I even challenged a few with 4-digit numbers. And uh .. I really did a lot of practical work with them that I can see I will not be able to do with this group". Ms. Anton's discussion of what mathematics students should learn seemed to be somewhat more broad than Ms. Harper's, particularly in the emphasis she put on students ability to show her "how they got it". But her view of the responsibilities of teacher and student placed the

responsibility heavily on the teacher. Her role as teacher was to keep presenting the material until most of the students caught on:

> I teach them the most obvious way, and maybe 80% will get it. And then I take another way of teaching it, and maybe 10 more percent will catch on. Then I've got 90% of the class understanding it and I've only presented it 2 different methods. So I'm probably going to have to do it 2 or 3 more different ways before the entire class catches on. And that's okay, and that's worth it to me.

Although she stressed the fact that different ways of getting the correct answer were acceptable and that she "wouldn't count that against them", she went on to say "I would show them a shorter more convenient, easier way, and I'd want to see that the next time". There was no penalty for different initial paths, but the teacher was still responsible for directing students to conform to a particular way of solving problems.

Finally, in discussing what changes, if any, these teachers had made as a result of being involved in this project (Q11 & Q12 in Table 1), all of the teachers focused on the use of manipulatives as the only possible addition to their teaching that they would attribute to having observed this instruction.

The middle ground. Three of the teachers, Ms. Davidson, Ms. Knight and Ms. Walters, recognized some of the features of the instruction that we believe were crucial, and some even viewed them as worthwhile. But, from our perspective, they did not connect these features with larger goals and treated them in narrow, overly-constrained ways. For example, Ms. Davidson seemed to see some implications of this approach for teaching other mathematics topics, as well as for other subject areas, but her view of some critical features, like the children's explanations of strategies, was more narrow than intended by the instruction. Although she saw this practice as beneficial to the child doing the explaining, she was uncertain as to how beneficial it would be to other children, and felt that the alternative instruction would be

improved by having power and authority for the correct explanation ultimately returned to the teacher. Many of her comments also indicated a degree of hesitancy or uncertainty, as though the process of observing had made her question some of her views of instruction. One example of this was her discussion of the notion of doing fewer problems: "I was hesitant .. their philosophy was it's not the number of problems, it's just that you've hit on each different type of problem in the homework. ... I liked it, but I was hesitant."

Discussions with Ms. Davidson about her practice were complicated by the fact that the year she observed the alternative instruction was her first year teaching, and the following year, when the interview took place, Ms. Davidson was working with preschoolers. This may help to explain both her openness to the instruction, as well as her hesitancy in determining the implications of these new ideas for her own practice.

A second teacher in this category, Ms. Knight, not only recognized and valued all the critical features we had identified in the instruction, but spoke of the instruction as a system, rather than a set of isolated features. For example, after having discussed these features she was asked if any of these were more "crucial" to the instruction, her response was "well I think they were all connected". However, as she went on to discuss this connectedness, it became apparent she had interpreted some of the features in ways different than we intended. For example, she viewed the story problems as primarily an interest-capturing device:

> I don't know that she [the teacher implementing the instruction] would have had to have story problems all the time. But the kids liked that part of it: where she would- when she would put it up on the board and have them written out. Um .. if they were reading it themselves for my poor readers, and there were some children that- they had a hard time with that, understanding the word problems. Where they could do better if it was just the addition and subtraction and they had to just do the process rather than read the story problems. And that's just connected with reading. So, um .. I'm sure for the higher math it was excellent though. You know because they wouldn't have trouble with the reading of it.

The bottom line for Ms. Knight was that her students be able to "do the process", and the story

problems were viewed as possibly detracting from this, rather than providing meaning for those very processes.

Of the three teachers in this category, Ms. Knight offered the clearest example of how teachers' beliefs about mathematics and teaching can influence their interpretation of alternative instruction. This relationship is exemplified in Ms. Knight's discussion of what she thought was most important for her students to get out of math this year. In this discussion she mentions word problems as being important, and thus her role is to provide the students with strategies to deal with them, such as the use of keywords.

> Probably that .. they can explain the process, or the reason that they got to that answer, the strategies they used to get to that answer more than the answer they got. If they can explain, and understand place value or the concept- like the concept of time and money is very difficult. But if they can grasp some of that I guess that would be the most important thing .. and word problems, and some critical thinking. We need to do more word problems, and I'm trying to give them keywords for them. Cause some of mine, you know they can't read the story so they, they are very frustrated from the beginning, so I try and say "Now look, try and find some keywords that are the important words in the story. You don't have to worry about someone's name or some of the other words, but look for those keywords", you know more, less, or greater than, those. So some strategies that they can use for problem solving and word problems.

