Transformation of Teacher Attitude and Approach to Math Instruction through Collaborative Action Research

By Patricia J. Bonner

What causes a teacher to change and grow? What factors in professional development enable a teacher to apprehend new instructional approaches and new attitudes toward practice and toward students? As a university professor who has taught at the teacher education, masters, and doctoral levels, the life of teaching has been an enduring interest, particularly teaching that occurs in K-12 settings. From my own work as a K-12 teacher and administrator to my earliest studies of effective teaching and in my own university teaching, I have been interested in the complex practice of teaching and in how to make the practice more effective for student learning and more satisfying and fulfilling for the teacher.

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During my K-12 teaching and administrative years, my experience with professional development was limited to what is commonly known as the "training model" (Sparks & Loucks-Horsley, 1990). Zeichner (2003) reports that the training model is the predominant professional development model in the U.S. and is usually a "one-shot, one day or even briefer experience" (p. 301) that is selected and planned by someone other than the individual teacher. It was not

until I taught a master's level course, *Research for Educators*, that I became familiar with the professional development experience called action research. Because in this course I guided classroom teachers in action research projects, I perceived a need to experience the process more "first hand." Thus, I engaged in a yearlong action research project with a fifth-grade teacher who happened to be my daughter.

My objective was to better understand the action research process; I had not anticipated the multi-faceted results in terms of student benefits and my daughter's increased sense of self-efficacy and professionalism (Bonner & Bonner, 1996). I attributed the positive results of this endeavor to the objectivity that was inserted into a fairly common teacher activity, that is, identifying a problem and "trying out" a solution. However, such action does not routinely include the collecting of data to assess how an intervention is working (Richardson, 1994). In addition, I perceived that collaborative inquiry was also valuable to the process. By having another person (myself) involved with the classroom teacher throughout the year, the opportunity to jointly question what was happening, to make changes, and to assess those changes turned out to be very important in the overall results. Finally, the documentation, writing, and presenting of the results locally and at a state conference validated the contribution and professionalism of this classroom teacher.

As a result of that yearlong endeavor, the principal of my daughter's elementary school invited me to work as a consultant with any of his teachers who might elect to engage in an action research project with my guidance and support. This article describes my experience in working with two bilingual fifth grade teachers in such a process. The focus of the article is on the transformation of these experienced teachers and on factors in the process that I believe contributed most strongly to their professional growth. Not only was there development in their mathematics instructional approaches, but even more noteworthy, in their attitudes toward their students, toward math as a content area, and toward themselves as teachers of mathematics.

Background

In the United States, where the call for educational reform is ongoing, there is a general recognition by educational leaders, government agencies, higher education professionals, and the public that the teacher is the key ingredient in student learning and in educational reform (California's Colleges and University Presidents and Chancellors, 2001; Cochran-Smith & Lytle, 1999; Darling-Hammond, 2001; National Commission on Teaching and America's Future, 1996). This is not a new nor recent acknowledgement, for as Stenhouse said in 1976 "It is teachers, who in the end, will change the world of the classroom by understanding it" (as cited in Al-Qura'n, 2001, p. 396).

However, teachers who persevere in the profession and "change the world of the classroom" must add "knowledge-*in*-practice" and "knowledge-*of*-practice" (Cochran-Smith & Lytle, 1999) to formal knowledge and theory gained in their professional

preparation programs. In order for this necessary, ongoing learning to occur, conditions within the teaching environment must support and encourage teacher learning. In fact, leaders in education reform, in addition to declaring that teacher learning is critical for student learning, are also suggesting that schools must be places where both teachers and students learn (Hargreaves, 1995; Smylie, 1995; Smylie & Hart, 1999). Schools must provide the environments that enable teachers to develop and improve as they practice the art and craft of teaching. Conditions that are associated with the professional growth and the ongoing learning of teachers include

- opportunities for *collaboration* (Darling-Hammond & McLaughlin, 1995; Fullan, 1995; Hargreaves, 1995; Lieberman, 1995; Smylie, 1995; Smylie & Hart, 1999; Zeichner, 2003);
- *autonomy* and *choice* in teachers' work (Smylie, 1995; Zeichner, 2003);
- *reflection* (Burton, 1986; Canning, 1991; Eraut, 1995; Killion & Todnem, 1991; Lytle & Cochran-Smith, 1992; Patterson, L & Shannon, P., 1993; Schon, 1995);
- *time* within the workday for professional development (Cochran-Smith & Lytle, 1999; Corcoran, 1995; Darling-Hammond & McLaughlin, 1995; Lieberman, 1995; Maeroff, 1993; U.S. Department of Education, 2000; Zeichner, 2003); and a
- *culture* of *inquiry* (Fullan, 1995; Lieberman, 1995; Sparks & Loucks-Horsley, 1990; Zeichner, 2003).

This study reveals the efficacy of the action research process in eliciting, not just teacher learning, but teacher transformation in attitude and instructional expertise with concomitant beneficial effects on student attitude and learning. I will highlight the factors that I suggest were particularly salient in effecting the transformation: autonomy, time, culture of inquiry, collaboration, objectivity, and reflection.

Autonomy

An important factor in human motivation is the aspect of autonomy or self-determination, that is, the sense of volition or being able to choose one's direction or action (Ryan & Deci, 2000). I believe that self-determination was a particularly important contributor to the growth of these teachers in the action research process. They were able to choose whether to participate, decide which "problem" to isolate and address, and select "how" to address it, plus elect to write their studies and present them at a statewide conference. This aspect of autonomy is evident as I describe the unfolding of the year-long endeavor.

Context and Participants

After the principal invited me to work with other teachers who might be

interested in engaging in action research to study and improve their practice, I attended the first staff meeting of the year at which the principal and I made the opportunity available to the entire teaching staff. In addition to the provision of a consultant and the invitation to the teachers, the principal also used the incentive of allowing the action research process to substitute for the annual teacher evaluation procedure. Even with this incentive, only the four fifth-grade teachers who had most closely observed the effects of the action research process on their colleague and her students, elected to work with me over the school year. This fact clearly suggests that the process was indeed volitional, and participation was completely voluntary and up to the individual teacher.

This study specifically describes the work of two of the fifth-grade teachers who chose to examine their mathematics instructional practices because they team-taught and worked together with the same students in the areas of reading, math, social science, and science. The other two fifth-grade teachers focused on the implementation of literature circles, and although the process was beneficial to both teachers and their students, these two teachers did not team-teach and thus did not experience the same level of collaboration that occurred with the bilingual math teachers who are the focus of this paper. In addition, an aversion toward their subject matter was not present with the two teachers who focused on literacy, thus the attitudinal transformation toward the content area was not present and the results not as dramatic. Hence, only two of the four teachers are the focus of this aspect of the study.

The study took place in a suburban school district in Los Angeles County with 11,350 students, approximately 55% with a primary language of Spanish. The specific school site had 575 students with approximately 78% with Spanish as their primary language. The two teachers, Thelma Cervantes and Rosa Juarez (pseudonyms), were both Hispanic, Spanish-speaking bilingual teachers who team-taught two fifth-grade bilingual Spanish classrooms of 30-32 students each. Their students were primarily low SES, Hispanic, and limited-English-speaking students. Thelma had been teaching for 13 years and Rosa for four.

Time

Although time is more of a structural factor, which will not in and of itself assure quality professional development, historically in the U.S. there has not been provision made for time within the workday to accommodate the necessary ingredients for teacher learning, particularly collaboration and reflection (Maeroff, 1993). In discussing the salient dimensions of inquiry communities, Cochran-Smith & Lytle (1999) describe time as one of the most critical dimensions when teachers come together as researchers because they "need sufficient chunks of time in which to work and sufficient longevity as a group over time" (p. 294). Zeichner (2003) echoes the necessity of the longevity of the process, emphasizing the need for at least a year of working together as a group. This study included both time within the workday and time across an entire school year.