This view of the teacher as being responsible for removing obstacles from her students paths to understanding is also revealed in the way Ms. Knight implemented the place value instruction that she observed. When it is time to teach place value, Ms. Knight now pulls out the lesson plans (given to her after the project ended) and implements a modified version of it. She explained:

> Now I did change, I, I know when [Ms. Major] was here the kids had to find out on their own if they were- in other words if the problem was 73 added to 26. They could start over in the tens column, and they had to figure out themselves, she wasn't supposed to tell them that you start in the ones column. ...
> I just said "we have a rule, you're going to start in the ones column and you're going to go to the tens. Only because I didn't want to go through all of that where they had to: "now where do you think would be better to start?" You know because they were supposed to discover that on there own. ... So I did change that a little bit. But other than that I pretty well stuck to their lesson plans and their

> word problems and copied them and wrote up some of my own, very similar, you know.

Thus Ms. Knight as the teacher maintained more control over the acceptable solution paths of her students, while apparently maintaining the belief that she was implementing the alternative instruction with only minor changes.

The final teacher in this category, Ms. Walters, did not seem very reflective when discussing her impressions of the project. Perhaps the fact that in the two and a half years between the time that Ms. Walters observed the instruction and when we discussed it, she had adopted a new mathematics program--Mathematics Their Way (Baratta-Lorton, 1976). Although she pointed to the alternative instruction as one of the things that pushed her towards this change, any impact it may have had on her seemed to be overpowered by the process of learning this new mathematics program. Thus Ms. Walters placement in this category is based on what little information she did offer. In reflecting on the instruction, Ms. Walters focused on the manipulatives as the most positive aspect of the instruction and said little about the other features. Her reports of implementing the lessons when it is time to teach "tens and ones" indicates a more narrow view of the instruction as being tied to a particular mathematical topic. Ms. Walters' discussion of her own teaching in this new mathematics program also indicated a need to maintain control over the ways in which students approached problems. For example, consider the following description offered by Ms. Walters of how her children learn the basic facts:

> So let's say this particular child chose to work on four .. or nine or whatever the number is. I mean we do go in sequence. So they make all kinds of patterns and everything and figure it out every way they can possibly figure it out.
> ...
> But let's say that we're working on four, and so I'll take beans or something, I carry them around with me in my pocket, and I'll say if there's one in this hand how many are in this hand [the closed hand; child knows how many beans there are altogether]. And they have to tell me the correct answer, and then I show them, and so we just keep doing this until we've done all of the facts of four and

> I'm confident that they know four. And when i'm confident that they know four, they move on. Um and you know, they'll work on five 'til they know five.
> ...
> And some children go from 5 to 7, and then back up to 6. It doesn't seem to make any difference, it always surprises me though.

On the one hand, the process by which her students come to know the facts is based on the student discovering the different possible arrangements and patterns with a particular number. On the other hand, Ms. Walters maintained her notion of the importance of learning these facts "in sequence" despite her acknowledgement that the children did not seem to need to do this. In this way Ms. Walters evidenced signs of being somewhere in the middle of our continua, though perhaps more because of the presence of seemingly contradictory beliefs than because of a more coherent, central position like that of Ms. Knight.

The other extreme: A point well taken. The two teachers in this category tended to recognize and internalize the instruction as the developers intended. These teachers recognized the instruction as a coherent whole that consisted of more than merely the sum of its features. For example, Ms. Callahan spoke about the project in ways that went beyond the individual features. In particular, Ms. Callahan spoke of the way the alternative instruction tried to link various representations:

> First of all, the preparation for it was fantastic because everybody had their own little kits of things [manipulatives] to use, and therefore the preparation was great. The follow through was great, even when they went to the pencil and paper tasks, the kids could always relate to what they were doing.

Although this linkage was alluded to by teachers in other categories, Ms. Callahan's discussion of this linkage projected an image of a continuous process while for other teachers' this process was considered as an aide to initial understanding, but unnecessary beyond this.