In addition, the school was a California Restructuring School authorized by California State Senate Bill 1274 that had included in its restructuring plan a reconfiguration of time. Certain days were lengthened each week in order to provide student-free time for teachers' meeting, planning, and professional development. Thursdays were pupil-free beginning at 2 p.m., and Fridays were pupil-free from 8 to 9:30 a.m. This provided workday time for us to meet throughout the year, approximately twice a month, and was a key factor in our being able to devote the necessary effort to the action research process and to dialogue together, bringing our "perspectives to bear on inquiries into the complexities and messiness of teaching and learning" (Cochran-Smith & Lytle, 1999, p. 279).

Culture of Inquiry and Collaboration

In describing the action research process, the important components of a culture of inquiry and collaboration are interwoven. A culture of inquiry encompasses learning about teaching while teaching and the continuous questioning of the dynamic process of teaching and learning. Fullan (1995) describes it as "internalizing norms, habits, and techniques for *continuous learning*" (p.256). Zeichner (2003) emphasizes respect for the "voices of teachers and the knowledge they bring" (p. 318). A "culture" of inquiry, implies the social context in which individuals inquire together and thus the component of collaboration that is so desperately needed in the teaching profession. The need for collaboration in teaching is described by Smylie (1995) as: "An optimal school learning environment would provide teachers opportunities to work and learn together" (p. 104). The interaction between questioning and learning among myself and the teachers was infused throughout the process as is evident in the description which follows.

In October I began meeting with the four fifth grade teachers, and we initiated discussions of areas about which they were concerned and on which they might wish to focus their inquiry. The two teachers in this study, Thelma and Rosa were concerned about their students' low performance in mathematics on the Stanford Achievement Test (SAT) utilized by the district to assess student performance in core academic subjects. In addition, Thelma expressed concern that she lacked confidence in her knowledge of the subject of math.

Because low math achievement, as evidenced by test results, was the initiating factor for their concerns, we acquired the standardized test results for the previous year and agreed to review them individually, looking for relative strengths and weaknesses. When we met again, we agreed that the test results revealed a weakness in students' ability to solve word problems. In addition, Rosa noticed that the area she had not covered adequately in relation to word problems was identifying the "information needed" and the "information not needed." Knowledge gained from the test results guided the rest of our inquiry and influenced the focus of the action research.

To stimulate their thinking regarding math pedagogy, I gave the teachers an

article which described Cognitively Guided Instruction (Viadero, 1995), that is, basing instruction on children's intuitive understandings about math, helping students build on what they already know, and helping them learn from each other, in an attempt to guide them in the direction of listening to and learning from their students. I also asked them to read the "Strategies for Increasing Achievement in Mathematics" in *Educating Everybody's Children* (D'Ambrosio, 1995, pp. 121-137) that reviewed the latest research and theory on effective instructional approaches in mathematics. To explicate some of those approaches, I gave them articles on the use of writing in mathematics instruction (Johnson, 1983; Keith, 1988; Powell & Ramnauth, 1992; Waywood, 1992) and grouping in mathematics (Good, Reys, Grouws, & Mulryn, 1990). The rationale that we discussed was that if they wanted a change in their students' learning of mathematics, they would likely need to consider a change in their math instructional approaches.

As we continued meeting, we reviewed the different mathematics teaching strategies recommended in *Educating Everybody's Children* and discussed which of those they were currently using. In describing this process, Thelma wrote in her case study, "I also began to question my math instructional approaches and to take a strong look at how I was teaching as well as what I was teaching." Based on two specific approaches from the chapter on mathematics strategies, "Use Errors to Enhance Learning" and "Encourage Oral and Written Expression," she decided she would try math journaling to learn what her children thought and how they did the math and that she would specifically focus on word problems. In addition, both teachers expressed an interest in having students explain how they derived their answers, right or wrong. Rosa indicated that, based on the readings, she had tried having each small group of students explain their answers that week and the students had responded very positively, providing her with insight to guide her inquiry and their learning.