When comparing what she had heard about the project before she became involved with what she discovered after observing it, Ms. Talstead described a view of the instruction that was

consistent with ours:

> So they [other teachers at the school] thought that the university was trying to see if using the manipulatives helped.
> ...
> *And what did you think, in general about-*
> I didn't really think that it was the manipulatives as much as, it seemed to me that it was more having the kids be able to vocalize what they were doing, and be able to describe their thinking processes, and also having the kids understa- realize that there's no one right way in math, there's lots of different ways, but there's one or two ways that are more efficient than other ways. So, being able to pick out the most efficient way and decide if that works for you, if you're going to use it. But I think mostly describing what they did and be able to vocalize it and explain it to other kids and then they can share their thinking and see there's lots of different ways of doing it.

For Ms. Talstead the instruction was not simply about using manipulatives, as those in the first category, and to a lesser extent the second category, seemed to view it. Even when discussing the aspects of the instruction that she thought the children did not like, Ms. Talstead was more reflective than other participants in considering possible reasons for this:

> I think the part that the kids didn't like, or whatever or were unhappy with was the fact that they didn't have that much computation to do, but I think its that we train them to - that you should be sitting there doing all these problems and I think that there were days that they felt like they didn't really accomplish that much, because they didn't have a lot of problems.

Thus even when realizing that her children were sometimes uncomfortable with this instructional approach, Ms. Talstead was able to look at the situation with a broader lens and consider how prior experiences may have preconditioned them to feel that way.

Related to her interpretations of the alternative instruction are Ms. Talstead's beliefs about the importance of mathematical processes and students' responsibility in constructing them. For example, when discussing the students' roles in the observed instruction Ms. Talstead focused on them coming up with and discussing their own strategies and did not seem to feel that the student should eventually use the most efficient algorithm. In fact she proposed that removing this pressure allows more students to be "good at math":

> They're not just saying "he got the right answer, he got the prize", they're saying "he figured it out the right way". Even if he added wrong or multiplied wrong or forgot his facts, he had the right idea and he followed through the process correctly, you know, once he gets down the fine tuning or whatever. And then another thing is discussing the most efficient way. That's another thing we've been doing and saying this is a way to do it, here's another way, here's another way, this is the most efficient, the quickest way, but you don't have to use it. If you want to use it and it works for you then that's good, but you don't have to do it this way. And I think it allows for more kids to be good at math. More kids feel like - hey I'm a good math student because there's more acceptable ways to do it, it's not one thing is the only answer.

When discussing what she got out of observing the instruction Ms. Talstead again focused on children's thinking about processes rather than products:

> Oh sure, I use a lot of these things now, this year, that are, I think really help out my math program. Like discussing the different ways of doing it, and how each kid figured it out, cause I think, if you give them a chance to explain how they figured out, first off it puts value on each kids thinking, and they realize - hey this is important - you know, and I'm important and the way I figured this out is important and they're thinking more about the process than the product.

Ms. Callahan's beliefs about what mathematics students should learn and how it should be taught also reflected the process/student responsibility end of the continua. In describing what mathematics students should learn, Ms. Callahan gave the following definition of number sense in the primary grades: "If they can get a feel for more and less, for combining sets, and for seeing how numbers fit together. To add or subtract .. seeing how to combine". Her description of the roles of teacher and student in her classroom indicated an emphasis on the student as determiner of how problems will be solved: "We always do something concrete first, at least to introduce. And the manipulatives are always always available for whoever wants them. And if the children feel that they don't need them, than they can opt at some point not to use them."

Although the pattern and categorization discussed above helps us make sense of the data, such patterns and categories never fully fit the individuals that we place in them. The extremes, though interesting in theory, rarely occur in practice. For example, the teachers on

the skills and teacher responsibility end of our continuum did not totally discount the importance of understanding, nor did they feel that the stude: s have no responsibility for their own learning. Having said this, it is still valuable to note the differences in the degree to which these things were important. Now we will move to discuss those teachers who implemented the instruction. By focusing on the two of these teachers who have been teaching since their involvement with the project we can look more deeply at the patterns described above, as well as the complexities of changing one's practice even when one is convinced of the need for change.

Responses of the Teachers who Implemented the Instruction

The teachers who implemented the instruction were more intimately involved with the project. Although the lessons were developed prior to their involvement, they were not merely given the plans and left to implement them. Discussions were held with the teachers each day of implementation, often before and after each lesson, regarding ways to make the implementation most effective. They were also involved in periodic discussions regarding the rationale for the instructional approach. Given this intensified involvement, one would expect that the effect would also be intensified. Although the data support this general statement, a look at the particulars reveals ways in which these teachers differed in their responses, differences that can be understood, in part, in terms of their beliefs about mathematics and teaching.

The three teachers who implemented the instruction were all quite articulate in discussing the intent of the instruction and it's salient features in a way consistent with our views. For example, Ms. Jones' spoke of the way the project used "situations that they [the students] might be familiar with". This is a broader, more sophisticated view of the use of story problems than the views of most observing teachers. Like Ms. Talstead and Ms. Callahan, all three of these teachers acknowledged the importance of the manipulatives and the story problems, but focused on the student creation and discussion of strategies as critical to the

instruction. For example, in talking about how this instruction fit her previous teaching, Ms. Eckert discussed the fact that she had used manipulatives before becoming involved in the project, but not in the same ways as she did when using the alternative instruction. In addition, she noted that before this experience: "I still didn't do much discussion which is one thing that Jim and Diana influenced with- influenced me the most, to actually talk about problems". The most striking example of a teacher vocalizing this kind of broader conceptualization of the instruction is found in Ms. Majors' discussion of the difference between this kind of instruction and other forms of instruction that might use similar features. She explained that before being involved in the project she would do some activities consistent with those done in the alternative instruction, but she would "still tell them what to do". Ms. Majors' then proceeded, saying: "now I wouldn't. I'm not God anymore. I think that's what happened, I'm not God anymore."

All three of these teachers understood the intent of the instruction. All three tended to speak of what children should learn in mathematics as more processes than products. All three placed emphasis on the student's role as creator of knowledge in their discussions of instruction. But in their discussions of what they were currently doing in the classroom, Ms. Majors and Ms. Eckert revealed important differences that offer insight into the difficulties of change.

Reflecting on her teaching of mathematics before her involvement with this project, Ms. Eckert joked about the ways she taught:

> When I got to first grade I was real insecure, probably coming from like fifth and sixth - "oh no first". So I probably went back pretty much to the textbook. And that was at _ ___ elementary school. And in fact, actually what I did do, I was influenced that year by a partner, you know team colleague in first grade. And she had a system where kids moved at their own pace, kept a folder, you know numbered from 1 to 50. When you finished page 1 you got page 2, when you .. you know. I pretty much did all the pages. Um, in fact I did worse than that, I did the skill masters, or you know the little dittos that went with it.
> ....
> I look back and I think I can't believe I did that.

Ms. Eckert went on to discuss how she had infused the use of manipulatives into this set-up, but in a limited capacity. Shortly before implementing the alternative instruction, Ms. Eckert had begun a graduate degree in education with a focus on literacy. In addition, she had worked with one of the science educators at the university, an experience that she spoke of as getting her into the "Can you explain how you got that?" mode. Thus before being asked to implement this instruction, Ms. Eckert had begun actively seeking ways to expand her view of education.

Although it is clear that Ms. Eckert recognized and internalized the intent of the instruction, her own account of her current mathematics instruction was not that dissimilar from the way she taught before this experience:

> I still used the self-paced folders .. and the textbooks because the textbooks were paid for. And I do think the self-paced parents-- the parents that are most involved, which are usually the high kids, are real happy with that, because their kids are beyond everyone else and they're not being held back. But what I found was that even when I was doing that I would spend- Like instead of maybe game days with the manipulatives that I had .. we'd have a day where we would just try to talk about problems. If the majority of the kids are going into an addition chapter or something we would do it. We would, you know, like do a few problems, it's like you explain how you did that. But I still use, maybe 9 days out of 10, I was using the folders. Then when I came into a chapter in the book that was you know the place value, I would just implement Diana's lessons for first grade. And the big thing about it was trying to get all the materials ready. And fortunately I had a planning period before math, so I usually had time to get the bags out or whatever.
>
> ...
>
> But um .. I'd only do Diana's lessons like during, you know if it was a 3 week thing together. And I sort of thought well I'd love to have just plans for a whole year. That would take, I mean, so much time to write up.

In spite of Ms. Eckert's insightful descriptions of the goals of the alternative instruction, it is clear that she had not internalized the characteristics of the instruction as a general approach or orientation to teaching. She viewed the instruction more as a curriculum, a set of materials and activities. Implementing this form of instruction depended on having written lessons with the problems and potential questions spelled out.