Simultaneously with exploring the focus for inquiry and possible instructional modifications, I began explaining action research, gave them articles about the process (Bennett, 1993; Calhoun, 1993), and emphasized the importance of recording and reflecting on what they were doing as well as how the students were responding, using journaling and field notes. I encouraged them to retain student work samples so that we could examine and discuss them. I had seen that it was, in fact, the documentation of results in my daughter's study that had validated what she had discovered and that had raised her sense of competence, self-efficacy, and professionalism (Bonner & Bonner, 1996). In addition, the action research projects of the students in my classes were clearly of little value without accompanying evidence.

Reflection

In my judgment the incorporation of reflection in the action research process was another prominent feature in terms of the learning that the teachers experienced. Merriam and Caffarella (1991), in their discussion of experiential learning in adults, note that learning does not automatically occur from experience, and they describe

Jarvis' conception of the highest form of learning as *experimental learning* (the result of a person experimenting on the environment) combined with *reflective practice* (thinking about and monitoring one's practice as it is happening) (pp. 225-26). Reflection was built into the entire yearlong process and was an aspect that the teachers came to understand was fundamental to their learning.

Implementation of the Action Research

The two teachers devised a brief 20-question assessment of basic math skills that they used to ascertain which students were higher-achieving in math and would receive instruction from Thelma and which were lower-achieving and would be instructed by Rosa. Thelma decided to use math journals and whole group discussions. As students progressed in their journaling, they not only wrote how they solved the problem but also drew their solutions to the problems. Rosa used cooperative groups and assigned a word problem two or three times a week. Students worked on the problem independently at home and then together in teams the next day with each team making a poster depicting the solution to the problem that they then used to explain to the class how they solved the problem.

Both teachers introduced a four-step word-problem-solving strategy to their students: (1) write out the entire problem, (2) cross out unimportant information, (3) draw the problem, and (4) solve the problem. Heretofore, neither teacher had provided her students with any specific strategy for solving word problems. As a result, the teachers gained insight that students could be helped by learning to differentiate between important and unimportant information in the word problems and by the other components of the four-step strategy. In both classes, individuals or groups of students frequently explained to the entire class how they had solved a problem and drew the solution depicting how they solved it. To assist in the math journaling, since it was a new strategy, I provided a book for Thelma on the use of math journals entitled *Writing to Learn Mathematics: Strategies That Work* (Countryman, 1992), which she began to use as a guide for her students' math journal assignments.

Because action research is not static and linear but dynamic and changing in response to reflections on each phase (Noffke, 1997), strategies used by both teachers evolved as they reflected upon their own actions and on the responses of students and as they discussed their reflections with their inquiry community — all four fifth grade teachers and myself. In the fourth month, I observed teaching episodes in each of the classrooms and discussed my observations with the teachers, providing some suggestions related to the math instructional approaches they were using. We continued to meet and discuss what they were observing as well as the action research process itself and the importance of maintaining their ongoing data collection, e. g., their reflective journal entries, student work, and field notes.

Between January and March, while continuing with the research, we worked on formalizing written case studies of each of the projects to be submitted for

publication and presentation at the California School Restructuring Symposium in May. Again, the principal's support by providing time and resources was critical. In March he provided substitute teachers so the four teachers could spend a day with me finalizing their case studies. The case studies from this one elementary school became four of only 24 teacher case studies statewide presented and published for the event, thus validating the provision of time and the culture of inquiry.

Methodology

In June I interviewed each of the teachers, asking 13 questions (see Appendix A.1), to probe their perceptions of the action research process and their own learning. I asked each teacher to select four students from her class to be interviewed: (a male and female with high math achievement, and a male and female with low math achievement from each class). I interviewed a total of eight students using an interview protocol with nine open-ended questions (see Appendix A.2). I did a follow-up interview of the two teachers in November of the following school year to assess whether there had been carry-over of the new approaches into their on-going teaching behavior and to gather their perceptions on the action research process a few months removed from it (see Appendix A.3).