Ms. Eckert's limited view of the alternative instruction may be explained partly by the realities of teaching multiple subjects in elementary school. She viewed herself primarily as a literacy teacher and indicated that there was not much time to redo her mathematics instruction However the restrictions she placed on implementing an alternative form of mathematics instruction can also be explained by her beliefs, especially those regarding the responsibilities of teachers and students. In discussing her instruction prior to her involvement in the project, Ms. Eckert complained that when she did self-paced instruction, the kids "got a lot less instruction", and therefore some kids "slipped through the cracks", but she kept doing it because it made parents happy. She hinted that, in some ways, she was abdicating her responsibility because she was not teaching in a traditional sense. She worried about this. In discussing the alternative instruction Ms. Eckert viewed the written lessons as doing the instruction: "I think Diana wrote lesson plans that somehow would do the teaching indirectly". In order to change her instruction, she would need to create an entire set of new lessons to achieve the goals of the alternative instruction. Because this would involve time that was not available, the only possibility was to implement this alternative place value unit, and leave all other instruction virtually unchanged.

There are many ways one can envision changing one's instruction. Ms. Eckert's view was, in some ways, quite similar to Ms. Walter's view. They both stepped out of their usual instruction when it was time to teach place value, and inserted the alternative lessons. Ms. Eckert did not leave her other instruction totally unchanged; she also inserted a day of discussing student explanations approximately one day out of every ten. And so, although she spoke of the importance of children knowing that "there's a lot of paths to an answer", she also felt that the teacher was responsible for this knowledge and must carefully plan a way to enable children to acquire it. In this way she also bears some resemblance to Ms. Knight.

The experience that Ms. Majors' brought to this project, as well as her views of what

mathematics is important and how to teach offer an interesting contrast to Ms. Eckert. Ms. Majors had more than five years of experience as a classroom teacher and many years of experience as a private tutor. The tutoring experience, as well as her two years spent implementing the alternative instruction, had a significant impact on the way Ms. Majors reported to now teach. From her work as a tutor she realized that " 'show me how to do it and I'll copy what you're doing' isn't going to make them learn anything because they're parrots". But she felt that working with a class was much more difficult than working with one student, and she described the difficulties she had in letting the students take more control. At the time of the interview she described her current practice, which involved pulling out children of different ages and skills for group remediation, as being more congruent with the spirit of the alternative instruction than her previous teaching. She always started out "with a scenario, just like Jim and Diana's type", posed questions, and had students explain what they were doing. When she was discussing the way she worked with similar students before her involvement with the project she noted the difference:

> But I was still in the "I'll show you how to do it" mode, rather than "What do you think?" That's the one phrase that was never part of my vocabulary. And I must have said that, over the course of those 2 years, at least a thousand times. And I say it at least .. let's see .. 20 times a day.

Ms. Majors seemed to have internalized the principles of the instruction to a greater degree than Ms. Eckert. Whereas Ms. Eckert spoke of the need to spend a summer writing the new lessons required for this instruction, Ms. Majors spoke of coming up with situations that would provide meaning for the concepts and processes at hand. In fact, as Ms. Majors described how her experiences teaching the alternative instruction affected her, she concluded by stating: "The lessons taught me how to be that way, but the lessons themselves aren't crucial to me now .. it's the whole outlook." This may be due to her prior tutoring experiences that placed an emphasis on listening to students, to her longer involvement with the project, or to her beliefs

about mathematics and teaching. Listing these "separate" reasons is deceiving in many ways. For example, Ms. Majors' stated beliefs about mathematics and teaching were likely shaped, in part, by her extensive experience as a tutor. In addition, she described changes in her beliefs during the project itself. Her tone frequently suggested an intense battle between the instructional features she had identified and her earlier beliefs about teaching mathematics. What seems to be the case, however, is that her beliefs and her analysis of the instruction changed together over the course of her involvement. This would support our hypothesis regarding the close relationship between these constructs.

DISCUSSION

It is reasonable to believe that changes in teaching practice would be supported by providing teachers with models or images of alternative forms of instruction. Alternatively it can be argued that obstacles to change include the absence of alternative models or images. Without such models, it may be difficult for teachers to imagine themselves as teaching differently. What would different instruction look like?