The data I collected included: (a) teachers' regular journaling of what was occurring in the classroom and their own reflection on what was happening, (b) students' journals and drawings, (c) researcher's notes from 15 regular meetings with the fifth-grade teachers, (d) researcher's field notes of classroom observations and subsequent discussions with the teachers, (e) case studies written by the two teachers and presented at the statewide symposium (f) researcher's June interviews of the two teachers, (g) researcher's June interviews of eight students, (h) school district proficiency assessment test—Mathematics Application Performance Assessment (MAPA), and (i) researcher's interviews of the two teachers, conducted the following school year.

I collected all of these data and read through all of the sources multiple times. Certain recurring themes and patterns emerged in terms of the effects of the process on teachers and students. I summarized the most prominent themes and discussed them with the two teachers who concurred with the findings. Because much of the data was their data, that is, their journals, their students' work, their written case studies, and we had been discussing the findings as the process evolved, the teachers were familiar with the information and were able to recognize and affirm these emergent themes.

Findings

Findings surfaced in the following areas: (a) teacher knowledge regarding math instruction, (b) teacher attitude toward math instruction, (c) student attitude toward math, (d) teacher attitude toward students, and (e) value of action research process.

Again the component of a culture of inquiry was a key factor in the learning and change of these teachers. Sparks and Loucks-Horsley (1990) describe *inquiry* as one of five models of teacher professional development. It is based on three assumptions:

> (a) teachers are intelligent, inquiring individuals with legitimate expertise and important experience; (b) teachers are inclined to search for data to answer pressing questions and to reflect on the data to formulate solutions; and (c) teachers develop new understandings as they contribute to and formulate their own questions and collect their own data to answer them. (p. 243)

As Thelma and Rosa inquired into an area of concern to them, studied student performance data, and consulted the knowledge of experts and knowledge they had acquired through their own experience, they began to gain new knowledge about their practice. Both teachers reported that they learned the value of understanding students' thinking processes in the solution of math word problems and the value of having students orally express, write, and draw how they arrived at their solutions. Rosa discovered that by implementing these new approaches she "could make math interesting" to herself and to her students. Thelma reported in her case study that

> Math journaling also allowed me to take a look at how the students think. I noticed differences when it came to computation (for example, one child choosing to add while another multiplies) as well as differences in how they depict the solution as in the case of the student who solved the above division word problem [250 divided by 5] by adding 50 five times. Another student divided and another student multiplied.

Both Thelma and Rosa were enthusiastic about their learning of new math instructional approaches, which was powerful because they had discovered and implemented them on their own and documented the results in their students. They both noted that they had not previously taught their students any formal method for solving word problems and had discovered the value of teaching students to eliminate the unimportant information and follow the four steps described earlier. Thelma exclaimed in her journal, "Wow, what a difference it made to have the kids find the important information and list it!!!"

In her case study Rosa described her discovery of the value of students' explaining their thinking processes and was gratified to see carry-over into other math areas:

> Another aspect . . . which has helped my students immensely, has been orally expressing how they solved the problems—in their teams and in front of the class. Not only have I seen improvement in the students' understanding of word problems, but I have also seen a lot of improvement in how students approach other basic math skill problems.

While the teachers were undertaking their collaborative inquiry, students were

participating in a similar collaborative inquiry and problem solving experience. Rosa discovered the benefits of having students work in groups to solve the word problems:

> Teamwork has also been a bonus in helping the students become more confident in their problem solving abilities. As a group, they seem to be willing to take more risks and explore new materials with a more positive attitude. As I was walking by one of the teams I overheard Roger tell Don, "No, Don, you can't add the two scores. They're not asking for the total, they are asking for the difference. I think they want us to subtract."