Although there are good reasons to believe that providing teachers with alternative models of instruction would be beneficial and support changes in practice, the responses from the teachers in this study suggest that the effects of this inservice approach are not straightforward. Teachers respond in a variety of ways. Some teachers miss the point of the alternative instruction, as envisioned by its creators. Others recognize some central features of instruction, but reject their merits. Others embrace a version of the instruction that the designers would describe as distorted and inappropriate. Still others seem to internalize both the spirit and the specifics of the instructional approach.

There are many factors that will ultimately account for differences in how teachers respond to observing alternative forms of instruction, or to implementing such instruction, but

we believe that two important influences are the beliefs teachers hold about mathematics and about teaching and learning mathematics. To the extent that these beliefs view mathematics as a series of procedural rules and see the teacher as responsible for students acquiring these rules, they will acquire little from watching demonstrations of reform-minded instruction. Even more intense involvement in implementing such instruction may not radically alter their practices. Experiences that effectively facilitate change will be experiences that, at least, encourage teachers to question their own beliefs.

As we are quickly learning, changing practice is a complicated and gradual process. Watching others engage in different practices may not alter our own. We have many indications that this is true with students learning mathematics; it should not be surprising that it is also true of adults as we continue learning to teach.

TABLE 1: Outline of Interview Questions

I. Biographical information

I'd like to start out by getting to know a little about you and your teaching experience.

Q1: a) What grade are you teaching now? b) Tell me about your class.

Q2: a) Have you been teaching this grade for long?

b) What other grades have you taught? c) How long have you been teaching?

II. Practice

Q3: Do you have any general routines or regular features in your math class that you think are important for the kids?

CLARIFICATION: Is there anything that you do, for example every day or once a week that you feel is particularly important for your students?

GENERAL PROBES: Can you give me an example of that? Why do you do that? How would that work on a particular day?

Q4: Have you changed your approach to teaching mathematics since you started teaching? Please tell me about that.

P: Causes for change?

Q5: What do you think is really important for your students to get out of mathematics class this year?

C: What would you like them to know when they leave your class @ the end of the year?

P: Why do you feel that this is important?

P: What else? Could you give an example?

P: Is there anything more specific/general?

III. Projec. specific questions

You were teaching _____ grade when your class was involved in this project, right?

I'd like to learn about your involvement with the project at that time.

Q6: Do you remember how you felt about the project before they entered your classroom?

Q7: Did you sit in on any of those classes?

Q8: Do you remember what a typical lesson would have looked like?

P: What kinds of problems did they do?

P: What was classroom discussion like?

[Pull out specific lesson(s) to use as a basis for the discussion.]

Here is an example of a fairly typical lesson.

Q9 How did the children seem to react to the whole project?

P: How did they react to doing story problems?

P: How did they react to being asked to explain how they solved a problem?

P: How did they react to working with the materials?

Q10 a) How did you to react to the whole project?

b) Was there anything you specifically liked?

c) Would you feel comfortable doing any of those things now or in the future?

P: Was there anything you specifically were uncomfortable with?

P: What did you think of the story problems?

P: What did you think about the students being asked to explain how they solved

a problem?

P: What did you think about the materiais?

Q11: Has being involved in this project changed how you think about teaching mathematics?

Q12: Has it changed your practice?

P: In what ways?

P: Can you give me an example of that?

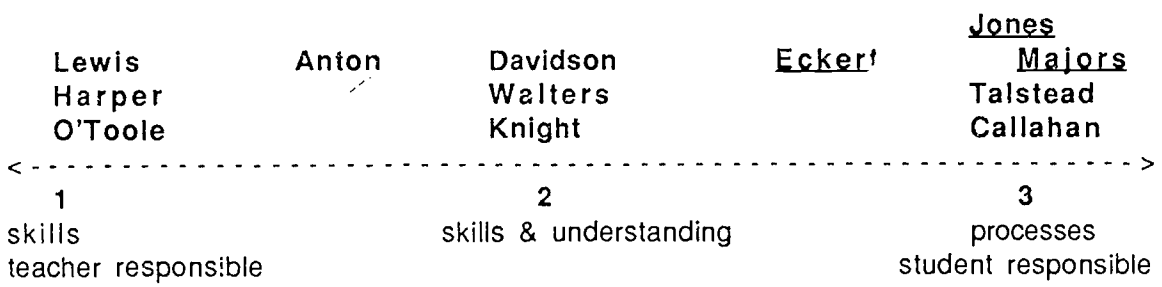

FIGURE 1: Placement of the teachers along a continuum

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