In contrast to the minimal impact of traditional types of staff development, particularly the training model (Joyce & Showers, 2002, p. 78), both Thelma and Rosa reported in the interview the following school year that they were utilizing the learning that they had gained from their own inquiry in their math instructional practices. Thelma said, "I use everything I had learned last year" and specifically mentioned the strategies of having students identify the important parts of a word problem, draw the solution, and articulate how they developed the answer. Rosa, as well, described the integration of the new approaches into her repertoire of math instructional strategies.

Teacher Attitude toward Math Instruction

Although the learning of a more effective way to teach problem solving, and the value of understanding the students' thought processes, was not a surprise to me because I observed this development as it unfolded, the change in the teachers' attitude toward math instruction and the resultant sense of self-efficacy in teaching math was not foreseen. The teachers also did not anticipate this transformation in their attitude toward teaching math. Rosa's affect toward math instruction was transformed from aversion to pleasure and self-confidence:

> Although in the past I enjoyed math as a student, last year I began to dislike teaching math. It became repetitive and boring, and I could tell that the students hated it just as much as I did. Fortunately, since we began working on this action research/case study project, I have started to enjoy teaching math again. It has made me have self-confidence about teaching math, more willing to try different approaches. It has made me like math more.

Not only did Thelma not enjoy teaching math, she lacked confidence in her own math competence and thus confidence in being able to teach it. She discovered a new sense of efficacy and enjoyment in teaching math:

> I discovered that I liked math, doing it this way, teaching math, because it has not been a subject I have enjoyed teaching. I learned how to teach it better, and I enjoyed it also.
>
> I feel more confident now because I have tried a new approach to teaching math and have made some important discoveries which have clearly enabled my students to perform better and to feel more confident themselves.

Student Attitude toward Math

The effect of the transformation of teacher attitude toward math was apparently transmitted and "caught" by the students. Although the teachers had commented on this change in our discussions, I had not expected it to show up so strongly in the data. In unstructured and episodic observations, the teachers noted that students were demonstrating a change in their attitudes toward math. Teachers observed increased student enjoyment of math activities, an increase in math self-efficacy, and a decrease in apprehension regarding math. Rosa noted her pleasure at seeing the students "excited" about math and "really happy" and wanting "to do math," even during reading. In her journal and case study she described the change in students:

> When I first began the case study, I detected a very negative attitude from the students when I assigned math word problems, even though they were working in teams. As the weeks went by, however, I noticed the students asking me for more word problems. For example, Maria, said to me one day, "Mrs. Juarez, I sure like math a lot." All the students seemed to feel this way. I thought it was because they enjoyed working in teams, but soon I realized they actually enjoyed solving the word problems on their own. Even the problems completed at home showed a lot of effort, detail and some improvement in finding correct solutions.
>
> The number of students turning in their homework daily has increased, and their work habits have improved. I sometimes catch them trying to do their math during reading. Furthermore, I can now name at least 10 students who have said to me, "Mrs. Juarez, I really like math."

Students themselves reported similar changes in affect toward math and self-confidence in mathematics competence. Of Mrs. Juarez's *four* students (low skills group) who were interviewed:

- ◆ When asked what was easy for them, *four* indicated some aspect of "math."
- ◆ When asked how Mrs. Juarez helped them this year, *three* indicated some aspect of "math."
- ◆ When asked what they especially enjoyed this year, *two* responded "math."
- ◆ When asked what they learned this year, *two* indicated some aspect of "math."

Thelma observed the dramatic change in attitude through her students' math journals, particularly in six students, who at the beginning of their journaling, described negative feelings about the subject. In March when asked again to describe their feelings toward math, these same students each indicated that they liked math, using words like "cool" and "fun."

Thelma indicated in her interview that her students ended up liking math a lot because it was not boring. Further observations were recorded in her case study:

> My observation is that the children are participating more in class and seem to have a different perspective about math. They consider math "fun." While giving my class a compliment about the strides they have made one student's comment was: "I know I'm learning. I never used to get word problems correct and now I am amazed with myself." They are excited when they realize they have done the problems right; their faces tell the story. When a child sees math as "fun and exciting" rather than the opposite I have conquered half the battle.

Teacher Attitude toward Students

Possibly the most important, and hopefully long-lasting outcome, and certainly the most powerful insight for the teachers related to their perception of the academic capacity of their students. Although both teachers were Hispanic, bilingual Spanish-speaking, empathic and conscientious, they discovered greater potential in their students than they had previously envisioned. In the interview, when describing what she had learned about her students, Rosa said,

> I learned they were a lot smarter than I thought. They have a lot more potential than I thought. At the beginning, I figured they were low on our exam, they were not going to learn as much as they have. I was pleasantly surprised.

Thelma reported a similar reappraisal of her students' capabilities:

> I learned I could push them a lot more than I thought. You always hear you can only push them so far because of SES. I learned it doesn't matter who they are, if you push and prod, they will get it to a level that is very high.

Value of Action Research Process

Both Rosa and Thelma found significant value in the reflection aspect of the action research project. The process also caused them to examine, implement, and study effective new approaches to mathematics instruction. Rosa describes the value of the process for her:

> It made me think about what I was doing, not just plan lessons and present them but the journaling, the reflection, made me analyze what I was doing. The reading is what triggered me to work on the word problems because it mentioned a low math group and having them think about and verbalize the problems as a good thing to do.
>
> Without the action research process, I wouldn't even have thought about it (the math approach). It wouldn't have crossed my mind. I had tried working in small groups, one on one, and peer tutoring. I wouldn't have thought about having them articulate their thinking process. I might have had them write about it, but that would have made them more frustrated.

Thelma's analysis of the process focused not only on the benefits of reflection but also on how it addressed her need to change during the stable phase of her teaching career:

> After 13 years of teaching, I began thinking about what I was doing. I had gotten into a rut and it got me out of the rut. I have started thinking about how this was going to teach them. I took a different look at these kids in a different way.
>
> Regarding action research, I would tell another teacher to do it, especially if you are kind of stuck in a rut. It lets you look at something different. I would warn them that it is a lot of work and you must be consistent but it is very rewarding. It made me accountable.

In the second interview of the two teachers (November, the following school year), it also became clear that the experience of formally preparing both the written documents and presenting their studies at the California School Restructuring Symposium contributed to an enhanced sense of professionalism and personal growth for each teacher. The act of writing a case study was also an endeavor in reflection, and because it was done together with the other fifth-grade teachers and myself across a full work-day with subsequent readings and revisions, it encompassed the elements of collaboration and inquiry as well

Issues

The issues which detracted from a fully-satisfying action research process related to the difficulty in adequately substantiating student learning through the district standardized achievement tests and the recognition by the teachers of factors that could have strengthened the process and their learning but which were not adequately included in the process.

Achievement Test Results

Although efforts were made to ascertain if students had demonstrated increased learning on standardized testing, it was impossible to determine anything definitive. Student transiency contributed to the difficulty; however, the main difficulty was that some students were tested in Spanish on the Aprenda in fourth grade and subsequently on the Stanford Achievement Test (SAT) in fifth grade. Aprenda was the standardized achievement test used by the district to assess achievement in Spanish-speaking students. The perception of the fifth grade teachers was that the Aprenda was an easier test than the SAT and that students would not demonstrate adequate growth if tested on the Aprenda in fourth grade and tested on the SAT in fifth grade. Indeed, the fluctuation of achievement in students who were tested on the different measure, as much as 2+ grade levels in both directions, precluded any meaningful conclusions from the standardized test results.

Both teachers did report a marked improvement in their students' performance on the MAPA (Mathematics Application Performance Assessment) which was the district-developed assessment of student math proficiency. Thelma reported that all of her students passed the MAPA, compared with only 40% to 50% in previous years. Rosa reported that seven of her lower-achieving students had passed the MAPA, compared with none passing in previous years.

Limitations

There was a consensus among the participants in this study that it would have been strengthened by (1) an explicit pre- and post-assessment to accurately ascertain student growth in solving math problems, (2) increased regular journal entries by the teachers, and (3) videotaping of the teachers' lessons to assist them in analyzing their behaviors and student responses.

Discussion

My own experience with one teacher in a yearlong action research process and then with these two teachers in another yearlong action research process profoundly influenced my belief in the transformative power of action research as professional development. Although it is a "messy" process, with each case having its own distinctive, sometimes esoteric, elements, there are important factors that I believe were particularly contributory to the outcomes in the professional lives of these teachers, and consequently, in the lives of their present and future students.

From my perspective these key ingredients were the components of (1) *autonomy* or volition, with teachers choosing to engage and selecting the areas of need or problem and the strategies to employ; (2) *time* within the workday to question, plan, analyze, and discuss plus prolonged time over a school year to continue to reflect and inquire with colleagues; (3) the emphasis on *objectivity* through the collection and examination of multiple sources of data; (4) immersion in a *culture of inquiry* where teachers "construct knowledge by conjoining their understandings in face-to-face interactions with one another over time" (Cochran-Smith & Lytle, 1999, p. 280); and as part of the "culture" of inquiry (5) *collaboration* with other teachers and with a resource person who was not an authority figure and thus was able to facilitate a "safe and supportive group environment" (Zeichner, 2003); and finally (6) the emphasis on *reflection*, that is, deliberately thinking about and examining what one is doing and how one's students are responding.

Borko and Putnam (1995) assert:

> Persons who wish to reform educational practice cannot simply tell teachers how to teach differently. Teachers themselves must make the desired changes. To do so, they must acquire richer knowledge of subject matter, pedagogy, and subject-specific pedagogy; and they must come to hold new beliefs in these domains. Successful professional development efforts are those that help teachers to acquire or develop new ways of thinking about learning, learners, and subject matter, thus constructing a professional knowledge base that will enable them to teach students in more powerful and meaningful ways. (p. 60)

Throughout this action research professional development experience Rosa and Thelma acquired "richer knowledge" of how to teach math. Their transformation was evidenced in new viewpoints about the teaching of mathematics and "new ways of thinking" about learning, about their students, and about themselves. They certainly

believe, and the evidence would support, that they acquired knowledge and beliefs that enabled them to teach their students in "more powerful and meaningful ways" and in ways that resulted in transformation of their students' attitudes toward math and the students' sense of competence in learning mathematics.

Teacher change, like most human change, must emanate from within. Governments and agencies can mandate changes in teaching, but cannot through that requirement alone bring it about. Although large-scale, mandated efforts to reform schools are undoubtedly necessary, they have thus far not been uniformly effective. According to *general systems theory* "a change in one part of the group affects some or all of the others" (Rohmann, 1999, p. 395). This study suggests that perhaps teaching and teachers can be changed individually, almost one at a time, and thereby change the "system" of schooling through the transformative learning that is possible in action research as professional development.

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Appendix A.1

Teacher Interview 1 (June)

1. What did you learn from the action research project?
   a. about teaching math?
   b. about your students?
   c. about yourself?
   d. about the process?
2. What did your students gain?
3. What was frustrating to you in the process?
4. What was exciting?
5. What would you do differently next time?
6. Would you do an action research project again?
7. What would you say to a teacher considering taking on an action research project?

Appendix A.2

Student Interview (June)

1. How did you like the school year?
2. What did you especially enjoy? Why?
3. Was there anything you did not like? What?
4. What did you learn this year?
5. What was easy for you?
6. What was difficult for you?

7. How did Mrs. (teacher) help you?
8. What did you like best about Mrs. (teacher)?
9. What do you wish were different about this year?
10. What do you want to do/be when you finish school/grow up?

Appendix A.3

Teacher Interview 2 (November)

1. What has been the carryover this year, if any, from what you did last year?
2. What was the value of doing the CCSR (California Center for School Restructuring) Symposium?
3. What is the evidence, if any, of improved student learning?